1. INTRODUCTION TO FRESH WATER AQUACULTURE

1.1 Introduction

Aquaculture has been defined in many ways. It has been called as the rearing of aquatic organisms under controlled or semi controlled condition - thus it is underwater agriculture. The other definition of aquaculture is the art of cultivating the natural product of water, the raising or fattening of fish in enclosed ponds. Another one is simply the large-scale husbandry or rearing of aquatic organisms for commercial purposes. Aquaculture can be a potential means of reducing over need to import fishery products, it can mean an increased number of jobs, enhanced sport and commercial fishing and a reliable source of protein for the future.

Fish is a rich source of animal protein and its culture is an efficient protein food production system from aquatic environment. The main role of fish culture is its contribution in improving the nutritional standards of the people. Fish culture also helps in utilising water and land resources. It provides inducement to establish other subsidiary industries in the country.

The basic principle of composite fish culture system is the stocking of various fast-growing, compatible species of fish with complementary feeding habits to utilize efficiently the natural food present at different ecological niches in the pond for maximising fish production. Composite fish culture technology in brief involves, the eradication of aquatic weeds and predatory fishes, liming: application of fertilizers on the basis of pond soil and water quality, stocking with 100 mm size fingerlings of Indian major carps-catla, rohu, mrigal, exotic carps, silver carp, grass carp and common carp in judicious combination and density; regular supplementary feeding and harvesting of fish at a suitable time. Composite fish culture system is conducted by adopting three types of combinations viz., culture of Indian major caps alone, culture of exotic carps alone, and culture of Indian and exotic carps together. Fish production ranging between 3,000 to 6,000 Kg. per hectare per year is obtained normally through composite fish culture system. Development of intensive pond management measures have led to increase the fish yield further. Integated fish and animal husbandry systems evolved recently are the fish-cum-duck culture, fish-cum-poultry culture, fish-cum-pig culture, utilization of cattle farm yard wastes and recycling of biogas plant slurry for fish production. Advantages of the combined culture systems, number of birds/animals, quantity of manure required and fish production potentiality of the recycling systems are described. Fish culture in paddy fields is an important integrated fish cum agriculture system. Essential requirements of paddy fields to conduct fish culture, characteristic features suitable for culture in rice fields, constraints to culture fish in paddy fields due to recent agrarian practices, and improved fish-paddy farming methodologies are discussed. Freshwater prawn culture is a recent practice. Giant freshwater prawn Macrobrachium rosenbergii and Indian riverine prawn M. malcolmsonii are the two most favoured species for farming purposes in India. Breeding, hatchery management, seed productio, culture systems and production potentialities of the freshwater prawns are presented. Commercially important air-breathing fishes of India are the murrels, climbing perch, singhi and magur. Techniques of their seed production and culture systems are described.

1.2 Fresh Water Culture Systems

Cultivable organisms are cultured in different types of culture systems. Many culture systems are based on traditional ideas that have been used for years, but some encompass new and some times radical concepts that make them unique. There are three major culture systems - open, semi-closed and closed culture systems. Each has its special characteristics, advantages and disadvantages. The choice of system is largely dependent on the function of the organisms to be grown and the resources and ideas of the farmer.

1.2.1 *Open culture systems*

Open systems are the oldest and its farming is the use of the environment as the fish farm. Natural resources can be used as culture systems and organisms to be cultured are stocked in the water body. Capital expenses are low for the open culture systems. There is less management than in the other systems. The conditions are more natural and uncrowded in the culture environment, less time is required in monitoring the condition of the culture organisms in open systems. The disadvantages like predation and poaching are common. The growth rate and the uniformity of the product are variable compared to other systems. Cages, long lines, floats, rafts, trays and clam beds are examples of open system techniques.

1.2.1.1 Cage culture:

It is the culture of fish or other organisms in a river, lake or bays by holding them in cages. Cages are built of metal rods, bamboo mesh or PVC pipes and covered by mosquito cloth or nylon net.

Cage culture, in recent years, has been considered as a highly specialized and sophisticated modern aquaculture technique, receiving attention for intensive exploitation of water bodies, especially larger in nature, all over the world. In India, cage culture was attempted for the first time in case of air breathing fishes tikeH.fossilis and A. testudineus in swamps.

1.2.1.2. Pen culture:

Pens are the specially designed nylon or bamboo made enclosures constructed in a water body into which fish are released for culture. Such type of culture is referred to as pen culture.

1.2.1.3. Raft culture:

Rafts are generally made of bamboo poles or metal rods with buoys at the top for floating in the water. These are used in the culture of oysters, mussels and seaweeds in open seas.

1.2.1.4. Rack culture:

Racks are constructed in brackishwater areas and inshore areas for rearing oysters, mussels, seaweeds, etc.

1.2.2 *Semi-Closed Culture Systems*

In semi-closed culture systems, water is taken from natural sources or ground water and is directed into specially designed ponds and race ways. These systems offer an advantage over open systems in that they allow greater control over the growing conditions. A greater production per unit area is possible in addition to crop being more uniform. Water can be filtered to remove predators, diseases can be observed and treated more easily in semi-closed systems. The main disadvantages are more expensive and require more complex management. Ex:- ponds and raceways.

1.2.2.1. Pond Culture:

The majority of aquaculture throughout the world is conducted in ponds. Earthen ponds or reinforced concrete ponds are used for culturing the fish, shrimp, prawn, etc. in both freshwater and brackishwaters.

1.2.2.2. Raceway culture:

A series of earthen or cement tanks are constructed along the course of a river or stream and are used for fish culture. Raceway is a culture chamber that is generally long and narrow. Water enters at one end and leaves through the other end in most cases.

1.2.3. *Closed Culture System*

In closed culture systems, no water is exchanged and the water is subjected to extensive treatment. Extremely high densities of organisms may be raised under these conditions. Farmer has complete control over growing conditions in closed systems. The temperature is regulated, parasites or predators are not found and harvesting is simple. Food and drugs can be added efficiently into the system to grow quickly and uniformly. Fish or prawn culture in water recirculation systems is good example for closed systems.

1.2.3.1 Water recirculation systems:

Here the water is conserved throughout most or all of the growing season by circulating in the culture tanks after purifying it through biological filters. Closed recircu-lating water systems are being used primarily for experimental work and for the rearing of larval organisms in commercial or research facilities. Closed systems are generally comprised of four components; the culture chambers, a primary settling chamber, a biological filter (biofilter) and a final clarifier or secondary settling chamber for purification of water for reuse.

Table-1.1 Inland water resources in India

	Resource	Extent	Type of fisheries
a.	Rivers	29,000km	capture fisheries
b.	Canals & streams	1,42,000km	capture fisheries
c.	Lakes	0.72m ha	capture fisheries
d.	Reservoirs	3.152m ha	
	Large	1,140,268 ha	capture fisheries
	Medium	527,541 ha	capture fisheries
	Small	1,485,557 ha	culture-based fisheries
e.	Ponds & tanks	2.85 m he	culture fisheries
f.	Flood plain wetlands (Beels / Ox-bow lakes)	202,213 ha	Culture-based fisheries
g.	Swamps and Derelict waters	53,471 ha	Nil (not known)
h.	Upland lakes	720,000 ha	Not known
i.	Brackish water	2.7 m ha	
	Estuaries	300,000 ha	capture fisheries
	Back waters	48,000 ha	capture fisheries
	Lagoons	140,000 ha	capture fisheries
	Wetlands (Bheries)	42,600 ha	culture fisheries
	Mangroves	356,000 ha	subsistence
	Coastal lands for aquaculture	1.42, m ha	culture fisheries

m ha - million hectares

1.3 Inland Water Bodies Suitable for Culture in India

India is endowed with vast and varied aquatic resources (marine and Inland) amenable for capture fisheries and aquaculture. While the marine water bodies are used mainly for capture fisheries resources, the inland water bodies are widely used both for culture and capture fisheries. Most of the inland water bodies are captive ecosystems where intensive human intervention in the biological production process can be possible and thereby holding enormous potential for many fold increase in fish output. Inland water bodies include freshwater bodies like rivers, canals, streams, lakes, flood plain wetlands or beels (ox-bow lakes, back swamps, etc.), reservoirs, ponds, tanks and other derelict water bodies, and brackish water areas like estuaries and associated coastal ponds, lagoons (Chilka lake, Pulicat lake) and backwaters (vembanad backwaters), wetlands (bheries), mangrove swamps, etc., The inland water resources available in India are given in Table-1.1.

The inland water bodies which are used for culture and culture-based fisheries are detailed hereunder.

1.3.1. *Freshwater Bodies*

1.3.1.1 Ponds and Tanks

There are innumerable ponds and tanks of different size, both perennial and seasonal. With the rapid development of aquaculture in the last two decades, the ponds have been increasing tremendously. Not only the waste and low-lying lands but also the vast tracts of agricultural land are being converted to myriads of fish ponds. The area under ponds and tanks available for freshwater aquaculture in India has been estimated at 2.85 m ha. Ponds and tanks are more numerous in West Bengal, Andhra Pradesh, Bihar, Orissa and Tamilnadu. The ponds offer scope for enhanced productivity through semi-intensive and intensive aquacultural practices. Indian freshwater aquaculture has evolved from the stage of a domestic activity in West Bengal and Orissa to that of an industry in recent years, with states like Andhra Pradesh, Haryana, Maharashtra, etc., taking up fish culture as a trade. With technological inputs, entrepreneurial initiatives and financial investments, pond productivity has gone up from 600-800 kg/ha/yr to over 8-10 tonnes/ ha/year. While carps (Indian and exotic) are the main species cultured in ponds, others like catfishes, murrels, freshwater prawns and molluscs for pearl culture are also being cultured in ponds.

1.3.1.2 Swamps

In India an estimated 0.6 million ha of water remains unutilized for fish production. This is in the form of marshes and swamps alone. Reclamation of such swamps into fish ponds is recognized as an effective means of making them productive but difficult for fish culture from production standpoint. However, these can be made productive with the introduction of cage-culture of air breathing fishes. The success is largely due to the fact that the two main obstacles of swamp can be overcome by this. Cage culture precludes all risks of cultured fish being lost during harvesting in these weed infested waters. Secondly, selection of air-breathing species of fish eliminates the danger of mass kill under conditions of deoxygenation. A number of air-breathing fishes are indigenous to our waters, and many of these are popular as food fishes among the Indians. The important ones are: magur (Clarias batrachus), singhi (Heteropneustes fossilis), koi (Anabas testudineus), murrel (Ophiocephalus (=Channa) spp.) and chital (Notopterus spp). An exotic fish, gourami (Osphronemus gorami) is also equally valuable for cultivation in swamps.

1.3.1.3 Reservoirs

Reservoirs are defined as “man-made impoundments created by erecting a dam of any description on a river, stream or any water course to obstruct the surface flow”. . However, water bodies less than 10 ha in area have been excluded from this definition. The Ministry of Agriculture, Government of India classified reservoirs as small (<1000 ha), medium (1000 to 5000 ha) and large (>5000 ha) for the purpose of fishery management. Reservoirs constitute the single largest inland fisheries resource in terms of resource size and production potential. It has been estimated that India has 19,134 small reservoirs with a total water surface area of 1,485,557 ha, 180 medium reservoirs with 527,541 ha and 56 large reservoirs with 1,140,268 ha. Thus, the country has 19,370 reservoirs covering 3,153,366 ha.

The medium and large reservoirs are predominantly capture systems. Although many of them are stocked, their fisheries continue to depend, to a large extent on the wild or naturalized fish stock. Conversely, small reservoirs are managed as culture-based fisheries, where the fish catch depends on stocking. More than 70% of the small reservoirs in India are small irrigation impoundments created to store stream water for irrigation. They either dry up completely or retain very little water during summer, thus ruling out any possibility of retaining broodstock for recruitment. Thus, culture-based fishery is the most appropriate management option for the small reservoirs in India. The key management parameters of culture-based fishery are species selection, stocking and environmental enhancement (enriching the water quality through artificial eutrophication).

Today, most of the states being capable of producing carp seed through hypophysation and the culture-based fisheries of small reservoirs in India largely center round the three species of Indian major carps viz., Catla catla, Labeo rohita and Cirrhinus mrigala. The Indian major carps have an impressive growth rate and their feeding habits are suitable for utilization of various food niches. In addition, the stocking of many exotic species (Tilapia, common carp, silver carp, grass carp) have also contributed substantially to commercial fisheries. The other groups having countrywide distribution are the catfishes, featherbacks, air-breathing fishes and the minnows.

1.3.1.4 Floodplain Wetlands

The floodplains are either permanent or temporary water bodies associated with rivers that constantly shift their beds especially in the potamon regimes. The Ramsar Convention defines wetlands as “areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water which is static or flowing; fresh, brackish or salt including areas of marine waters, the depth of which at low tide does not exceed nine.meters”.

The beels, or floodplain wetlands usually represent the lentic component of floodplains viz., ox-bow lakes, sloughs, meander scroll depressions, residual channels and the back swamps and excludes the lotic component (the main river channels, the levee region and the flats). In addition, tectonic depressions located in river basins are also included under beels. Thus, all the wetland formations located at the floodplains can be termed as floodplain wetlands (beels). They are either shallow depressions or dead riverbeds generally connected to the principal rivers and/or receive backflow water from the rivers during floods or from the huge catchment area following monsoon rains.

Floodplain wetlands or lakes (202,213 ha) which form an integral component of the Ganga and the Brahmaputra basins. They constitute an important fishery resource in Assam (100,000 ha), West Bengal (42,500 ha), Bihar (40,000 ha) Manipur (16,500 ha), Arunachal Pradesh (2,500ha) Tripura (500 ha) and Meghalaya (213 ha).

Beels offer tremendous scope for expanding both capture and culture fisheries. They have high biological productivity. However, in many beels, the nutrients are usually locked up in the form of large aquatic plants like water hyacinth, and do not contribute significantly to fish production. The beels are considered as biologically sensitive habitats as they play a vital role in the recruitment of fish populations in the riverine ecosystem and provide excellent nursery grounds for several fish species, besides a host of other fauna and flora. The beels also provide an ideal habitat for pen and cage culture operations. If managed along scientific lines, fish production in beels can be increased significantly.

Beels are of two types viz., closed and open beels based on the water residence and renewal time as well as the extent of macrophyte infestation. The open beels are those which retain their riverine connection for a reasonably long time and relatively free from weed infestations. The management strategy is essentially akin to riverine capture fisheries. The closed beels are those with a very briefperiodof connection with the river is more like small reservoirs. The basic strategy here will be stocking and recapture offish i.e. culture-based fishery.

Beels are systems, which combine the norms of capture and culture fisheries. The marginal areas of beels are cordoned off for culture systems either as ponds or as pens and the central portion is left for capture fisheries (Fig. 1-1). Beels can also be part of an integrated system including navigation, bird sanctuary, post harvest, aquaculture and open water fisheries. A proposed scheme of closed beel (Fig. 1-1 has been shown as an example. This plan is a part of holistic development of the wetland, which can benefit the local people and help retaining the biodiversity of the beel and its environment. Pen and cage culture of fish and prawn is a very useful option for yield enhancement in beels especially those infested with weeds. Pens are barricades erected on the periphery of beels to cordon off a portion of the water body to keep captive stock of fish and prawn. Pen culture offers scope for utilizing all available water resources, optimal utilization offish food organisms for growth and complete harvest of the stock. Pen culture involving major carps has indicated a production possibility upto 4 t/ha in 6 months from a ‘maun’ in Gandak basin while production varying from 1.9 to 4.8 kg have been obtained from 2 sq.km cages in 90 days from a weed choked Assam beels by rearing air-breathing fishes, Glorias batrachus and Heteropneustes fossilis.

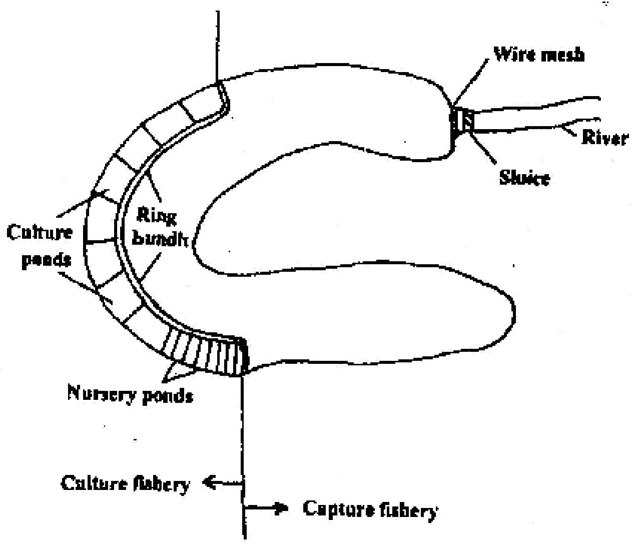


Fig. 1-1. Culture-cum-capture fisheries

Beels are the ideal water bodies for practising culture-based fisheries for many reasons. Firstly, they are very rich in nutrients and fish food organisms, which enable the stocked fishes to grow faster to support a fishery. Thus, the growth is achieved at a faster rate compared to reservoirs. Secondly, the beels allow higher stocking density by virtue of their better growth performance and high yield. Thirdly, there are no irrigation canals and spill ways as in the case of small reservoirs which cause the stock loss, and the lack of effective river connection prevents entry of unwanted stock. The beels also allow stocking of detrivores as the energy transfer takes place through the detritus chain.

Summary

Aquaculture has been called as the rearing of aquatic organisms under controlled or semi controlled condition

Fish is a rich source of animal protein and its culture is an efficient protein food production system from aquatic environment.

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

Natural resources can be used as culture systems and organisms to be cultured are stocked in the water body. Capital expenses are low for the open culture systems. Cages, long lines, floats, rafts, trays and clam beds are examples of open system techniques.

In semi-closed culture systems, water is taken from natural sources or ground water and is directed into specially designed ponds and race ways.

In closed culture systems, no water is exchanged and the water is subjected to extensive treatment.Fish or prawn culture in water recirculation systems is good example for closed systems.

Inland water bodies include freshwater bodies like rivers, canals, streams, lakes, flood plain wetlands or beels (ox-bow lakes, back swamps, etc.), reservoirs, ponds, tanks and other derelict water bodies.

Questions

1. Describe the fresh water culture system.

2. Give an account on introduction to fresh water aquaculture.

3. Describe the following
   a) Reservoirs
   b) Flood plain wetlands
   c) Swamps

2. SEED PROCUREMENT

2.1. Introduction

Fish seed is the most important component for fish culture. The freshwater resources of our country for fish culture are estimated to be 2.85 million hectares of pond and tanks. In addition to this, another 2.05 million hectares of water area is available in the form of reservoirs or lakes. It has been estimated that nearly 14250 million fry would be required for stocking even the present available cultivable resources of 2.85 million hectares on a conservative stocking rate of 5000 fry/ha. The present production is 15007 million fry. Apart from this, at least an additional quantity of 4100 million fry are required for stocking the available area of lakes and reservoirs with an average stocking rate of 2000 fry/ha. This indicates that there is a necessity to raise the fry to stock the available water resources.

The fish seed is obtained from 3 sources - riverine, hatcheries and bundhs. The collection of seed from riverine source was an age old practice. This method is strenuous and we get the mixture of wanted and unwanted fish seed. Hatcheries are the best way of getting fish seed. Apart from these, the bundh breeding is also a good method to collect the fish seed by creating a natural habitat.

The different river systems of India display variations with regard to the distribution and abundance of their fish fauna. This is mainly due to their individual ecological conditions, such as gradient, terrain, flow, depth, temperature, substrata, etc. The northern rivers are perennial and support rich commercial fisheries. Except for the deltaic regions, the fishery of the peninsular rivers is poor both in the upper and middle reaches.

2.2. Natural Seed Resources

2.2.1 *Major River Systems*

The different river systems of India display variations with regard to the distribution and abundance of their fish fauna. This is mainly due to their individual ecological conditions, such as gradient, terrain, flow, depth, temperature, substrata, etc. The northern rivers are perennial and support rich commercial fisheries. Except for the deltaic regions, the fishery of the peninsular rivers is poor both in the upper and middle reaches.

India has five major river systems (Fig. 2.1). These are : Ganga river system, Brahmaputra river system, The Indus river system, East coast river system and West coast river system.

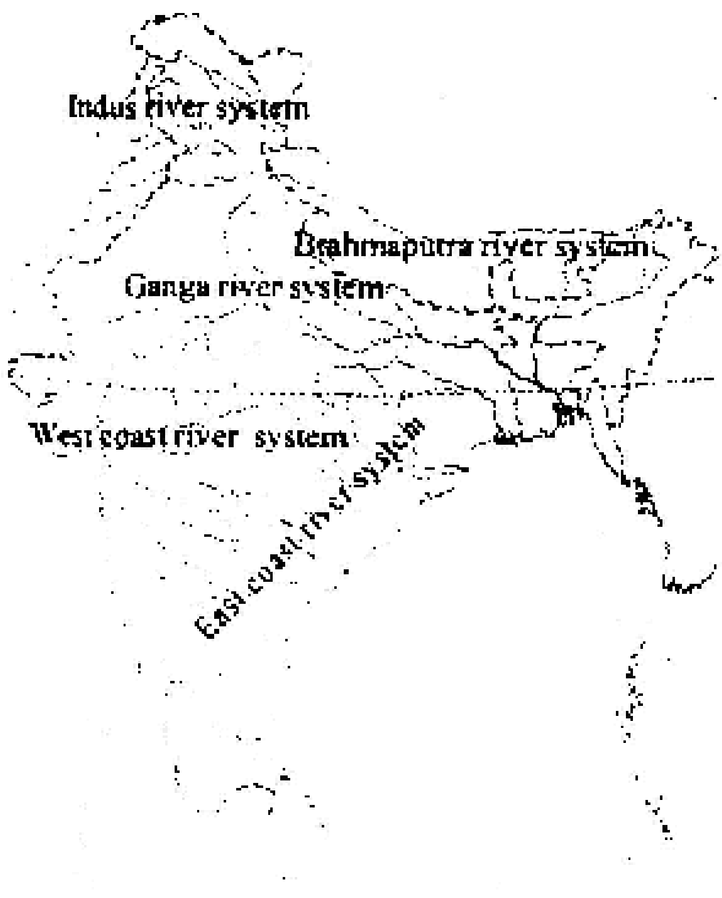


Fig. 2.1 : Indian major riverine systems

2.2.1.1 The Ganga river system:

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

2.2.1.2 The Brahmaputra river system:

It is found in the states of Assam, Nagaland, Tripura and comprises the fast flowing river, which distribute the commercially important major carps. Length of this river system is 4,023 km. The north-bank tributaries of Brahmaputra are comparatively large with steep shallow-braided channels of coarse sandy beds and carry heavy silt charge, while the south-bank are comparatively deep. The seed collection is made in this fast-flowing river with steep banks by fixing two long bamboo poles near the banks with a boat tied on to them across the current. The percentage of major carps are poor. The northern Gauhati centre investigated in 1969 revealed only rohu content of 9.58%. The river, being torrential and flashy due to steep gradients of its tributaries, changes its current pattern very rapidly, hence, the carp seed is less and difficult to collect.

2.2.1.3. The Indus river system:

It is rather rich when compared to the Brahmaputra river. The Beas and the Sutlej and their tributaries cover the states of Himachal

Pradesh, Punjab and Haryana. There is no commercial fishery for major carps in Himachal Pradesh, with the upper reaches having cold water forms. Punjab is a good source for carp fishery. Length of Indus river system is 6,471 km.

2.2.1.4 East coast river system:

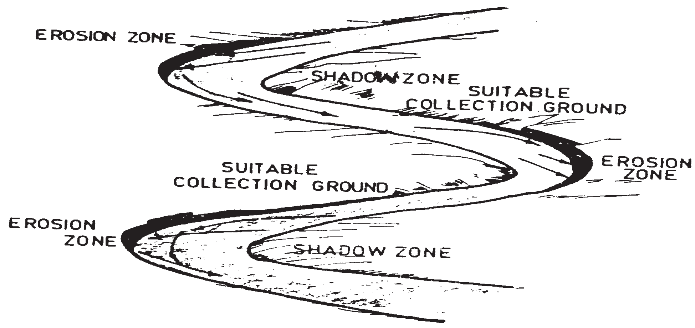
The rivers flow towards the east into the Bay of Bengal. It comprises the Mahanadi, Godavari, Krishna and Cauvery river systems. The length of east coast river system is 6,437 km.Mahanadi is the largest river of Orissa and the state's only major source of fish seed. The river mainly harbours the hill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

2.2.1.5 West coast river system:

The major rivers of the west coast are Narmada and Tapati, which are found in Madhya Pradesh, Maharashtra and Gujarat. Length of the river system is 3,380 km. The upper stretches of the rivers being rocky and unproductive, are not suitable for seed collection. The remaining parts are good for seed collection.

The major estuarine systems of India are the Hoogly-Matlah estuary of river Ganga, Mahanadi in Orissa, the Godavari-Krishna in Andhra Pradesh, the Cauvery in Tamil Nadu and the Narmada and the Tapati in Gujarat. The important brackishwater lakes of the country are the Chilka in Orissa, the Pulicat in Tamil Nadu and the Vembanad in Kerala. The common feature in the estuaries is the occurrence of horse-

Fig. 2.2 : The erosion and shadow zones of the river



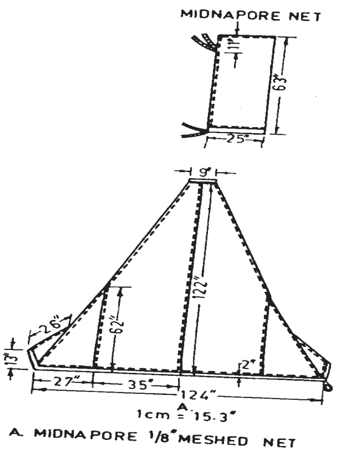


Fig. 2.3 : The shooting net

shoe shaped sand bars at river mouths. Estuaries receive freshwater during the south-west monsoon months, from July to October. All the estuaries are good sources of freshwater and brackishwater fish and prawns.

2.2.2. *Lakes and Reservoirs*

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

2.3. Collection of Seed from natural resources

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

With a view to providing scientific basis, seed prospecting investigations were initiated in various river systems of in India. Attempts wer made to standardise the spawn collection nets, to evolve methods of collection and to ascertain factors responsible for fluctuations in the availability of fish seed in relation to time and place.

2.3.1 *Site Selection for Seed Collection*

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

2.3.2 *Methods of Seed Collection*

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

Benchi jal is used to collect the seed in Bengal. Midnapur net is also used in Bengal, especially in the south-western parts, to collect the seed. The shooting net (Fig. 2.3) is fixed in line with the water current direction. The bamboo poles are fixed firmly at the selected site and the net is fixed to bamboo poles. Two bamboo poles are fixed near the mouth and other two poles are fixed at tail ring. The anterior end of gamcha is then tied round the tail ring. The gamcha is fixed in position with the help of two more bamboo poles.

In order to select the spot of maximum availability of spawn within a specified stretch of the river concerned, a number of trial nets are simultaneously operated at a number of suitable spots. After selecting the spot, the operation is started with full battery of nets. Once it is done, the collection from the tail piece of each net is scooped one after the other in quick succession every 15 minutes or depending upon the intensity of spawn. The contents of the gamcha are then scooped immediately in to a container half filled with river water. The collection is then passed through a mosquito netting sieve so that the unwanted organisms and non floating debris can be removed. The spawn are measured and kept in hapas for conditioning, then transported to fish farms and stocked in nurseries.

2.4 Factors effecting seed collection

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

2.4.1 *Flood:*

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

2.4.2 *Water Current:*

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

Table 2.5 Distinguishig Features of Seeds of Major Indigenous Carps

	Fish Seed	Catla	Rohu	Mrigal
1.	Eggs	Non-floating Non-adhesive	Non-floating Non-adhesive	Non floating Non adhesive
	Diameter (mm)	5.3 to 6.5	5.0	5.5
	Shape	Round	Round	Round
	Colour	Yolk light red	Reddish	Golden
2.	Hatchlings Size	4.68 mm (average)	3.7 mm (average)	4.68 mm (average)
	Yolk sac	Both, the bulbous and narrower parts fo yolk sac are equal in lenght	Like Catla	Bulbous part smaller than narrower part
	Somites	About 26 pre anal and 14 post anal myotomes	Like Catla	28 pre anal and 14 post and somites
3.	Fry	Dorsal fin rays more than 11	Like Catla	Like Catla
		Head large.	Head small	Head small, body slender,
		No spot at coudal peduncle.	Transvers band at caudal peduncle.	A triangular dark spot is present on caudal peduncle.
		No barbel, Lips thick, Unfringed	A pair of maxillarybarbel present, lips fringed	No barbel. Lips thin, unfringed, posterior edge is concave
4.	Fingerlings	Head large. No spot on caudal peduncle	Head moderate, Dark transvers band at caudal	Head moderate. Spot becomes diamond shaped
		No barbel	2 pair of barbels (maxillary and rostral).	Barbels, apparently not visible.
		Lips thick and unfringed.	Lips thin and fringed	Lips thin but not continous at corners of mouth
		Dorsal, anal, and caudal fins are dark gray in colour	Dorsal, anal, and caudal fins have reddish tinge with dirty gray margins.	Tip of lower lobe of caudal fins is reddish.

2.4.3 *Other Factors*:

There is no effect of turbidity, pH and dissolved oxygen on spawn availability in the rivers. However, turbidity is associated with floods, and determines the efficiency of spawn collection. The turbidity reduces the mesh size of the net, and it is better to clean the nets at regular intervals. Air and water temperatures never show any effect on the spawn availability. The optimal temperature is 28-31^{0}C. Overcast conditions with breeze and with or without drizzle is found ideal for spawn collection. The stormy weather is totally unfavourable for spawn collection due to disorder currents and waves and the uprooting of shooting nets. Light also does not show any effect on spawn collection. The occurrence of plankton have no connection with the availability of spawn or its abundance in rivers. Spawn associations found abundant from the onset of monsoon dwindle thereafter to almost nil at the end of the season.

2.5. Seeds Seggregation :

Indian major carps seeds can be identified and seggregated with the help of characters as discribed in table 2.5

Summary

The fish seed is obtained from 3 sources - riverine, hatcheries and bundhs. The collection of seed from riverine source was an age old practice.

India has five major river systems. These are : Ganga river system, Brahmaputra river system, The Indus river system, East coast river system and West coast river system. Naturally formed lakes and man-made reservoirs constitute great potential fishery resources of India.

The bends and curves of various shapes in the river course often show a precipitous, fast eroding bank on one side called erosion zone and a flat, gently sloping bank exactly opposite called shadow zone. These banks are not useful for spawn collection. Best seed collection sites lie on the side of the sloping bank but at the spot the current force the seed to the sides by centrifugal force. These spots are best to operate nets to collect large amounts of spawn.

Shooting nets are used to collect the seed in the rivers.

Floods and water currend play an important role in the collection of seed. There is no effect of turbidity, pH and dissolved oxygen on spawn availability in the rivers.

Questions

1. Give an account on major riverine systems of India.
2. Describe the collection of seed from natural resources.
3. What is seed? Describe their identification characters and seggregation.
4. Give a brief account of the following
   a. Shooting net
   b. Factors effecting the seed collection.
   c. Ganga river system.

3. SEED PRODUCTION TECHNOLOGIES

Fish seed is the most important component for fish culture. The freshwater resources of our country for fish culture are estimated to be 2.85 million hectares of ponds and tanks. In addition to this, another 2.05 million hectares of water area is available in the form of reservoirs or lakes. It has been estimated that nearly 14250 million fry would be required for stocking even the present available of 2.85 million hectares on a conservative stocking rate of 5000 fry/ha. The present production is 15007 million fry. Apart from this, at least an additional quantity of 4100 million fry are required for stocking the available area of lakes and reservoirs with an average stocking rate of 2000 fry/ha. This indicates that there is a necessity to raise the fry to stock the available water resources.

The fish seed is obtained from three sources - riverine, hatcheries and bundhs. The collection of seed from riverine source was an age old practice. This method is strenuous and we get the mixture of wanted and unwanted fish seed. Hatcheries are the best way of getting fish seed. Apart from these, the bundh breeding is also a good method to collect the fish seed by creating a natural habitat.

The different river systems of India display variations with regard to the distribution and abundance of their fish fauna. This is mainly due to their individual ecological conditions, such as gradient, terrain, flow, depth, temperature, substrata, etc. The northern rivers are perennial and support rich commercial fisheries. Except for the deltaic regions, the fishery of the peninsular rivers is poor both in the upper and middle reaches.

3.1 Induced Breeding Technology

Carps breed in flowing waters like rivers. Naturally they never breed in confined waters. The seed collected from natural resources is generally a mixed stock with both desirable and undesirable varieties. Separation of desirable seed from mixed stock is a big problem. Due to the handling, the desirable varieties may die. If any predaceous fish seed is found, they injure desirable fish seed. Another big problem is never get required number in natural collection. Availability of pure seed is very difficult. To overcome all these problems induced breeding is an excellent technique to get pure and required fish seed. It has several advantages.

With induced breeding pure seed of desirable species can be obtained. Suppose rohu seed is necessary, only rohu seed can be produced in a couple of days. Required number of seed can be produced with this technique. Suppose a fish farm needs 1 crore fish seed, this number can be produced very easily in less time. The problems of identification and segregation of seed does not arise. This technique is very simple. Healthy seed can be produced. Fish can be spawn more than one time in one year. Hybridization is possible.

In induced breeding techniques, four main types of materials are used to give injections to fish - pituitary gland extractions, HCG, ovaprim and ovatide.

3.1.1 *Induced Breeding with Pituitary Gland Extraction*

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

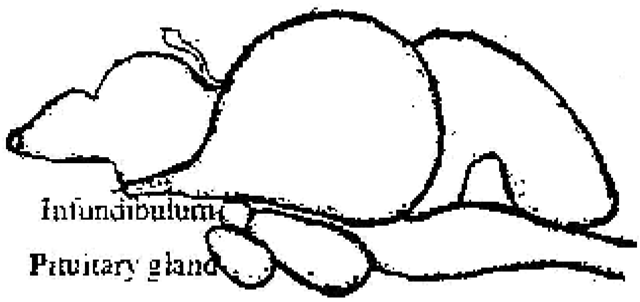
3.1.1.1 Historical Background:

The present day concept of the role of pituitary in the reproduction of vertebrates is reported to have originated from the experiments of Aschheim and Zondek in 1927 when they found that pituitary implants accelerated the sexual development of female mice. Three years later, in 1930, Houssay of Argentina performed the first such experiment on a fish. He injected a small viviparous catfish, Cresterodon decammaculatus with extracts of pituitary gland prepared from another fish, Prochilodus platensis bringing about the premature birth of developing young. In 1934, a successful technique could be worked out by Von Ihring in certain Brazilian pond fishes were made to spawn by injecting them with a suspension of fresh pituitary glands collected from other less valuable species of fishes. The Brazilians, thus, were the first to use the technique of fish breeding successfully through hypophysation. In 1937, Russian scientist Gerbiskii succeeded in inducing a significant number of sturgeons, Acipenser stellatus.

India is the third country in the world to make the technique an integral part of its piscicultural programme. The first attempt at hypophysation in India was made by Hamid Khan in 1937 when he tried to induce spawning in Cirrhinus mrigala by the injection of mammalian pituitary gland. The next attempt was made by Hussain in 1945 with certain hormones like 80-120 RV Prolan and Antuitrin-S into female Labeo rohita and Cirrhinus mrigala. In 1955, Hiralal Choudhuri succeeded in inducing spawning in Esomus danricus by intraperitonal injection of pituitary extract of Catla catla. He also succeeded in the breeding of Pseudotropius atherinoides. Ramaswamy and Sunderaraj succeeded breeding in Heteropneustes fossilis and Clarias batrachus in 1955 and 1956 respectively. The first success in induced breeding of Indian major carps through hypophysation was achieved in 1957 by Hiralal Chaudhuri and Alikunhi at CIFRI, Cuttack.

3.1.1.2 Fish Pituitary Gland:

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



(Fig. 3.1): Pituitary Gland

Pituitary gland secretes the gonadotropic hormones, FSH or Follicular Stimulating Hormone, and LH or Luteinizing Hormone. Both hormones are secreted through out the year, but the proportion in which they are secreted is directly correlated with the cycle of gonadal maturity. The FSH causes the growth and maturation of ovarian follicles in females and spermatogenesis in the testes of males. LH helps in transforming the ovarian follicles into corpus lutea in females and promoting the production of testosterone in males. These hormones are not species specific, i.e., a hormone obtained from one species is capable of stimulating the gonads of another fish. However, there is great variability in its effectiveness in different species. Experiments conducted on induced breeding of fishes have clearly shown the relative effectiveness of fish pituitary extracts over mammalian pituitary hormones, sex hormones and various steroids. This is the reason why fish pituitary is being extensively used today in fish breeding work all over the world.

3.1.1.3 Collection of Pituitary Gland:

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

Several techniques are adopted for the collection of pituitary glands in different countries. In India, the commonly adopted technique of gland collection is by chopping off the scalp of the fish skull by an oblique stroke of a butcher's knife. After the scalp is removed, the grey matter and fatty substances lying over the brain are gently cleaned with a piece of cotton. The brain thus exposed is carefully lifted out by detaching it from the nerves. In majority of the cyprinids, when the brain is lifted, the gland is left behind on the floor of the brain box. The duramater covering the gland is then cautiously removed using a fine needle and forceps. The exposed gland is then picked up intact without causing any damage to it because damaged and broken glands result in loss of potency.

Glands are also collected through foramen magnum. It is, in fact, a much easier method of gland removal which is commonly practiced by the professionals for mass-scale collection in crowded and noisy fish markets. In this method of gland collection, the fish is required to be essentially beheaded. In markets, glands are collected from fish-heads that are already cut by retailers. In the cut fish-heads, the foramen can be clearly seen from behind holding grey matter and fatty substances in it. The brain lies on the ventral sides of the foramen. For taking out the gland, the grey matter and fatty substances are first removed by inserting the blunt end of the forceps into the foramen and pulling out the entire matter without disturbing the brain. The brain is lifted up carefully and pushed forward or is pulled out of the hole. The gland lying at the floor of the brain box is then picked up using a pair of fine tweezers. An experimental worker easily manages to collect about 50-60 glands in one hour by adopting this technique of collection.

3.1.1.4 Preservation of Pituitary Glands:

If the collected glands are not meant for use then and there, they must be preserved. Due to their glyco- or muco- protein nature, they are liable to immediate enzymatic action. The pituitary glands can be preserved by three methods - absolute alcohol, acetone and freezing. Preservation of fish pituitary gland in absolute alcohol is preferred in India. Moreover, experiments done so far with alcohol preserved glands on Indian major carps have given more positive results than with acetone preserved glands.

The glands after collection are immediately put in absolute alcohol for defatting and dehydration. Each gland is kept in a separate phial marked serially to facilitate identification. After 24 hours, the glands are washed with absolute alcohol and kept again in fresh absolute alcohol contained in dark colour bottles and stored either at room temperature or in a refrigerator. Occasional changing of alcohol helps in keeping the glands in good condition for longer periods. In order to prevent moisture from getting inside the phials, they may be kept inside a dessicator containing some anhydrous calcium chloride. It is preferable to keep the glands in a refrigerator. They can be stored in refrigerator upto 2-3 years and at room temperature upto one year.

Acetone also is a good preservative. In this method, soon after collection, the glands are kept in fresh acetone or in dry ice-chilled acetone inside a refrigerator at 100 C for 36-48 hours. During this period, the acetone is changed 2-3 times at about 8-12 hours intervals for proper defatting and dehydration. The glands are then taken out of acetone, put on a filter paper and allowed to dry at room temperature for one hour. They are then stored in a refrigerator at 100 C, preferably in a dessicator charged with calcium chloride or any other drying agents. The preservation of glands in acetone is largely practiced in USSR and USA.

3.1.1.5 Preparation of Pituitary Gland Extract:

Preserved glands are then weighed. This is essential for accurate determination of the dose to be given according to the weight of the breeders. The weight of the gland may be taken individually or in a group. To get a more accurate weight, a gland should be weighed exactly after two minutes of its removal from alcohol.

The pituitary extract should be prepared just before the time of injection. The quantity of gland required for injection is at first calculated from the weight for the breeder to be injected. The glands are then selected and the required quantity of glands is taken out of the phials. The alcohol is allowed to evaporate, if the glands are alcohol preserved ones. Acetone-dried glands are straight away taken from the phials for maceration.

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

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

3.1.1.6 Technique of Breeding:

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

1. Dosage of pituitary extract :

The most important aspect of induced breeding of fish is the assessment of proper dosages of pituitary extract. The potency of the gland varies according to the size and stages of sexual development of the donor, as well as the species of the donor fish, time of collection of glands and their proper preservation. The dose of the pituitary gland is calculated in relation to the weight of the breeders to be injected. It has also been noticed that identical doses to breeders of similar weights may give contradictory results owing to difference in maturity of gonads. Even heavy doses of hormones may not be effective if the gonads are in the resorption stage. By careful selection of breeders and administering a known weight of pituitary gland extract per kg body weight of the breeders, successful breeding can be obtained.

Experiments on standardisation of doses indicate that administration of a preliminary low dose in the female breeder followed by a higher effective dose after 6 hours proves more successful than a single knockout dose. A single high dose has been found useful when the breeders are in ideal condition and the weather is favourable. Rohu responds well to two injections while catla and mrigal to both one and two injections.

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

2. Method of injection:

Intra-cranial injections are preferred in USSR and intra-peritoneal in USA and Japan. Intra-muscular injection is the most common practice in India. The intra-muscular injection is less risky in comparison with the other mehtods. Intra-peritonial injections are usually given through the soft regions of the body, generally at the base of the pelvic fin or sometimes at the base of the pectoral fin. But there is some risk of damaging the internal organs, specially the distended gonads when administering an intra-peritonial injection in fully mature fishes.

Injections are usually given at the caudal peduncle or shoulder regions near the base of the dorsal fin. While giving injections to the carps, the needle is inserted under a scale keeping it parallel to the body of the fish at first and then pierced into the muscle at an angle. There is no hard and fast rule regarding the time of injection. Injections can be given at any time of the day and night. But since low temperature is helpful and the night time remains comparatively quieter, the injections are generally given in the late afternoon or evening hours with timings so adjusted that the fish is able to use the quietude of the night for undisturbed spawning.

The most convenient hypodermic syringe used for the purpose is a 2 cc syringe having graduations of 0.1 cc division. The size of the needle for the syringe depends upon the size of the breeders to be injected. No. 22 needle is conveniently used for 1-3 kg carps, No. 19 for larger carps and No. 24 can be used for smaller carps.

Use of anesthetics during injection would significantly increase the survival of brood fish. Commonly used anesthetics are MS 222 and Quinaldine. MS 222 may be added to water in doses of 50-100 mg/litre. A roll of cotton soaked in a 0.04 M of this solution can be inserted into the mouth of the fish. Quinaldine is used at the rate of 50-100 mg/litre.

3. Breeding hapa and spawning:

After the injection, the breeders are released immediately inside the breeding hapa. A breeding hapa is generally made of fine cloth in the size of 3.5 x 1.5 x 1.0 m for larger breeders and 2.5 x 1.2 x 1.0 m for breeders weighing less than 3 kg. All the sides of the breeding hapa are stitched and closed excepting a portion at the top for introducing the breeders inside. Generally, one set of breeders is released inside each breeding hapa, but sometimes, in order to save on pituitary material, community breeding is also tried by reducing the number of male breeders. After the release of the fish, the opening of the hapa is securely closed so that breeders may not jump out and escape. Instead of hapas, cement cisterns or plastic pools as big as hapas can also be used for breeding.

Spawning normally occurs within 3-6 hours after the second injection. Soon after fertilisation, the eggs swell up considerably owing to absorption of water. Fertilised eggs of major carps appear like shining glass beads of crystal clear transparency while the unfertilised ones look opaque and whitish. The size of eggs from the same species of different breeders varies considerably. Fully swollen eggs of the Indian major carps measure 2.5 mm in diameter, the largest being that of catla and the smallest of rohu. The carp eggs are non-floating and non-adhesive type. The yolk possesses no oil globule. The Indian major carps have a profuse egg laying capacity. Their fecundity, on an average, is 3.1 lakh in rohu, 1-3 lakh in catla and 1.5 lakh in mrigal.

The developing eggs are retained in the breeding hapa undisturbed for a period of at least 4-5 hours after spawning to allow the eggs to get properly water-hardened. After this, the eggs are collected from the hapa using a mug and transferred into a bucket with a small amount of water. The breeders are then taken out and weighed to find out the difference before and after spawning. This gives an idea of the quantity of the eggs laid. The total volume and number of eggs can be easily calculated from the known volume and the number of eggs of the sample mug. Percentage of fertilised eggs is also assessed accordingly by conducting random sampling before and after spawning. This gives an idea of the quantity of the eggs laid. The total volume and number of eggs can be easily calculated from the known volume and the number of eggs of the sample mug. Percentage of fertilised eggs is also assessed accordingly by carrying out random sampling.

4. Stripping:

Chinese carps however do not spawn naturally and when they spawn, the percentage of fertilisation is generally very low. Stripping (Fig. 3.1) or artificial insemination is therefore followed. The female fish is held with its head slanting upwards and tail down and belly facing the vessel, and the eggs are collected into an enamel or plastic trough by pressing the body of the female. The male fish is then similarly held and milt is squeezed out into the same trough. The gamets are then mixed as soon as possible by means of a quill feather to allow fertilisation. The fertilised eggs are then washed a few times with clean water to remove excess milt and allowed to stay undisturbed in freshwater for about 30 minutes. The eggs are then ready for release into the hatching tanks.

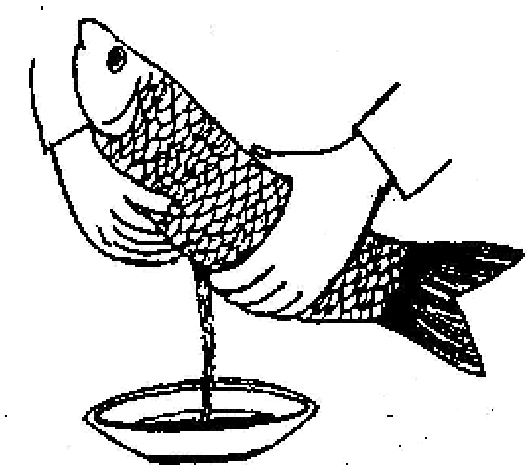


Fig. 3.1 : Stripping

3.1.1.7 Technique of hatching the eggs:

The eggs collected from breeding hapas are transferred into the hatching hapas (Fig. 3.3). A hatching hapa consists of two separate pieces of hapas, the outer hapa and the inner hapa. The inner hapa is smaller in size and is fitted inside the outer hapa. The outer hapa is made up of a thin cloth in the standard size of 2 x 1 x 1 m while the inner hapa is made of round meshed mosquito net cloth in the dimension of 1.75 x 0.75 x 0.5 m. All the corners of the outer and inner hapas are provided with loops and ropes to facilitate installation. About 75,000 to 1,00,000 eggs are uniformly spread inside each inner hapa. The eggs hatch out in 14-20 hours at a temperature range of 24-310 C. The period of incubation, in fact, is inversely proportional to the temperature. After hatching, the hatchlings escape into the outer hapa through the meshes of the inner hapa. The inner hapa containing the egg shells and the dead eggs which are removed when the hatching is complete. The hatchlings remain in outer hapa undisturbed till the third day after hatching. During this period, they subsist on the food stored up in their yolk sac. By the third day the mouth is formed and the hatchlings begin directive movement and feeding. At this stage they are carefully collected from the outer hatching hapa and stocked into prepared nurseries.

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

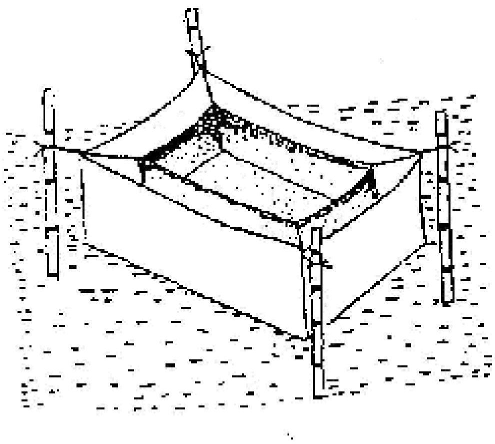


Fig. 3.3 Hatching hapa

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

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

To overcome these problems, Human Chorionic Gonadotropin (H.C.G) has been found as an alternative for pituitary gland. H.C.G. was discovered in beginning of 1927 by Aschheim and Zondek. They extracted good quality hormone with luteinising gonadotrophic activity from the urine of pregnant women. Russian workers first used chorionic gonadotropin in 1964 with a trade name as Choriogohin and got good results on Loach. Bratanor (1963) and Gerbilski (1965) used H.C.G on carps and trouts and achieved great success. Tang (1968) stated that when Chinese carps were treated with fish pituitary in combination with C.G., effectiveness on induced breeding increased. A perusal of literature indicates that H.C.G. is effective either alone or in combination with P.G. extract in inducing various fishes all over the world.

H.C.G. is a glyco-protein or sialo-protein, because of the carbohydrate molecules attached to the protein molecules. Its primary function is to maintain the production of oestrogen and progesterone by the corpus luteum. It is produced by the placenta and excreted through the urine during early stages of pregnancy (2-4 months). H.C.G comprises of 2 sub-units a and b and has a molecular size of 45,000-50,000 daltons. There are 17 amino acids in it, out of which alanine, proline, serine, cystine and histidine are important. Due to the large number of amino acids, H.C.G. has a high protein content. The molecular weight has been reported as 59,000 by gel filtration and 47,000 by sedimentation equilibrium.

During early stages of pregnancy H.C.G. is rich in the urine of pregnant women. Several methods are employed for the extraction of H.C.G. Aschheim and Zondek (1927) used ethanol for precipitation. Katzman and Caina used different absorbents. Commercial crude H.C.G extraction is made with gel filtration.

Follicle stimulating hormone (FSH) and luteinising hormone (LH) of the pituitary play an important role in the normal reproduction of fish i.e., in promoting the development of gonads, growth, maturity and spawning. H.C.G is more or less similar in character and function to F.S.H and L.H. As pituitary gland is used for induced fish breeding, H.C.G can also be used for early ripening of gonads.

Superiority of H.C.G over P.G can be measured on the following grounds. Fish attains maturity faster with H.C.G ., the spawn of the breeding season can be increased with H.C.G ., H.C.G. ensures better survival of spawn, it reduces the time gap between preparatory and final doses, H.C.G is more economical and has a long shelf life, H.C.G is easily available from a standard source, hence is more reliable, periodical injections of H.C.G throughout the year ensure better health and increase in weight and gonadal development Potency of H.C.G is known (30 IU/mg), available in neat packets of known weights, no preservation is involved, cannot be spurious, H.C.G treated fishes can be used more than once for induced breeding in the same season, mortality rate of hatchlings is negligible, consumption of the drug is less during induced breedings, H.C.G can be used as growth hormone and absorption of eggs at the end of the breeding season is comparatively less by the administration of H.C.G.

The crude H.C.G is in powder form and greyish white or light yellow in colour. It dissolves easily in water. The calculated quantity of crude H.C.G is taken into a tissue homogeniser and stirred for 5-10 minutes with measured distilled water. It is centrifuged for 3-5 minutes. The clear light yellowish supernant liquid having the H.C.G hormones is taken and injected immediately. Any delay in use will result in the loss of the potency.

In case of silver carp (Hypophthalmichthyes molitrix), use of H.C.G is found to be quite successful. The dosage is 4-6 mg/kg. body weight of male, and 6-8 mg/kg body weight of first dose and after about 6-7 hours, 10-12 mg/kg body weight of second dose for female which gave good results. Use of only H.C.G in the breeding of Indian major carps has not given successful results so far. A combination of 60-80% H.C.G and 40-20% P.G for Indian major carps and grasscarps (Ctenopharyngodon idella) is successful. Fishes which are induced to breed with H.C.G alone are mullets, Cyprinus carpio, Lctalurus punctatus, Oreochromis nilotica, Aristichthys nobilis, Misgurnus fossilis, Esox lucius and Epinephelus tauvina.

Recent work shows that the combination of H.C.G and P.G. is more recommendable than H.C.G or P.G alone. More work needs to be done to standardize the dosage of H.C.G for induced breeding of major carps and Chinese carps.

3.1.3 *Induced Breeding with Ovaprim*

Due to the problem of varying potency of pituitaries, alternatives were tried. Attempts have been made in various countries to use the analogues of luteinizing hormones - releasing hormones (LH-RH) for induced breeding of fishes with varying degrees of success. However, the success achieved with LH-RH was not always consistent, apart from its higher dose requirement for induction of spawning. This epoch making investigation paved the way for developing simple and effective technology for induced breeding of most of the cultivable fishes. In a joint collaborative project, funded by International Development Research Centre, Canada to Dr. Lin of China and Dr. Peter of Canada, a series of investigations were carried out to develop a reliable technology for breeding fishes. Their investigations led to the development of a new technique called as 'LNPE' method, wherein an analogue of LH-RH is combined with a dopamine antagonist. Based on the principle, M/s Syndel Laboratories Limited, Canada have manufactured a new drug called as ovaprim.

Ovaprim is a ready to use product and the solution is stable at ambient temperature. It contains an analogue of 20 µg of Salmon gonadotropin releasing hormone (sGnPHa) and a dopamine antagonsist, domperidone at 10 mg/ml. The potency of ovaprim is uniform and contains sGnRHa which is known to be 17 times more potent than LH-RH (Peter, 1987). The dopamine antagonist, domperidone used in ovaprim is also reported to be better than another commonly used antogonist, pimozide. Ovaprim being a ready to use product and one which does not require refrigerated storage, appears to be the most convenient and effective ovulating agent.

This drug is administered to both female and male brood fish simultaneously in a single dose, unlike pituitary extract which is given in two split doses. This reduces not only the handling of brood fish but also helps in saving considerable amount of time and labour which will add on to the cost of seed production. The spawning response in treated species is found to be superior to the pituitary extract injected species.

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

In many countries including our country, ovaprim is used on a large scale for induced breeding of all cultivable fishes successfully. In India, initial trials were conducted during 1988 in Karnataka, Andhra Pradesh and Tamil Nadu.

Ovaprim has unique advantages over pituitary hormone - ready to use liquid form in 10 ml vial, consistent potency and reliable results, long shelf life, and can be stored at room temperature, formulated to prevent over dosing, male and female can be injected only once simultaneously, reduces handling and post breeding mortality, repeated spawning possible later in the season and high percentage of eggs, fertilization and hatching.

3.1.4 *Induced breeding with ovatide*

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

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

3.1.5 *Induced Breeding with Ovopel*

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

The required amount of ovopel was calculated on the basis of weight and condition of brood fish. The pellets were pulverized in a mortar and dissolved in distilled water. The trails were conducted in July-August of 1999.

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

3.1.6 *Other Substances used for Induced Breeding*

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

3.1.6.1 LH-RH analogue:

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

3.1.6.2 Steroids:

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

3.1.6.3 Clomiphene:

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

3.2 Estimation of Eggs:

The eggs are collected from the hapa by means of cup or tray or beaker and transferred to the buckets. The breeders are also removed from the hapa and their weights areoted. The difference in weights reveals approximately the number of eggs laid. The eggs are kept in a rectangular piece of close meshed mosquito net and allow the water to drain off. The eggs are measured in a beaker, mug or cup of known volume and transferred to hatcheries. Thus estimation of total quantity is made from total volume of the eggs measured. Percentage of fertilization can be arrived at by counting the number of fertilized eggs from egg samples of 1 ml measure.

3.3. Breading of Common carp:

Common carp (Cyprinus carpio) generally breeds in confined water. Spawning takes place in shallow marginal, weed infected areas from January to March and from July to August. Common Carp is also observed to breed round the year. Controlled breeding of common carp is conducted to achieve better spawning and hatching. A set of selected brooders one female and two males are put together in breeding hapa. In order to ensure successful spawning sometimes the female fish is injected with pituitary gland extract at a low dose 2 to 3 mg per kg. Body weight. Freshly washed aquatic weeds (Hydrilla, Najas, Eichhornia etc) are uniformly distributed inside the hapa. These aquatic weeds act as egg collections. The quantity of weed used is roughly double the weight of the female introduced. Each weed attached with 40,000 to 1,00,000 eggs are distributed into a single hatching hapa. After 4 or 5 days the weeds are taken out carefully.

3.4. Factors Effecting Induced breeding:

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

3.4.1. *Temperature*:

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

3.4.2. *Light*

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

3.4.3. *Water currents and rain*

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

3.4.4. *Hormonal influence*

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

3.5. Carp Hatcheries

3.5.1.*Types of hatcheries*

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

3.5.1.1. Earthen hatching pits

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

The advantages of earthen hatching pits are :

1. These are best suited for hatching eggs from dry bunds. Wide areas near dry bunds can be used for digging earthen pits, so as to use a less quantity of eggs in each pit.
2. Fresh accumulated rain water from the bunds enters into the pits for hatching.
3. Expenditure is very low and the technology is inexpensive.

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

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

3.5.1.2. Earthen pot hatcheries

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

3.5.1.3. Cement hatching pits

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

3.5.1.4. Hatching hapas

Double cloth hatching hapas are most extensively used. The hapa is fixed in the water with the help of bamboo poles in shallow waters. This hapa is double walled, with an outer wall made of either thin or coarse muslin cloth, and an inner wall made of round mesh mosquito netting cloth. The most frequently used cloth for a hatching hapa is 2 x 1 x 1 m in size for the outer one, and the inner wall size is 1.75 x 0.75 x

0.9 m. The water depth is maintained around 30 cm. These hapas are arranged in a series. 75.000-1,00,000 eggs are kept in one hapa inside the inner wall for hatching. After hatching, the hatchlings enter into outer hapa through the mosquito netting cloth, leaving the egg shells, the spoiled eggs and the dead eggs. After hatching, the inner hapa is removed. The hatchlings in the outer hapa are kept for a period of 40 hours till the yolk sac is absorbed. The percentage of hatching is 40-50%.

The main advantages are that the cost is very less and the eggs are away from earth which will not pollute and cause mortality. The disadvantages are the pores of hapas get clogged due to silt deposition which causes heavy mortality, crabs cut the hapas easily, they have a short life period of about 2 years, weather fluctuations result in mortality and they need more water.

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

3.5.1.5. Floating hapas

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

3.5.1. 6. Tub hatchery

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

3.5.1.7. Cemented cisternae hatchery

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

3.5.1.8. Vertical jar hatchery

This technique is an improved method over the hapa technique and ensures 90% survival offish hatchlings. The hatchery (Fig. 5.7) consists of a continuous water supply, breeding tank, incubation and hatchery apparatus and a spawnery. The vertical jars are made up of glass, polythene and iron.

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

2. It can be operated in a compact area. The space needed to accommodate the 40 jars unit would be around 10 square metres or at the most 20 sq. metres, and such a unit is sufficient for hatching

out 20 lakh eggs. Compared to this, the hatching hapa in ponds requires 150 square meters of space.

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

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

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

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

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

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

The main disadvantages are as it is made of glass, it is prone to easy damage; difficult to shift to different places and subject to breakage during transport; temperature control system is not provided; metabolites are not removed from the circulating water, and. additional air circulation is not provided.

In the transparent polythene sheet hatchery, glass jars are replaced by transparent polythene containers. Each polythene jar is 27 cm in height, 10 cm diameter and has a capacity of 2 litres.

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

3.5.1.9. Plastic bin hatchery

This unit consists of eight hatchery cum spawnery units (HCS units) and a 5,000 litres water tank. The tank receives water from a natural resource by pumping. The tank is connected to the inlet pipelines of each unit. The HCS units can be arranged in a series to facilitate inlet connections. In this hatchery 2 crore eggs are kept for hatching. The percentage of hatching is 70-80%.

Each unit consists of an outer container and the inner common egg vessel. The outer hatchery container is a rectangular aluminium sheet tub of 54" x 18" x 22" dimension and 243 litres capacity. It is unequally divided into three chambers. At a time 8 litres of eggs are placed for hatching in each hatchery unit. It also consists of an inlet outlet and drain pipe.

The common egg vessel is made of a 14 gauge aluminium sheet which has 2.5mm diameter perforations. Three egg vessels are placed in each outer container. It is cylindrical in shape with a 12" diameter and 12" height. There is an arrangement of a plunger-lid which can slide and can be fixed at any desirable height on a vertical aluminium rod having a series of holes at 1 cm distance. The lid is useful to cover the eggs placed in the vessel closely so as to prevent any over flow and at the same time to enable efficient circulation of water. Each egg vessel can hold about 2 lakhs of eggs.

The advantages are that the cost is less as it is primarily made of plastic, and is easy to operate. The disadvantages are that it has no temperature control device, no additional air circulation, metabolites may not be removed from circulating water and rhegaplankton may come from the overhead tank, which are injurious to the spawn.

3.5.1.10. Plastic bucket hatchery

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

3.5.1.11. Hanging dipnet hatchery

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

3.5.1.12. Circular cisternae hatchery

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

3.5.1.13. Chinese hatchery

The Chinese spawning and hatching systems are based on continuous flow of water by gravity to breed carps and hatch the eggs. The cost of construction and operation of a Chinese hatchery is less when compared to any other design for die same production capacity. In India also, the Chinese hatchery system is now considered to be highly suitable for the production of quality fish seed. Chinese type of. hatchery (Fig. 3.4) consists of four main components, viz., overhead water storage tank, the spawning/ breeding pond, incubation hatching pond and hatchling receiving pond. This system is designed for fish breeding and incubation. The water required for the hatchery system is regulated thf oogh the pipe supply from an overhead tank. The duration of one operation for hatching is 4 days. It can be repeated after a period of 4 days.

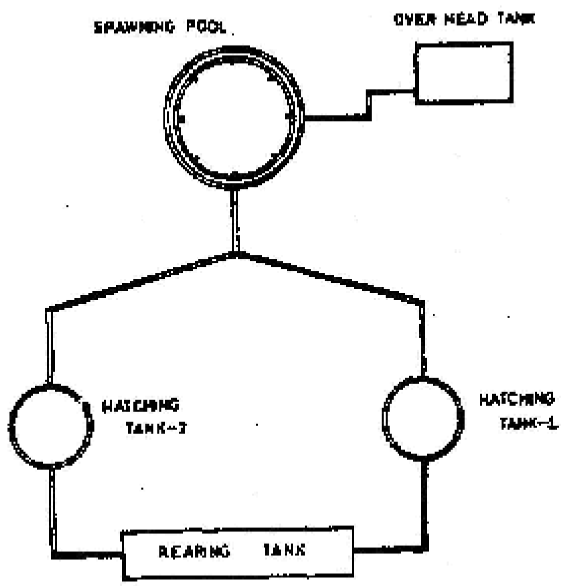


Fig. 3.4 Chinese hatchery

Overhead water storage tank : The floor of the tank should b 2.6m. above ground level. The inside dimension should be 5.5 x 2.7 x 2.2m and it should have a 30,000 liters capacity. Water supply to the overhead tank should be arranged by pumping water from an open well or a deep tube-well. The overhead tank is used to supply sufficient water for the spawning, incubation and storage tanks. A smaller overhead tank with a 5,000 litres capacity is also useful for this type of an operation.

Spawning pond: It is a circular masonary/concrete pond with an inside diameter of 8 m. It has 50 cubic metres of water holding capacity. The inside depth at the periphery is 1.20 m. which slopes down to the centre at 1.50m. A water supply line is laid along the outside of the wall, and the inlet to the pond is provided at 14-16 places equally spaced and fixed at an angle of 45° to the radius of the tank using a 20 mm. diameter pipe with a nozzle mouth, all arranged in one direction. These are fixed to the vertical wall and the nozzle mouth is flush with cement plaster face and near the bottom along the periphery of the pond. In the fitted through which, on opening the valve, fertilized eggs along with water are transferred into incubation pond for hatching. The \vater flow in the spawning pool create an artificial riverine condition for the fish to breed. The shower and a perforated galvanised iron pipe are useful to increase the dissolved oxygen. About 70 kg. of males and 70 kg. of females can be kept in the spanning tank which can yield 10 millions of eggs in one breeding operation.

Incubation ponds: There are two circular incubation ponds each of 3.6 m. internal diameter. There are 2 chambers in each pond. The dimension of the outer chamber is 4 m.. having an outer masonry/ concrete wall. Another circular wall with a fixed nylon screen is provided at 0.76 m. clear distance from the outer wall. These tanks are about one metre in depth with 9-12 cubic metres of water holding capacity. They hold 70,000 million eggs/cubic metre. The inner chamber is provided with 10 cm. diameter vertical outlets with holes at different heights for taking out excess of \\ater of the incubation pond. The spawn along with water flows from these ponds to spawn collection pond.

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

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

Operation of the Chinese hatchery: Brooders are kept in the spawning pond for about 4-8 hours for conditioning. Then between 4-6 PM, the first injection is given to the females. After 6 hours a second dose of injection is given to the female and one dose to the male. After 4 hours of the injection, the water jets are started so as to get the circular motion in the water. After 4-8 hours of the second injection, breeding takes place. One crore of eggs can be treated at a time in one operation. The eggs are collected from the bottom and are transferred into the incubation pools through pipes by opening the valves.

Arrangements are made to chum the water again in the incubation pools. In 4 days time, the spawn is about 6 mm in size and then it is taken into the hatching' spawn receiving pool. From there it is lifted and stocked in separate water ponds until they reach the fry stage. If oxygen is less, aeration can be given through a compressor in the incubation pool at the rate of 6 kg/ cm2 run by a 1 HP motor. For aeration- water showers, water jets, etc can also be provided depending upon the requirement. During the breeding season lasting about 120 days in a year, the breeding and hatching operations can be carried out in about 30 batches, each batch of 4 days. About one crore eggs can be hatched in one batch, and with a 95% hatching success, 285 million spawn of about 6 mm size can be produced. The main advantages are that the structures are of permanent nature, the hatchery is easy to operate and it needs less manpower.

3.5.1.14 D-variety Hatcheries

The seed production is dependent on nature, but the problem has now been solved with the evolving of a modern hatchery model CIFE-D-81. It is now possible to breed fish without rains in this modern hatchery. Thus, we have become independent of the monsoons and natural environment. The brooders are kept in the breeding unit, while hatching is done in jars having control over silt, oxygen, temperature and metabolites. This hatchery system (Fig. 3.5.) consists of breeding and hatchery units.

Breeding Unit: This unit consists of air conditioners, breeding tanks, sprayers, water current system, aeration system, water pumps, overhead tanks and a filter unit. The breeding unit is installed in an air-conditioned room. An air conditioner of 1.5 ton capacity is used. The air-conditioned room may have an area of 22.5 sq.m. and two breeding tanks of 440 x 115 x 80 cm size each, for breeding 240 kg females in 30 operations in four months of breeding season. The breeding tanks are either plastic pools, LDPE tanks, cement tanks or fibreglass tanks. The breeding tanks are provided with fine 75 mm diameter showers and spray channels arranged around the upper edge of the tanks. The spray and showers have independent operating systems, but can be used

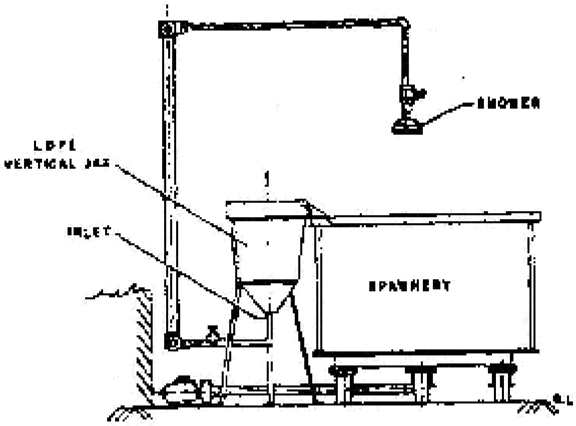


Fig. 3.5 : CIFE-D-81 hatchery

simultaneously if required. The water in the breeding tank is recirculated by a 1/16 HP pump and oxygenated through spray and showers. In each of the breeding tanks two floating hapas 180 x 90 x 90 cm in size are arranged. In each floating hapa a close net hapa of 170 x 80 x 80 cm size with a mesh of 20 mm and an opening for the introduction of injected brooders is fixed. In this system, 2.4 million eggs can be obtained in one operation.

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

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

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

Operation of D-81 hatchery unit: Selected breeders are subjected to induced breeding and introduced in the breeding hapas. In case the water temperature is too high, the fishes are acclimatized gradually by lowering the temperature to 26-27° in the breeding unit. Then the spray and showers are started. The air-conditioner is put off when temperature reaches 26° C, but the spray and showers are kept in operation.After breeding takes place, the big meshed hapa is removed along with the spent brooders. The eggs remain in the breeding compartment of the hapa. After 5 hours the eggs are transferred to the hatching unit.

After 4 hours of spawning the eggs are transferred to the egg vessel which is fixed in the hatchery jar. About 2 to 2.25 lakh eggs can be accommodated in each hatchery jar depending on the species. Continuous mild aeration and water flow are maintained in the jars for free floating of eggs. The rate of water flow is maintained at 1-2 litres/

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

The advantages are :

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

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

3.6. BUNDH BREEDING

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

3.6.1. Types of bundhs

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

3.6.1.1. Wet bundhs

These are also known as perennial bundhs. The wet bundh is a perennial pond located on the slope of a vast catchment area of undulating terrain with proper embankments having an inlet facing towards the upland and an outlet towards the opposite lower ends. During summer, only the deeper portion of the pond retains water containing breeders. The remaining portion is dry and is used for agriculture.

After a heavy rain a major portion of the bundh gets submerged with water flowing in the form of streamlets from the catchment area and excess water flows out through the outlet. The fish starts spawning in such a stimulated natural condition in the shallow areas of a bundh.

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

3.6.1.2. Dry bundhs

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

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

3.6.2. Site selection

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

1. Extensive upland area from where, with heavy rains, considerable

amount of rain water carrying soil and detritus enters the main pond.

2. The pond should have extensive shallow marginal areas which serve as ideal spawning grounds.
3. The soil should be of gritty nature which is considered to be the most suitable for the breeding of fishes.
4. Increase in oxygen contents of water which is due to the vast and shallow area of the pond.

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

3.6.3. Catchment area

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

3.6.4. Embankment

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

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

3.6.5. Factors responsible for spawning

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

3.6.6. Fish breeding techniques

Rohu, catla, mrigal, common carp, silver carp and grass carps are used to breed in bundhs. 100% pure seed can be produced in bundhs. Besides, more seed can be produced at a time. Once the bundhs are constructed, they can be used for many years to get more profits.

The brooders are collected in May and stocked in storage tanks where they are kept sex wise till the first monsoon showers. As soon as water accumulates in the bundhs, a selected number of these breeders are introduced into these bundhs and a constant vigil is maintained. In the olden days no importance was given to maturity, sex ratio, etc. The techniques were improved later and the breeding was done with a better understanding of sex, ratio and number of breeders. Fully ripe females and males 1:2 in number and of 1:1 weight were introduced into the bundhs on rainy days. Successive spawning could also be achieved as many as 5 times in one season.

In the modern techniques few pairs of females and males are being injected with either pituitary, or HCG or ovaprim extract and are released in the bundhs. This process, “sympathetic breeding in dry bundhs” has been used in West Bengal. By this method of partial hypophysation all the limiting factors for spawning like rain, thunder, storm and current of water can be bypassed. It is reported that about 160-200 million spawn of major carps has been produced.

Recently at Mogra, the farmers have created a cement pond of about 75* x 25'. The bottom of the pond is pucca, but divided into two portions possessing a gradual slope. When water is filled into the pond, the first part possesses about one meter depth of water an4 lower one has about 2 meters depth. The owners called it as West Bengal bundhs. The bottom is filled with 6" of fine river sand. Before releasing them into the pond, the male and female breeders are partially hypophysed. It is reported that 160-200 million spawn of major carps has been produced here.

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

3.6.7. Collection and handling of eggs

As soon as breeding commences, arrangements for collection and hatching of eggs are made. The eggs are collected by pieces of nylon net or mosquito netting, cloth or gamcha after lowering the water level and hatched in the double walled hatching hapas, ordinarily fixed in the bundhs. Collection of all the eggs is impossible, especially in case of wet bundhs, due to its larger areas. About 70% of eggs can be collected .from the bundhs. In Madhya Pradesh, the hatching of eggs is carried out either in double-walled hatching hapas fixed in the bundh itself or in rectangular cement hatcheries measuring 2.4 x 1.2 xO.3 m. However, in West Bengal, the eggs are kept for hatching in specially dug out small earthen pits with mud plastered walls. The hatchlings are lifted from the pits by dragging muslin cloth pieces after 12 hours of hatching and are transferred to similarly prepared bigger earthen pits. The survival rate is about 35-40% in the hapas. It can be increased to 97% by using modern hatcheries.

3.6.8. Improved features of dry bundhs

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

1. Selecting shallow sloping depressions and undulating terrain of sandy soils with maximum catchment areas.
2. Constructing a small earthen bundh at the far end of the depression opposite to the catchment area so that water could be retained for a certain period. A maximum depth of 2 meters of water is maintained in the bundhs and a fine meshed wire netting protects any overflow water.
3. Since major carps generally breed almost at any place in the shallow bundhs, it may be advantageous to prepare spawning grounds at different levels so as to get them flooded at different water levels in the bundh. But, it is necessary to have the spawning ground away from the direction of the current.
4. A few storage tanks, cement cisternae or earthen ponds can also be provftfed adjacent to the bundhs to store the breeders temporarily prior to their introduction in the bundh.

5. Constructing a battery of 10-20 rectangular cement hatcheries measuring 2.4 x 1.2 x0.3m.
6. Constructing a small double storied building which could serve as an observation tower cum store cum shelter.

3.6.9. Problems in bundh breeding

The problems encountered in bundh breeding are :

1. Sometimes it is difficult to coordinate the collection and hatching of large quantities of eggs at a time, particularly in the case of wet bundh breeding.
2. During egg collection from wet bundh, often unwanted fish spawn, and, predatory insect larvae, etc. are also collected.
3. In most cases, the hatching rate of eggs and survival of hatchlings upto the spawn stage have been poor, even when the fertilization rate of eggs was high. This could be improved by using modern hatchery techniques.
4. Presence of fairy shrimps (Streptocephalus sp. and Branchinella sp.) is in large numbers in dry bundhs particularly when breeding is late, i.e., three weeksof water accumulation during the collection of eggs. They can be controlled by sqjplying bleaching powder at the rate of 1 ppm on the first day of water accumulation,
5. Most of the dry bundhs primarily belong to the government. These are tasically meant for drinking water and irrigation purposes. Fish breeding in these bundhs is, therefore, a secondary activity. No control on the inflow and outflow af waters for fishery activities is possible.
6. The brood fish are mainly collected from the wild habitats for dry bundh breeding. Gillnets or cast nets are used for catching the brood fish thereby causing injuries to the brood fish.
7. Brood fish may carry some infection or injury.
8. When the rains are heavy after spawning is over the influx of water is so strong that much of the gonadal products are destroyed by mechanical injury.
9. Before the release of brood fish or at the time of spawning and development of the spawn, adequate attention is not paid to

monitoring the water quality as regards dissolved gases, toxic substances and predatory organisms.

10. In the late monsoon with accumulation of more waters, some dry bundhs start overflowing, thus increasing the risk of loss of seed from the bundh.
11. In the post-monsoon months with receding water level, the fmgerlings are" exposed to the risk of predation by the birds.
12. In some dry bundhs having a uniformly flat basin, when the water is reduced to critical level, seed collection becomes difficult and there may be mortality due to rise in temperature and turbidity in shallow sheets of water caused by repeated netting operations.
13. Late harvest of fish seed with decreased amount of water further aggravates the problem of poaching.
14. The early major carps are voracious in their feeding habits. If adequate food is not made available to them they become cannibalistic, especially if there is a noticeable difference in the size groups.This is especially true when brood fish-are released in batches.
15. Often, when the dry bundh is supporting a good number of fish seed, water is drained out for irrigation purposes. This may also cause loss of sizeable stock from the dry bundh.
16. In most cases the spawn is allowed to stay uncared for in the dry bundh under natural conditions. If in excess, the silt, predatory insects and copepodes cause heavy damage to the developing eggs and subsequently to the juvenile fishes.
17. When spawning occurs the water may recede to critical levels thereby exposing a large amount of eggs in the peripheral areas of dry bundh thus causing large scale mortality of spawn.

3.6.10. Economics

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

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

E. CARP HATCHERIES

Quality fish seed is the basic requirement for fish farming. Demand for fish seed has increased enormously in the recent past due to adoption of scientifically controlled fish culture practices in ponds. Dependence on riverine fish seed resources is not desirable as this fish seed is of a mixed variety of wanted as well as unwanted species offish. Moreover, owing to heavy exploitation of riverine fishery as well as growing domestic and industrial pollution in rivers, availability offish seed from this source is

3.7 Transportation of breeders and Seed

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

3.7.1 Reasons for Fish Mortality during Transportation

3.7.1.1 Effect of CO2 and Dissolved Oxygen:

Mortality of fish seed may be expected during transportation. It is mainly due to the depletion of dissolved oxygen and accumulation of gases like ammonia and carbon dioxide in the medium of fish seed carriers. These gases are lethal as they may reduce the oxygen carrying capacity of fish blood. However, the lethal limits owing to carbon dioxide in fish depends on the level of dissolved oxygen. It has been reported that fry of more than 40 mm in size may die at 15 ppm of carbon dioxide at a dissolved oxygen level of less than 1 ppm. Such fry may die only at 200 ppm, if the dissolved oxygen is around 2 ppm. Carbon dioxide given out during respiration dissolves in water and renders it more and more acidic which is injurious to fish. In transport of fish the shortage of oxygen has to be tackled either by replenishing the oxygen which is used up or by economising its use by regulating the number of fish seed and by reducing its oxygen demand.

The oxygen utilisation of fish in transport is dependent upon a number of factors like the condition of the fish - normal, active and excited condition of fish, temperature, size and species. The oxygen consumption of different species of the same size or weight varies considerably. For example, 400 common carp fingerlings of 40-50 mm size can be transported for two days in seven litres of water under oxygen packing. Only half of the number of other major carps and 1/8 of number of milk fish fingerlings of the same size can be transported under same conditions. Low to moderate temperatures are preferred for fish transport, since the amount of oxygen in water increases with the decrease of temperature and keeps the fish less active.

Increase of CO_2 depresses the active metabolic rate. Further increase proves fatal. In an oxygen packed closed system CO2 forms a limiting factor. Mortality of seed in such a system is mainly due to bacterial load in the medium. With the death of a few seed, bacteria increase enormously and utilise more oxygen. Bacteria increase from

250/ml in the beginning to over 110 million/ml in 24 hours. CO_2 is found toxic to seed at 2.5-5 ppm concentration.

3.7.1.2 Effect of Ammonia:

A large amount of NH_3 is excreted by fishes. If ammonia concentration is 20 ppm, total mortality of fish occurrs in oxygen packed packets. As NH_3 increases in water, the oxygen content of blood decreases and its CO_2 content increases. NH_3 interferes with O_2-CO_2 exchange capacity of blood with the outside medium. The rate of NH3 excretion increases 10 times with a rise in water temperature from 8-15^0C. Increase in water temperature and decrease of dissolved oxygen reduce the tolerance of fish to NH_3.

3.7.1.3 Effect of temperature:

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

Fish, prawn and their seed face hyperactivity during transportation. As a result, lactic acid tends to accumulate in their tissues and severe oxygen debts are created. Fish take a long time to overcome this oxygen debt even in their natural life in ponds and other habitats. This may be due to the death of fish after few hours after handling, transport and liberation even in oxygen-rich water. Hence, the use of sedatives is most important in modern live-fish transport technology.

Due to hyperactivity the bigger fish often suffer injuries which may cause death or severe external infection. If the fish and their seed are of different sizes, the smaller ones are very much affected and die. This risk may be avoided by selecting for transport fish of uniform size, and by sedating the fish.

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

3.7.2 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.

3.7.2.1 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.

3.7.2.2 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.

3.7.2.3 Double tin carriers:

Double tin carriers are made up of galvanised iron and has 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.

3.7.2.4 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. 20,000 fry can withstand packing in one bag for a journey of 12 hours. Similarly 200 fingerlings in one bag can withstand a journey of 12 hours. The number of fish seed to be packed in a bag has to be decided depending on the distance and size of the seed. A tube from the oxygen cylinder is then allowed into the bag and the portion of the bag, about 10 cm from the top is twisted and a string is kept ready for tying. The oxygen is then drawn in from the cylinder through the tube until 2/3 of the bag is inflated or the top of the inflated bag is slightly below the top of the tin. The string is tied round and the tin is closed. The packed tins are kept in a cool place. To ensure better survival rate, the tins should be transported during the morning or evening. Card board containers are used in place of tin containers.

3.7.2.5.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.

3.7.3 Use of Anesthetics in Transportation

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

Absorbants are added to the medium during transportation to eliminate toxic ammonia from the medium and safeguard the fish seed from mortality. These absorbants are permutit, synthetic amerlite resin, pulverised earth and clinoptilolite. Addition of sodium phosphate, which acts as a buffer, at a rate of 2 gm/lit. of the medium may bring about a favourable pH of the medium for fish seed during transit.

Due to the non-availability of some anesthetics and the risk involved in the improper use by laymen, the method has remained at the level of a scientist only.

3.7.4 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

$$N = \frac{(D - 2) \times V}{R \times H}$$

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

The densities of fish seed for transportation in 8 litres of water under oxygen packing at 250^0C and 300^0C are depicted in Table 3.1.

3.7.5 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,

Table 3.1: Number of fish seed packed at different temperatures

Fish seed	Average size (mm)	Temperature during transport (hrs.)					
		25^0 C			30^{0}C		
		6 hrs.	12 hrs.	24hrs.	6 hrs.	12 hrs.	24 hrs.
Spawn	10	12,000	6,000	3,000	10,000	5,000	2,500
Fry	40	600	350	175	500	300	150
Fingerlings	75	175	100	50	150	80	40

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%).

3.8 CARP BROOD MANAGEMENT

Catla catla, Labeo rohita and Cirrhinus mrigala are the fastest growing and consumer preferred species among Indian major carps. Besides exotic carps viz. Ctenopharyngodon idella and Hypophthalmichthyes molitrix do form an important component of composite culture. These carps do not breed spontaneously in confined water, need hormonal induction for the purpose. Hence, adequate prime brood are essential for commercial seed production. Brood management practices deals mainly with the brood recruitment, pond management and stress management.

3.8.1 RECRUITMENT

Recruitment is a process begin with collection of quality seed as a critical input, for raising and rearing the promising brood for induced breeding. Such critical input may be obtained from riverine collection or from extensive culture system. Seed input from selective breeding process are mostly preferred. However, care is to be taken not to collect any fingerlings from affluent contaminated water, overcrowded intensive carp culture system and pond with any disease outbreak during near past.

3.8.2 POND MANAGEMENT

Management practices play key role in raising and rearing programme. In the process ponds environment are maintained productive and stress free by application of liming fertilizer and feeding rate etc. Pond Management practices do complete in two phases. (A) Brood raising and (B) Brood rearing.

Catalogue of each stock of the breeding farm reflecting the details of gonadal maturation and breeding response is required to be maintained.

3.8.2.1 Brood Raising Pond Preparation

A suitable brood fish pond varies 0.2 ha to 0.5 ha preferably rectangular in shape and water depth 1.5 m during peak summer. Drainable pond with a provision of water replenishment facilities is most preferred. The pond should be free from aquatic weeds, predators and weed fish. Aquatic weed is to be removed manually and mechanically as far as practicable. Chemical weed control should be avoided to overcome the biological impact on brood fish. Methods adopted for eradication of predatory and weed fishes are by repeated netting, dewatering and application of suitable piscides before stocking, Mahua oil - cake 250 kg/ha or bleaching powder 300 kg/ha (25-30 ppm chlorine level) acts as effective piscides. Quantity of bleaching powder can be reduced to half when it is in combination with urea at 100 kg/ha. Its application should be 24 hours prior to bleaching application.

Stocking.

Yearling are preferably to be collected from different natural resources or from extensive culture system avoiding waste water, industrial affluent and sewage culture system and kept under quarantine condition for 2-3 months. Out of this, healthy and fast growing carps are selected for brood raising programme. Catla, rohu, mrigal, grass carp and silver carp in the ratio 3:2:2:2:1 are stocked @ 1500 kg/ha. Overcrowding and intensive carp culture practices which may invite physiological stress to fish. They are to be fed with formulated diet for proper gonadal development.

Fertilization

Fertilization and liming programme schedule is important to maintain ponds hygiene, pH and optimum plankton (2 ml sediment of plankton in 50 I of water). Plankton free clear water allow the growth of aquatic weeds and algalmat. Quantity of such inputs in brood ponds are subjected to manipulation according to water quality as follows :

Table 3.2 Fertilizer requirements

	Low	Med	High
Available Nitrogen mg/100g soil	<2S	25-50	>50
Available Phosphorus mg/100g soil	<3	3-6	>6
Organic carbon (%)	<0.5	0.5-1.5	>1.5

Inorganic Fertilizer : (In splitted dose as per requirement)

	Low	Med	High
Nitrogen (kg/ha/yr)	200	150	100
Phosphorous kg/ha/yr (Single Super Phosphate)	100	75	50

Note : 1 kg Urea - 0.46 kg Nitrogen
1 kg SSP - 0.16 kg Phosphorus

Organic Manure

Raw Cowdung - @ 50 - 10 t/ha - Base manure
10 - 20 + /ha - Fortnightly

Table 3.3. Liming

Soil pH	Dose of Lime ($CaCO_2$) kg/ha
4.0-4.5	1,000
4.5-5.5	700
5.5 - 6.5	500
6.5-7.5	200

3.8.2.2 Brood rearing Stocking

The prospective spawners are selected and reared at least 5-6 months ahead < the breeding season. Healthy adults of 2-4 kg and 2 + years of age is reared @ 10C kg/ha following principal species rearing method i.e. 60% dominant species and othei as subsidiaries required for maintenance of brood pond ecosystem. Spent broods < preceeding breeding season are also brought in for the purpose which are termed i professional brood. Such brood are always preferred as the initial stock for multipl breeding programme. This brood certainly spawn 1-2 months early and show bette brooding response as compared to traditional breeders.

Feed for brood rearing

A supplementary protein rich feed is given daily @ 2-3% of the body weight, i the prepatory phase. Brood in maturing phase require reduced diet @ 1-2% of the body weight. Powdered feed is brodcasted in catla dominated pond. Rohu dominate brood stock prefer semi soaked ingredients suspended in the column water in perforated bag whereas application of soaked feed is prescribed in mrigal and grass car rich pond. Silver carp dominated pond needs special attention towards supplementar feed. Regular removal of weed fishes required to avoid competition for food with car brood. The composition of formulated feed is

Table 3.4 Formulated feed for Indian Major Carps

Ingredients : (in kg)	
Ground nut oil cake	70.00
Rice bran	28.40
Sodium chloride	1.50
Trace element	0.10
Ferrous sulphate	50.00g
Copper sulphate	8.00g
Zinc oxide	6.70g

Manganese sulphate	15.40g
Potassium iodide	4.20
Cobalt'chloride	2.00g
Calcium carbonate	13.70g
Vitamins suppliment per 100	Kg of feed
Vit C	10.00
Vit E (Evion, E-Merk India Ltd.)	3.00

Table 3.4 : Formulated feed for grass carp

Ingredients : (in kg)	
Soyabean cake	50.00
Ground nut oil cake	25.00
Rice bran	20.00
Fish meal	5.00

3.8.2.3 MANAGEMENT OF SPENT BROODS

Spent brood is reared in separate plankton rich pond by following same brood husbandry practices. Broods should be treated at regular interval with pottassium permanganate solution (5 ppm) until they become free from secondary infection. The recovered individual may again incorporated with brood rearing system.

3.8.3 Stress management

During the course of brood rearing breeding stress are needed to be minimised for achieving optirnum production of seed. Some are dealt as follows :

3.8.3.1 Chemical Stress

Often the brood develops argulosis and the pond are treated with insecticide like malathion and gammexine (BHC) etc. It is observed that treated broods give very poor breeding response and poor quality of gametes. Thus treatment should be done in isolation, not in enmass. The water quality is maintained by following proper fertilization and liming schedule. Some of the optimum physical and physico-chemical parameters of pond water are as follows :

Table 3.5 : Optimum basic parameters of water

Physical parameters	Brood pond
Temperature	20-35
Colour	Greenish
Turbity in cm	8-20
Chemical parameters	
PH	7.2-7.5
DCO_2	L4.0- 12.0
Total alkalinity	80 - 150
Ammoniacal Nitrogen NH4N (mg/1)	0.2-0.5
Nitrate Nitrogen NOrN (mg/l)	0.2-0.2
Nitrite Nitrogen NO_2 - N (mg/1)	<0.014
Phosphorus P_2O_5 (mg/1)	0.01-0.5
Iron (Admissible range) (mg/1)	0.05 - 0.02
Manganese (Admissible range) (mg/1)	0.01 - 0.04

3.8.3.2Oxygen stress

Sometime the brood pond develop bloom, resulting drop down of dissolve oxygen below 4 ppm which gives physiological stress to brood. In such events certai measures like reduction of feeding rate and aeration of pond helps to overcome th situation.

3.8.3.3 Physical stress

The carps are found to breed at a fairly wide range of pH and dissolved oxygen But many fishes do not breed in water which is poor in oxygen content. Renewal of water induces them to breed.

Summary

Fish seed is the most important component for fish culture.

The fish seed is obtained from three sources - riverine, hatcheries and bundhs. The collection of seed from riverine source was an age old practice. This method is strenuous and we get the mixture of wanted and unwanted fish seed. Hatcheries are the best way of getting fish seed. Apart from these, the bundh breeding is also a good method to collect the fish seed by creating a natural habitat.

Carps breed in flowing waters like rivers.

In induced breeding techniques, four main types of materials are used to give injections to fish - pituitary gland extractions, HCG, ovaprim and ovatide.

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

Fish pituitary gland is a small, soft body and creamish white in colour. It is more or less round in carps. It lies on the ventral side of the brain

Pituitary gland secretes the gonadotropic hormones, FSH or Follicular Stimulating Hormone, and LH or Luteinizing Hormone. Both hormones are secreted through out the year, but the proportion in which they are secreted is directly correlated with the cycle of gonadal maturity. The FSH causes the growth and maturation of ovarian follicles in females and spermatogenesis in the testes of males. LH helps in transforming the ovarian follicles into corpus lutea in females and promoting the production of testosterone in males.

The pituitary glands can be preserved by three methods - absolute alcohol, acetone and freezing. Preservation of fish pituitary gland in absolute alcohol is preferred in India.

H.C.G. is human chorianic Gonadotropin is produced by placenta in pregnent ladies. During early stages of pregnancy H.C.G. is rich in the urine of pregnant women.

Ovaprim is a ready to use product and the solution is stable at ambient temperature. It contains an analogue of 20 µg of Salmon gonadotropin releasing hormone (sGnPHa) and a dopamine antagonsist, domperidone at 10 mg/ml. The potency of ovaprim is uniform and contains sGnRHa which is known to be 17 times more potent than LH-RH (Peter, 1987). The dopamine antagonist, domperidone used in ovaprim is also reported to be better than another commonly used antogonist, pimozide. Ovaprim being a ready to use product and one which does not require refrigerated storage, appears to be the most convenient and effective ovulating agent.

Ovatide is an indigenous, cost-effective and new hormonal formulation for induced breeding of fishes. The new formulation is having the base of a synthetic peptide which is structurally related to the naturally occuring hormone, goanadotropin releasing hormone (GnRH). GnRH is not a steroidal hormone and belongs to the class of organic substances called peptides.

Ovopel, developed by the University of Godollo in Hungary, is a preparation containing mammalian GnRH and the water-soluble dopamine receptor antagonist, metoclopramide. The concentration of D-Ala6, Pro9NEt-mGnRH and metoclopramide are in the form of 18-20 micro gm/pellets and 8-10mg/pellets respectively.

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

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

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

Transportation of breeders, fry and fingerling is a common phenomenon in fish culture systems. The fish seed are transported from hatchery units to the fish farm to rear them in culture systems. The breeders are usually transported from culture system to hatchery units for breeding either by induced breeding or naturally.

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.

Recent investigations have shown that the fish seed could be anesthetised for transportation for ensuring better survival rate. The purpose of this is to ensure that the fish seed survives for a longer period of time, and also to minimise the concentration of toxic gases like ammonia and carbon dioxide in the medium by lowering the metabolic rate of the fish seed. Anesthetised fish seed have been found to survive for double the time of unanesthetised seed, besides ensuring a better survival rate, which is about 90%. Carbonic acid has been found to be the best anesthetic compared to others such as quinaldine, sodium amytal, urathane, veronal chloroabutanal and TMS-222 (Tricaine Methan Sulphonate). Carbonic acid is not only cheap but also safe and easy to use.

Hence, Adequate prime brood are essential for commercial seed production. Brood management practices deals mainly with the brood recruitment, pond management and stress management.

Questions

1. Whate is Induced breading? Explain its methodology with Pituitary Gland Extract.

2. Describe different types of fish hatcheres.
3. Describe the components and management of D-veriety hatecheres.
4. Describe the components and management of Chinese hatechery.
5. Explain the modes of fish seed transportation.
6. Describe carp brood stock management.

4. Layout of fish farm

In nature, many fish never reach adult size because they are eaten by other animals or predators or die from disease or lack of oxygen. Fish culture in ponds try to control the situation in order to produce more fish. In ponds, predators can be controlled so that the pond yields more fish than the natural waters. Growth of fish in ponds is mainly due to the fact that fish cannot escape, and feeding, breeding, growing and harvesting the fish is carried out in a well-planned way.

Fish culture is practised in ponds. These are small shallow bodies of water in natural conditions and completely drainable, usually constructed artificially. The natural ponds differ from the lakes in having a relatively large littoral zone and a small profundal zone. Their source of water may also vary.

4.1 Site selection

One of the most important aspects of the planning of fish farms is the selection of the site for the fish ponds. If the site of the ponds is well chosen, the pond can be more productive than the land itself. When considering a site for the fish ponds, several aspects have to be considered like the type and number of ponds to be constructed, the topography of the area, the water supply and the type of fishes to be reared.

Poor agricultural land can be converted into very good fish farms. If the soil is good the fish production will be high. If a pond is constructed on agricultural land which is not producing good crops, and the pond is managed correctly, eventually the pond bottom soil will become more fertile than it was earlier. After harvesting, the pond can be planted again with a land crop like corn and allowed to grow. When the corn is harvested, the land can be turned back into a fish pond. This means that the land can be used for 2 economically viable crops (one fish crop and the other corn crop) instead of one poor crop. Fish can be cultured along with paddy in the paddy fields. This means that the land is used for both the purposes, and in such cases, the choice of how the land should be used is very important. Only fishes can be reared in the ponds throughout the year.

4.1.1. Criteria for site selection:

1. Availability of land in a continuous, suitably shaped plot of optimum size with all facilities.
2. The site should have assured water supply of adequate quality either surface or ground water.
3. Soil and water of the site must be suitable for fish culture.
4. The site should be free from floods.
5. The site should have good transport facilities and approach roads.
6. The site should have electrical and telephone connections.
7. The fish seed should be available easily and in plenty in that area.
8. Marketing facilities should be available near the site.
9. The site should be away from populated areas.
10. The site should be connected to a drainage system.
11. The site should be away from polluted areas.
12. The fishermen or labour should be available near the site.

The following are the major factors that work together to make a good site for a fish pond.

4.1.2 Water supply:

Water supply is the most important factor in selecting a site. Fish depend upon water for all their needs. If a site has water available all the year-round, that site passes its first test easily. If water is not available all the time but there is some way to store water for use when the natural water supply is low, then that site may still be considered. The most important factor is that water must be available at all times and in good supply. A dependable source of water supply must be available near the site. There should be adequate water to fill the ponds and maintain water level which does not fluctuate more than 50 cm.

Common water sources for carp culture ponds are rivers, streams, springs, canals and surface runoff from rainfall. Water from any of these sources would be suitable for fish culture, provided it is free from contamination. The natural sources of water are;

1. Natural water : Most ponds are filled with water that comes from natural springs or that has been diverted and brought in from rivers, streams, or lakes.
2. Springs : Some ponds are built where there is a spring to supply the water. Spring water is obtained from underground, and is a very good source for fish culture because it is uncontaminated, without undesirable fishes and fish eggs. If the water from a spring has travelled very far, it may need to be filtered before it is used for a fish pond.
3. Rainfall : Some ponds called "sky ponds", rely only on rainfall to fulfil their need for water.
4. Run-off : Some ponds are gravel and sand pits which fill when water from the surrounding land area runs into them.
5. Wells : The best source of water for a fish pond is well water. Continuous water supply can be obtained from wells. Well and spring waters are often low in oxygen content, and fish need more oxygen in the water. The oxygen can be added to the water by agitating the water in the pond, stirring the water in the pond, by beating the water with bamboo sticks, and by running small motors in the pond.

In most of the cases, water from the rivers, streams or lakes is used for filling the fish pond. A diversion canal is dug between the water source and the pond to take water from the source to the ponds. It is a good way to fill a pond because the water can be controlled easily. When the pond is full, the channel can be blocked with a gate or a plug and water will stop moving into the pond.

There are a few problems with this type of water supply. In the tropical areas, streams flood during the rainy season. This extra water can be dangerous to the pond, and should be sent out through a channel. When a pond floods, all the fish escape and the pond is empty. This water should be filtered, otherwise, unwanted fishes and their eggs enter into the pond. If the water is very clear, which is from the water source, it may have to fertilize the pond because there are not enough nutrients. If the water is muddy, it will have to settle before it is used in the pond. A separate place will have to be made where the mud can settle out of the water before this water enters the pond. If the water is bright green in colour, it has a lot of fish food organisms. If the water is dark, it may have acid in it, and lime has to be added to the water.

4.1.3 Soil:

The other important aspect of the site selection is the soil of the area. The soil of the pond must be able to hold water. It also contributes to the fertility of the water due to its nutrients.

The best soil for a pond is one that contains a lot of clay. Clay soils hold water well. If the soil feels smooth and slippery, it probably means there is a lot of clay in it. If it feels gritty or rough to touch, it probably contains a lot of sand. The smooth soil is good for a fish pond. If the clay is more in the soil, its water retention capacity is more, and it is better for building a pond.

A good way to ascertain whether the soil is right for a fish pond, is to wet a handful of soil with just enough water to make it damp and then squeeze it. If it holds its shape when the hand is opened, it is considered to be good for a pond.

In sandy soils also ponds can be constructed, but more efforts are required which sometimes may not be successful. Large ponds can be constructed in clay soils only. If the soil is rocky or of shifting sand, only small ponds are possible. Soil also contributes to the pond’s fertility. Fertility is a measure of the nutrients in the pond and it simply refers to how much food is available in the pond for the fish. Usually fertile ponds contain large amounts of fish food organism. The soil of the pond contains necessary nutrients like Fe, Ca and Mg. In addition, soil also consists of acid which is harmful to fish. Sometimes after a heavy rainfall, high fish kill is observed in new ponds. It is due to the heavy rains carrying large amounts of acids from the soil into the ponds.

A good indicator of the quality of soil is whether it has been used for growing crops. If crops grow well in that location, the soil will be good for the fish ponds.

Porous and peaty soil must be avoided as this will neither retain water nor permit compaction. There will be excessive seepage of the soil if it is of organic nature and porous. The subsoil must be checked by taking random samples from the area in order to ascertain whether or not there is 1-1.5 m layer of clay under the pond bottom.

4.1.4 Topography:

The third important factor in site selection is topography. It is used to describe the shape of the land, whether it is flat or hilly, upland or lowland etc. The topography of the land determines the types of ponds which can be constructed. The location, shape and size of the pond are determined by the topography of the land and by the farmer's requirements. The most useful topography for fish ponds is that which allows water to fill the ponds and drain them by using gravity. Ponds built on a slope, can be drained easily. If the ponds are located on flat land, the pond must be built with a slope inside it so that it can be drained by gravity or it will have to be drained using a pump.

The ponds should generally be flat or gently sloping towards the outlets. Topography guides the cost of construction and intake and outlet of water for every pond. The site should be so selected that the earth available by excavation should, as far as possible, balance with the earth required in filling or raising dykes. Prior to designing and construction, the site should be thoroughly surveyed to determine the topography and land configuration.

4.2.The number, shape and size of ponds

The number of ponds depends on the possible site (Fig. 4.1 and 4.2). The site should have a place for nursery, rearing and stocking ponds. The size of the ponds depend on the topography, water supply and need. Nursery ponds are smaller than the rearing pond, because the fry are very small. Rearing ponds are usually bigger than nursery ponds and stocking ponds are the largest ponds in the fish farm.

The smaller ponds have the advantages like easy and quick harvest, quick drain and refill, easy treatment for diseases and are not eroded by wind easily. The advantages of the larger ponds are that it costs less to build the ponds, these ponds take up less space per hectare of water, have more oxygen in the water and can be rotated with rice or other crops.

More smaller ponds are better than few larger ponds in the fish farm as the larger ponds are difficult to manage. The width of the ponds should not exceed 40 m, so that relatively lesser and limited number of fishermen would be sufficient to harvest the fish. If the ponds are rectangular, the operations will be easier.

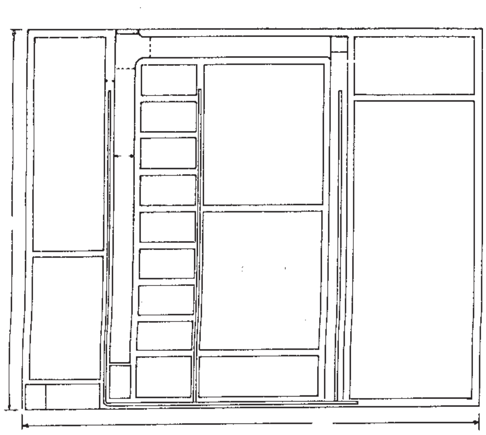


Fig. 4.1 Layout of a five acre model fish farm

The depth of the ponds depends upon the fish being grown. Fish species like different kinds of food, and the depth of the ponds affects the kinds of food produced by the pond. A common carp, for instance, eats worms and other bottom organisms and must have a pond that is

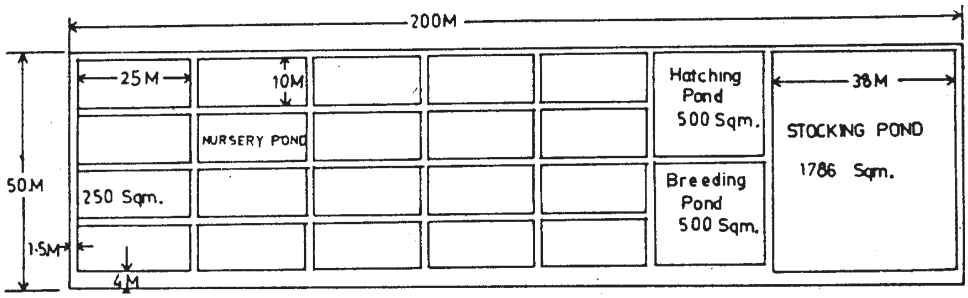


Fig. 4.2 Layout of one hectare model fish seed farm

not deeper than 2 m. But when the carp are in the fry stage, they eat only plankton and the tiny floating plants and animals suspended throughout the water. So nursery ponds for carp fry are often only 0.5 m deep. A deeper pond will not produce much food because the sunlight cannot enter into deeper parts of the ponds. A very shallow pond might become turbid, covered by water plants easily and also become very hot.

Square shaped ponds are economical to construct with minimum length of dyke. The width of the pond should not exceed 40 m for facilitating the netting operations, and hence a rectangular pond is preferable.

The slopes of the ponds and bundhs (Fig. 4.3) may vary from 1 ½ horizontal : 1 vertical to 2 horizontal : 1 vertical. The bottom of the pond should have a slope towards the outlet. Ponds should have controlled inlets and outlets, so that these can be drained and filled easily. The deeper ponds should be placed on the lower contours, so that lesser earth work is involved.

4.3 Survey

The first step in the construction of a fish pond is marking of the area of the proposed pond. The natural slope where the main wall is to be built should be ascertained. The main wall should be marked off at the lower end of the pond, where the slope is the greatest. This is where the drainage system of the pond will be laid. Even flat grounds have some kind of shape, although it may be very little. Before constructing, the land is surveyed to find out as to which side of the land has the slope.

4.4 Designing

While designing the fish ponds the first step should be to study the survey reports and maps, soil type, topography and water supply etc. The entire design and layout of ponds and dykes will follow according to the survey reports. In designing the fish farm, it should be decided as to where and how many nursery, rearing and stocking ponds are to be constructed.

In case of a fish farm constructed solely for the purpose of seed production, only nursery and rearing ponds may be constructed, with a nominal area for the stocking pond reserved for stocking the breeders.

In case of a fish production farm, more stocking ponds will be constructed to produce Table size fish after stocking fingerlings. For a composite fish farm all three types of ponds are required and their number should be based on the intended stocking density.

4.5 Construction

After the designing, it is necessary to prepare the detailed estimates of the items of work to be carried out as per the design. The approximate cost of construction is also to be estimated.

4.5.1 Construction time:

The construction time of the pond is an important factor for pond management. If the construction of the ponds is completed in summer, the pond can be used for cultivation immediately.

4.5.2 Preparation the site:

The site should be cleared before the construction. All the bushes and small plants, etc. should be cut and removed along with their roots. The roots should be totally removed, otherwise the leakage problem will arise later on. If there are any trees near the construction site, it is better to cut the branches towards the site, so that the sunlight is not blocked and the leaves do not fall in the water. It is better to have trees near the ponds, but only 5m away from the pond.

4.5.3 Mark out the ponds:

When the pond area is cleaned, it is necessary to mark the outlines of ponds and dykes. Mark out the main wall or dyke and other walls with stakes. The walls should be wide. Plan the depth of the pond and height of walls. The walls should always be at least 30 cm higher than the water level for a small pond, and at least 50 cm higher for a larger pond.

4.5.4 Excavation of the pond:

The excavation can be carried out either by manual labour or by bulldozers. If the bulldozer is used, final shaping should be given by manual labour. The sides and bottom of ponds should be properly finished and trimmed until a good slope for drainage is made. The pond bottom should usually have a slope of 2-5%. If the land for the pond is chosen well with regard to the natural topography, only a small part of the pond bottom will need to be dug out. The most important feature is to have the pond bottom slope such that the pond can be drained. If the pond site has a natural slope, the dyke or main wall should be constructed at the low level side. When the pond walls are constructed, the excavated soil can be placed on the top and planted with grass. This fertile top soil will root grass easily and this will help keep the walls from eroding.

The pond bottom must be cleared by removing small rocks, roots,

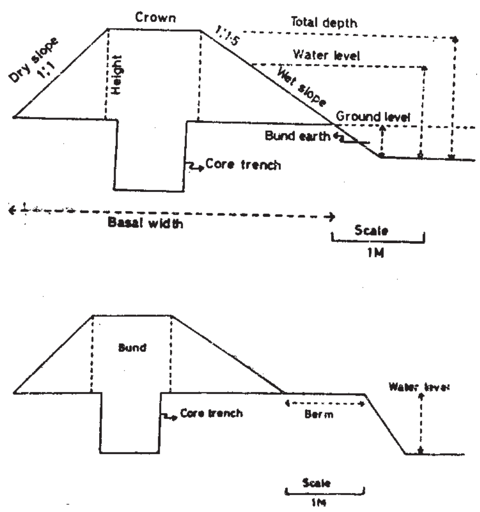


Fig. 4.3 Cross-section of an earthern bund
(a) and showing berm (b)

and stumps, so that the nets, during harvesting, will not get caught and torn. If grass is found in the pond bottom, it need not be removed, because after filling up the pond with water the grass will die and rot and add nutrients to the water.

When the stakes have been established for construction of dykes, about 2' top soil should be removed as it consists of large amounts of roots and other organic material. The core trench is cut immediately after the removal of the top soil. If the soil is porous, the seepage problem may arise at a later stage. It would be essential to provide a clay core in order to prevent seepage. A soil which is a mixture of sand and clay is best. Pure clay soil will give cracks and leak. If pure clay is to be used, it must be mixed with other soil before it can be used. Turf, humus or peaty soils should not be used. All stones, wood pieces and other material which may rot or weaken the wall must be removed before building begins.

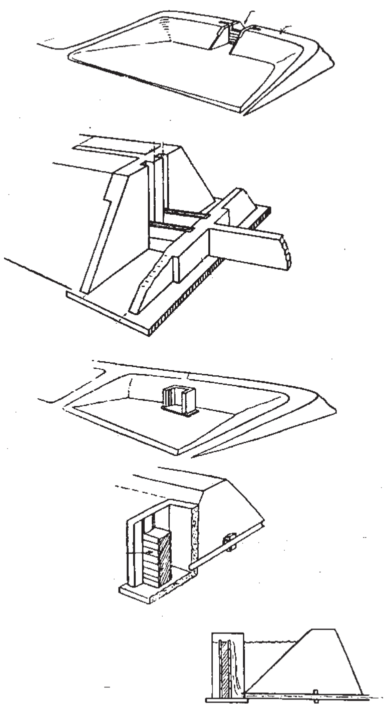


Fig. 4.4 Dyke, sluice and monk of a pond

The construction of the earthen dyke (fig.4.4) is always economical. The soil which is obtained from digging can be used to prepare the earthen dyke. The filling of earth should be done in layers not exceeding 20 cm in height and consolidate each layer by watering and ramming. The earth work for the dykes should be thoroughly compacted so that even minor seepage can be checked. If the fish farmer is economically sound, he can go for cemented dykes.

The dykes of a pond should be strong enough to withstand weather action. In big ponds erosion of dykes is a problem which requires regular attention. Brick and stone pitching may be provided to arrest erosion of dykes. The earthen dykes can be protected from erosions with bamboo piling with bamboo jabfree on the top. The holes, which is another common problem, should be closed immediately with stiff clay mixed with lime and cementing material and should be compacted properly. By using concrete blocks, stones or bricks the earthen dykes will be protected more permanently from crab or rat holes.

Side slopes of embankments depend upon the nature of material used for construction. The slopes should be flatter than the angle. Soil with a lot of clay in it can have a greater slope on the outside wall than on the inside wall. A typical embankment is built with an outside slope of 1:1 and an inside slope of 1:2. A slope of 1:2 means that for every change in length of 2 m there is a change of 1m in length.

Once the embankment is constructed, it is better to plant grass on it. The grass roots help to hold the wall together and prevent erosion of the soil. Trees should not be planted on the wall, as the tree roots grow they will crack and destroy the wall.

4.5.5 Drainage system:

A drainage system is used to empty the pond. It consists of the outlet system for letting water out of the pond and the drainage ditches which carry the water away from the pond. The best and easiest way to have a good drainage system is to build the pond in a place which provides a good slope. The drainage system must be built before the pond embankment because some drainage devices go through the walls. One of the easiest ways to drain the pond is to place a bamboo or plastic pipe through the base of the wall into the middle of the pond. The end of the pipe, which is inside the pond should have a screen over it to keep fish from entering the pipe. The other end of the pipe is plugged with wood or clay. To drain the pond during harvest time, the plug is pulled out. Other methods of draining the ponds are the siphon and the pump, which are not used as often. In the siphoning system, a rubber or plastic tube is fixed with one end inside the pond and the other end outside the pond, but this tube must be lower than the inlet. A vacuum is produced in the pipe to dewater the pond. Pumps can be run by engines to help drain the ponds, but it is a costly exercise.

4.5.6. Sluice:

The sluice can be a screened gate in a water channel going into the pond or a drainage gate leading water out of the pond.

In a pond drainage sluice gate is anchored into the main wall or dyke by extending the sides of the sluice into the wall so that the sluice structure stands upright and it is in the centre. The sluice can be made of wood, cement and brick. It can be made up of one or two wooden gates which are removed to empty or fill the pond. A sluice also has a screen gate to keep unwanted fish from entering at the inlet and pond fish from leaving at the outlet.

The monk (Fig. 4.4) is much like the sluice, but it is not built into the pond wall, the way a sluice is. A monk is never used at the inlet as a sluice can be. The monk type drainage system controls the level of the water and prevents fish from escaping from the pond.

4.5.7 Water inlet:

All the ponds, except for those filled directly by a spring or by rainwater, need water inlets. During the construction of inlets filters should be used in the channel so that the unwanted fish or other material do not enter into the pond and the water is clean. A water inlet can be as simple as a bamboo pipe of good diameter running from a water source through the wall into the pond. The inlet pipe should be placed above the water level.

A wire screen makes a good filter. The horizontal screen is very effective. Here the screen is placed so that the water passes through as it falls into the pond. The screen merely juts out from the wall at the inlet. The vertical screens can also be used. A nylon mesh bag makes a good filter and can be fixed to the inlet pipe. A sand and gravel filter is also used, but it requires a small tank at the water inlet, more effective and economical. A saram fibre filter is basically like a wire screen that is placed horizontally underneath the water inlet, but these must be cleaned often and are costly.

After examining the water source, selection of the filter is done. If the water is muddy, or has plenty of leaves or grass in it, the wire screen is better. If the water source is free from organic material, the mesh bag will work. If the water contains unwanted fish and more organic matter, the saram filter and sand and gravel filters are best. To clean the filters, it should be removed and cleaned with a brush and fresh water, or, the filter may be flushed with water against the water flow. This is known as backwashing. These filters should be cleaned each time when water is let into the pond.

4.5.8. Sealing the pond bottom:

The last step in pond construction is sealing the pond bottom so that it does not leak. If the soil has more clay in it, no special sealing is needed. If the bottom is sandy, it should be sealed to hold the water. To seal the bottom a clay core lining is built over the pond bottom. Another method of sealing the pond bottom is with cement blocks, but it is expensive. Sealing with polyethylene, or plastic or rubber sheet liner is another method of sealing. Yet another technique developed in the USSR, is called gley or biological plastic. In this method, the pond bottom is covered with animal manure after cleaning the bottom. The animal manure layer is then covered with banana leaves, cut grasses or any vegetable matter, and a layer of soil is put on it. The layers are rammed down very well and 2-3 weeks are allowed to elapse before filling the pond.

Summary

Growth of fish in ponds is mainly due to the fact that fish cannot escape, and feeding, breeding, growing and harvesting the fish is carried out in a well-planned way.

Fish culture is practised in ponds. These are small shallow bodies of water in natural conditions and completely drainable, usually constructed artificially.

One of the most important aspects of the planning of fish farms is the selection of the site for the fish ponds.

Fish depend upon water for all their needs.

The soil of the pond must be able to hold water. It also contributes to the fertility of the water due to its nutrients.

The first step in the construction of a fish pond is marking of the area of the proposed pond.

While designing the fish ponds the first step should be to study the survey reports and maps, soil type, topography and water supply etc. The entire design and layout of ponds and dykes will follow according to the survey reports. In designing the fish farm, it should be decided as to where and how many nursery, rearing and stocking ponds are to be constructed.

If the construction of the ponds is completed in summer, the pond can be used for cultivation immediately.

The dykes of a pond should be strong enough to withstand weather action.

A drainage system is used to empty the pond. It consists of the outlet system for letting water out of the pond and the drainage ditches which carry the water away from the pond.

The sluice can be a screened gate in a water channel going into the pond or a drainage gate leading water out of the pond.

Questions:

1. Describe the construction of fish farm.

2. What is the criteria for side sellection of a fish farm.

3. Discuss the drainage system of a fish farm.

5. Management of Culture Systems

5.1. PONDS

In nature, many fish never reach adult size because they are eaten by other animals or predators or die from disease or lack of oxygen. Fish culture in ponds try to control the situation in order to produce more fish. In ponds predators can be controlled so that the pond yields more fish than the natural waters. Growth of fish in ponds is mainly due to the fact that fish cannot escape, and feeding, breeding, growing and harvesting the fish is carried out in a well-planned way.

Fish culture is practised in ponds. These are small shallow bodies of water in natural conditions and completely drainable, usually constructed artificially. The natural ponds differ from the lakes in having a relatively large littoral zone and a small profundal zone. Their source of water may also vary.

5.1.1. History

Growing fish in ponds is a very ancient practice. Fish were cultured as long ago as 2698 B.C. in China. Fish culture seemed to occur whenever civilization was settled for a long period of time. Fish culture was done in ancient Egypt and in China, which has had a continuous civilization for over 4000 years. The first written account offish culture in ponds was by Fan Lai, a Chinese fish farmer in 475 B.C. Ancient Romans introduced carp from Asia to Greece and Italy. By the seventeenth century, carp culture was being practised all over Europe.

5.1.2. Why fish grow in ponds

The practice of fish culture in ponds is more advantageous. It is easier to catch fish from a pond than it is to catch them from a natural resource. Fish growth can be controlled. Fish can be fed extra food to improve their market value. Natural enemies can be kept out from killing the fish in the ponds. Fish can be protected from diseases. In ponds, the production offish can be increased with scientific management and more income can be generated. Fish farming can help a farmer make the best use of the land. Fish fanning can also provide extra income.

5.1.3. Types of fish farms

There are two major kinds offish farms mainly based on the nature of rearing.

1. The fish farms in which fishes are bred to raise the fry and fingerlings.

2. The fish farms in which the fry or fingerlings are raised to marketable size. The farmer has to decide what type of fish farm he is going to start.

5.1.*3.1. Based on water supply to ponds, they are classified into 5 types.*

Spring water ponds : Spring water ponds are supplied by ground water, either through natural springs at their bottom or through others lying adjacent to them. The spring water is good for fish culture because it is clean and has no unwanted fish or fish eggs in it. If the spring has covered a long distance before draining into the pond, it may have contaminants and should be filtered before its use.

Rain water ponds : These are also called as sky ponds. These are filled with rain water and the extent of their filling depends upon the amount of the rainfall.

Well water ponds: These are filled with well-water and considered very good for fish culture. They may be adequately supplied with water which has no contaminants.

Flood plain ox-bow ponds : Water for these ponds is supplied by the stream. These are highly productive due to the accumulation of organic materials and periodic flooding.

Water course ponds: These ponds are placed on the course of flowing water and divided further into two main types.

5.1.*3.2. Based on water supply, soil and topography the ponds are offivo types.*

Many aspects of the construction of these ponds are the same. The main difference between these is the water source. These are :

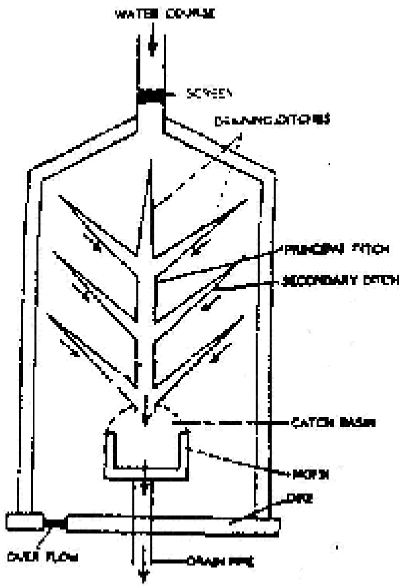


Fig. 5.1 Barrage pond

Barrage ponds: These ponds are usually filled by rainfall or by spring water. A spring, for example, sends water flowing through a small valley or down a slope into a low place. Or, a spring bubbles from the ground into a natural depression. The pond is formed by collecting water at the base of the valley and in the low places. The farmer does this by building a wall or dam which holds the water inside, what now, is the pond area. The number of pond walls that must be constructed depends upon the land and the drainage system. A barrage pond usually need only one wall - the main wall between the water source and the pond area.

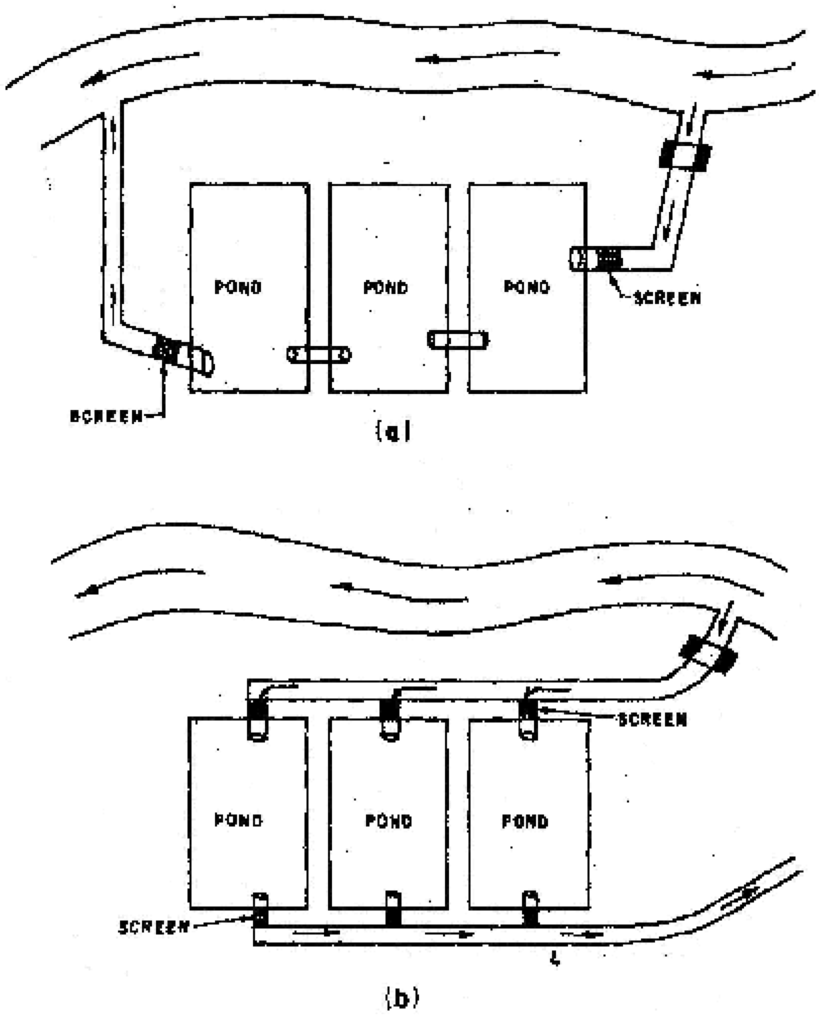


Fig. 5.2 Diversion ponds a) Rosary system b) Parallel system

One kind of drainage system called a sluice cart be used to let water both in and out of the pond. There are also a number of simple drainage systems which can be used that do not require any complicated construction.

Barrage ponds (Fig. 5.1) should not be built where the flow of water is too great as it is difficult to keep the water from breaking down the wall if the pressure of the water is too great. Brooks and streams which flow well, but not too strongly, make good sources for barrage ponds.

Even when the flow of water is not great, however, barrage ponds require overflow channels. Because barrage ponds are usually built in low areas, they are likely to get filled up during heavy rains. Overflow channels constitute any kind of a system which can be set up to stop the pond from collecting too much water. The overflow takes extra water away from the pond. If this extra water is not drained out, the pond wall may break.

Diversion ponds:

These ponds are made by diverting water from another source like a stream or river. Channels are dug to carry the water from the water source to the pond. Diversion ponds can be made in a number of ways. Sometimes a pond is dug in flat ground or can be made by slightly enlarging a natural depression in the land. These ponds require walls depending upon the topography of the land, the drainage system, etc.

In diversion ponds (Fig. 6.2), the water is always brought to the pond through diversion channels instead of running directly into the pond. Water can be diverted in a number of ways. A small stream which gets its water from a larger stream nearby can be dammed and used as a diversion channel to feed a pond. Diversion ponds can be built in two ways.

Rosary system :

These ponds are built one after another in a string. All the ponds drain into each other and must be managed as if they were one pond. If the first pond in the series with a water inlet is full of predators which must be poisoned, all the other ponds have to be harvested and drained before the first pond can be poisoned.

Parallel system:

Each pond has its own inlet and outlet. Therefore, each pond can be managed as a separate pond. The parallel system is a better system. But rosary systems are cheaper and easier to build. If the water source is good, and can be kept free of predators, and if management of the pond is done well, this is a cheaper and better system.

Diversion ponds are always better than the barrage ponds. This is due to the fact that they are less likely to overflow and the water source is more dependable throughout the year. Barrage ponds, however, require less construction and are likely to be cheaper.

5.1*.3.3. Ponds may also be classified according to their size and usage in a fish farm into five types*

These are constructed in accordance to the requirements of the fish or its stages of life cycle. These are:

Head pond :This pond is usually constructed near a perennial source of water. The main purpose of the pond is to meet the water requirements of the entire farm, taking into consideration the losses through seepage, evaporation etc.

Hatching ponds : These are also called as spawning ponds. These are small and mostly in the form of small tanks or plastic pools, made near the spawn collection centres. Hapas are fixed in these ponds. The eggs are collected and kept in the hapas for hatching. Similar ponds are also constructed in the fish farm. These are slightly deeper with water circulation. Here also, the hapas are fixed inside the ponds. The brooders are released into the hapa after giving them hormonal injections. Spawning takes place inside the hapa and the eggs are also allowed to hatch here.

Nursery ponds: These are also called transplantation ponds. These are seasonal ponds and are constructed near the spawning and rearing ponds. The main object is to create a suitable condition of food availability and growth of fry because at this stage they are most susceptible to hazards like the wave action and predators. These should be small and shallow ponds 0.02-0.06 ha. in size and 1-1.5 m. in depth. In the nurseries, the spawn (5-6 mm) are reared to fry stage (25-30 mm) for about 15 days. These ponds are usually rectangular in size. Extra care should taken for rearing the young stages, otherwise heavy mortality may occur. Sometimes the spawn are cultured for 30 days also. The pond bottom should gently slope towards the outlet to facilitate easy netting operations. Small and seasonal nurseries are preferred as they help in effective control of the environmental conditions. In practice about 10 million spawn per hectare are stocked in nursery ponds.

Rearing ponds : These should be slightly larger but not proportionally deep. These should be located near the nursery pond and their number may vary depending upon culture. They should preferably be 0.08-0.10 ha in size and 1.5-2.0 m in depth. The fry (25-30 mm) are reared here upto the fingerling (100-150 mm) stage for about 3-4 months. Carp fry grown in nursery ponds are relatively small in size and not fit enough for their direct transfer into stocking ponds. In stocking ponds bigger fishes are likely to be present which may prey upon the fry. Hence, it is desirable to grow the fry in rearing ponds under proper management practices upto fingerling size so that their ability to resist predation will be improved.

Stocking ponds : These are the largest ponds and are more deep, with a depth of about 2-2.5 m. The size of the pond may vary from 0.2-2.0 ha., but these should preferably be 0.4-0.5 ha in size. These are rectangular in shape. The fingerlings and advance fingerlings are reared upto marketable size for about 6 months. One year old fishes may grow upto 1 kg. or more in weight.

5.2. Nursery pond:

Management of nursery ponds is one of the most important aspect for successful fish culture practices. The hatchlings or spawn are reared to fry stages in small ponds called nursery ponds. The hatchlings, spawn and fry are extremely delicate, these should, therefore, be reared with utmost care to get a very good survival rate.

Nursery management has to be started right from the summer, so that the raising of a good crop of fry is possible. Drying up of nursery ponds in summer helps mineralization, removal of organic detritus and destruction of predators and aquatic weeds, which are more in perennial nurseries. The ponds have to be desilted, but the fine layers of the desilted earth containing rich humus matrix could be used to fill up the sides or eroded bundhs inside the nursery ponds. This helps in the manurial value of the rich superficial layer of earth and adds to the productivity of the pond. The outlets, inlets and strengthening of bunds have also to be attended to during the summer. The vegetation on the bunds are excellent breeding grounds for insects, hence, these should be destroyed and the vegetation burnt during summer.

If drying of the ponds is not possible, it is better to go in for poisoning of the pond. Poisons like endrin, tafadrin, derris root powder and Mohua oil cake are used to eradicate fish enemies. For successful nursery pond management the following pre and post stocking management techniques are to be followed.

5.2.1 Pre-stocking pond management

It involves site selection, eradication of weeds, insects and predators, liming, manuring, etc.

5.2.1.1 Green manuring in the pond:

The growth of plants in a pond bed is a necessity so as to enrich the soil. This process is known as green manuring. The short term crops of the leguminous family members like peas, beans, etc. help in enrichment of the soil with nitrogen. After the growth of the plants, the pond bed is ploughed and levelled with the roots of the plants in the soils. The nodules of these plant roots enrich the soil with nitrogen and are beneficial for enhancing pond productivity, resulting in a high survival rate and fast growth of fry.

5.2.1.2 Eradication of aquatic weeds and predators:

Aquatic weeds create certain problems in the ponds such as providing breeding grounds for aquatic insects, enabling to harbour predatory insects, restricting the free movement of fry, causing obstruction during netting and resulting in depletion of plankton production. Hence, the weeds should be cleared during summer either mechanically or by applying chemicals.

Predators injure the spawn and are responsible for a high mortality rate. Hence, the predators should be eradicated from nursery pond. The predatory fishes are *Channa* sp., *Wallago attu*, *Heteropneustes fossilis*, *Clarias batrachus*, *Anabas testudineus*, etc. which cause maximum harm to spawn, and use them as food. Weed fishes such as *Salmostoma sp., Amblypharyngodon mola, Barbus sp., Esomus danricus,* etc. are small sized and uneconomic fishes, which prey on carp spawn. They breed in the pond and compete with carp spawn in space and food.

Complete draining of pond is the best and simplest method to eradicate undesirable fishes. The drag nets should be used repeatedly for fishing. However, as most of the predator fishes are bottom dwellers, netting may not solve the problem. Therefore, the fish toxicants are used for eradicating them totally. Endrin at 0.01 ppm, dieldrin at 0.01 ppm, aldrin 0.2 ppm and nuvan at 30 ppm are useful to eradicate the forage fishes and all other fish enemies. These poisons are effective for 1-2 months and it is not advisable to use them repeatedly. The poisons get accumulated in the pond bed and it is impossible to remove them afterwards. These should be treated about 60 days prior to stocking.

Derris root powder (4 ppm) is good to eradicate forage fish from nursery pond and it is effective for one week. Mahua oil cake *(Madhuca latifolia)* at 250 ppm is lethal to forage fish. It should be applied a fortnight before stocking. After its lethal effect on forage fish, it is useful as manure later on. Sugarcane jaggery at 1% concentration is also lethal to the fish and its active poison is saponin. Tea seed cake is lethal to fish seed at the rate of 600 kg/ha. Application of 3-5 ppm of powdered seed kernel of *Croton tiglium*, 2-6 ppm of powdered root of *Milletia pachycarpa*, 20 ppm of powdered seed of *Barringtonia accutangula*, 12 ppm of powdered unripe *Randia dumetorum* and 10 ppm of powdered bark of *Walsula piscidia* is also effective.

5.2.1.3 Liming:

Liming is most essential to maintain the pH of water. The water should be slightly alakaline as it is useful for the eradication of microorganisms in the pond and also to help maintain the hygienic condition of water. Lime is useful to neutralise the acidic condition which will result while manuring. Lime is applied at the rate of 250 kg/ha. Its dose has to be increased upto 1000 kg/ha in highly acidic soils.

5.2.1.4 Watering:

While watering the pond, care should be taken to see that no forage fishes enter into the pond either at the egg, young or adult stage. For this, water should be let in through a fine sieve. The nursery pond has to be filled with water upto a depth of one metre.

5.2.1.5 Manuring:

Manuring has to be done after filling the pond with water. The main objective of manuring is production of adequate quantities of plankton, which is useful as natural food of carp seed. Several types of manures are available to increase the productivity of the pond. The most common , best and cheap of all the manures is raw cattle dung (RCD). Raw cattle dung at the rate of 10,000 kg/ha produces a good bloom of zooplankton in 10 days. The application of 5,000 kg/ha of poultry manure also produces good amount of plankton in pond. However, it is better to find a suitable manure which produces plankton within 3-4 days. A mixture of 5,000 kg/ha raw cattle dung, 250 kg/ha of single super phosphate and 250 kg/ha groundnut oil cake (GNO) has been found to yield plankton in about 3 days. This mixture is soaked in water, mixed thoroughly and spread on the surface of the water, so that the manure gets mixed thoroughly in water, thereby enhancing the pace of plankton productivity. It should be applied initially for about 10 days earlier to stocking and remaining seven days after stocking. If two or more crops of fry are to be produced from the same nursery pond, then the pond should be fertilized with 2,000 kg/ha of cattle dung a week before each subsequent stocking.

Inorganic manures are useful to fertilize the soil instead of water. 10:1 elemental ratio of N:P is required for phytoplankton growth. Inorganic fertilizers are usually applied in 10 equal monthly instalments at the rate of 100-150 kg/ha/yr.

5.2.1.6. Eradicating insects and other harmful biota:

Insects are usually found in large numbers in ponds over the greater part of the year, especially during and after rains. These insects injure the spawn and so have to be eradicated. Hence, the insects should be eradicated prior to stocking to ensure maximum survival of the spawn. Notonecta, Ranatra, Cybister, Lethoceros, Nepa, Hydrometra and Belostoma are highly destructive to the carp seed. The insects can be eradicated by using oil emulsions. After manuring the nurseries, they should be treated with oil emulsion.

The spraying of oil emulsion is 12-24 hours before stocking the spawn in nursery pond so as to eradicate the insects. The oil emulsion with 60 kg of oil and 20 kg soap are sufficient to treat one hectare of water. The soap is dissolved first in water and it is added to the oil and stirred thoroughly to get a brownish grey solution. It is then spread on the surface of the water. All the aquatic insects die because of suffocation due to the thin oil film on the surface of the water. The spiracles of insects are closed by the oily film so that they die.

An emulsion of 56 kg of mustard oil and 560 ml of Teepol is also useful to treat one hectare of water. An emulsion can also be prepared with diesel boiler oil and any detergent. Since soap has become very costly, one effective method is to use 50 cc of Hyoxyde-10 mixed in 5 litres of water with 50 litres of high speed diesel oil for a hectare of water.

The mixture of Herter W.P (0.6-1.0 ppm) and oil extracted from plant *Calophyllum inophyllum* is effective to insects as well as prawns like *Paleamon lamenii,* which is usually found in nurseries. A mixture of 0.01 ppm gamma isomer of benzene hexachloride and ethyl alcohol is also highly toxic to insects. Application of biodegradable organophosphates like Fumadol, Sumithion, Baytex, Dipterex, etc. (0.25 to 3 ppm) are useful to kill the insects.

Whenever an oil emulsion is applied, there should be no wind as it disturbs the oil film, and its effectiveness will not be felt on the eradication. Birds like king fishers, herons and cormorants are destructive to fry and fish. Thin lines stretched across the pond are the most effective means of controlling them.

5.2.2. Stocking:

After satisfying the physico-chemical nature of the water and plankton growth in the nursery pond, the spawn can be stocked in the ponds at the rate of 5-6 million spawn/ha. The stocking should be done either in the early morning or late evening after gradual acclimatization of the spawn to the pond water.

5.2.3 Post-stocking pond management

After preparing the nursery pond, it is better to maintain optimal physico-chemical properties and plankton. Brown colour of water reveals rich zooplankton growth. Green or blue colour reveals predominance of algae in the plankton. Dirty colour reveals suspension of silt in the water column. Maintenance of one metre water depth is enough in nursery ponds.

Among the chemical properties, 3-8 ppm dissolved oxygen is good for stocking spawn. Carbon dioxide above 15-20 ppm is lethal to fish life. A pH ranging between 7.5 to 8.5 is highly productive. The total alkalinity of 100-125 ppm is highly productive in water. 0.2 to 0.4 ppm of phosphates are good for plankton production and 0.06 to 0.1 ppm nitrates are considered enough for fish growth. 1 ml of plankton in 50 litres of water in nursery ponds is considered to be conducive for stocking spawn.

5.2.3.1 Feeding:

After stocking, during one or two days most of the plankton will be consumed by the spawn. Survival and growth of spawn are influenced by quality and quantity of food available in the pond. To ensure healthy growth of spawn, artificial feeding is necessary and is restored from the next day after stocking. The major carp spawn of 5-6 mm length weighs 0.0014 mg. The most commonly used artificial feeds are groundnut oil cake, rice bran, coconut, mustard cakes, etc. Finely powdered and sieved groundnut oil cake and rice bran mixed at 1:1 are used. The feeding schedule is as follows.

1-5 days after stocking - double the initial body weight of the spawn.
6-10 days after stocking - thrice the initial body weight of spawn.
11-15 days after stocking - three to four times the initial body weight of the spawn.

The level of artificial feeding has to be decided by the fish farmer based on the study of physico-chemical parameters and plankton.

5.2.2.2. Harvesting:

In 15 days of nursery rearing, the spawn grows to 20-30 mm size fry. At this stage, these fry could be transferred to rearing ponds. Supplementary feeding should be stopped a day before harvesting. The harvesting should be carried out in the early morning. In the same nursery pond, 3-4 crops of fry can be raised in a season.

5.3 Rearing Pond Management

Its management is similar to stocking pond management except stocking material and stocking densities. This stocking material is fry stage, which is reared up to fingerling stage for about 3 months. The stocking density of fry is 0.2-0.3 millions/ha.

5.4 Stocking Pond Management

After rearing the fish seed upto fingerlings in rearing ponds, these fingerlings are reared to marketable size in stocking ponds. The management techniques in rearing and stocking ponds are almost similar.

To get maximum quantity of fish utmost care should be taken through the most economic management measures. It should be clear that much of the success of a fish pond depends upon careful planning. The principles in the rational management of stocking ponds are increasing the carrying capacity of ponds by fertilization and supplementary feeding, optimal utilization of ecological niches in the pond by stocking manipulation, maintenance of water quality, the culture of quick growing species and fish health monitoring.

5.4.1 Pre-stocking management

It includes site selection, conditioning of the ponds, watering and fertilization of ponds.

5.4.1.1. Conditioning the pond:

If the pond is an old one from which the fish have been harvested, it should be completely ploughed. Ploughing helps in drying of pond bottom, increases the mineralisation, removes the obnoxious gases accumulated in the mud and destroys aquatic weeds and undesirable organisms. Ploughing of the pond bottom improves soil condition, but it should not be so deep so as to bury the fertile top layer and bring up the sterile layer to the surface. Desilting of the pond is essential to maintain productivity. The pond bottom should be cleared of any twigs, branches and stumps or dead fish. Then the bottom should be smoothened again. When the pond has dried enough, the soil will have large cracks in it. That means restoration of pond bottom is most essential now to improve the physical, chemical and biological condition of the soil.

5.4.1.2 Control of aquatic weeds:

The growth of aquatic weeds deprives the pond soil of nutritive elements, restricts the movement of fish, interferes with netting operations and harbours predatory and weed fishes and insects. Hence, the aquatic weeds should be controlled. The best way of weed control is pond drying and ploughing.

5.4.1.3 Eradication of undesirable organisms:

The real problem arises during the rearing of fish, when the other animals eat the fish. Frog, snakes and birds eat young fish and must be kept out of ponds. The worst predators are carnivorous fishes, which should be prevented from entering into ponds by screening the water inlets.

The common predatory and weed fishes (Fig. 5.3) in ponds are *Channa sp. Clarius batrachus, Heteropneustes fossilis,Wallago attu, Notopterus notopterus, Mystus sp., Ambasis ranga,Amblypharyngodon mola, Salmostoma sp., Esomus danricus, Puntius sp.,* etc. The weed fishes are small sized and uneconomical fishes and are usually found in ponds. The undesirable fishes enter into ponds accidentally, through incoming water along with carp spawn. The predatory fishes are harmful to all the stages from the spawn to the adult stages of carps and prey on these carps as well as compete with them for food and space.

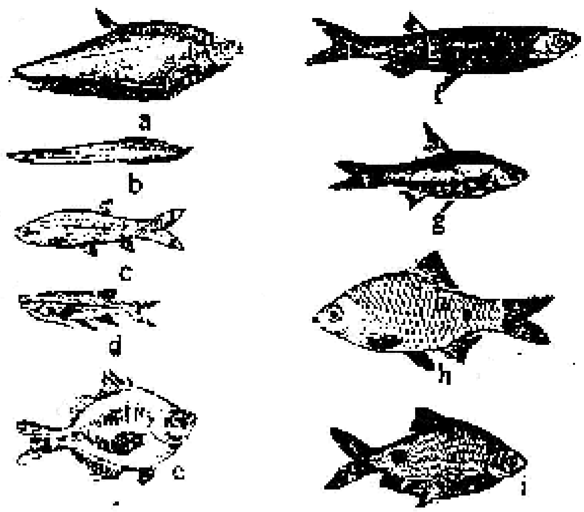


Fig. 5.3 Predatory and trash fishes of the pond
a) Notopterus b) Mastacembelus c) Rosbora
d) Esomus e) Amblypharyngodon mola
f) Salmostoma bacaila g) Ambasis
h) Puntius ticto i) P. conchoneus.

In any pond, all trash fishes and predators must be removed before stocking the pond. The simple methods of draining and drying of the ponds and then ploughing them are most effective in controlling them. If the draining is not possible, the pond as completely as possible, the undesirable fishes should be removed from ponds by repeated drag netting. However, many fishes escape the net by staying at the edges of the pond. The bottom dwellers like murrels, climbing perches, magur, singhi, etc., which burrow themselves in the mud are difficult to be caught by netting. Dewatering is the best method, wherein the water should be removed by pumping, although this is an uneconomical method. In this case, the best way to get rid of the undesirable fishes is to poison the water in a pond which cannot be drained.

Various types of fish poisons are available in the market. These are classified into 3 groups -chlorinated hydrocarbons, organophosphates and plant derivatives. Chlorinated hydrocarbons are most toxic to fish. These are accumulated in fish tissues and are stable compounds, which are not metabolised. Organophosphates are less toxic to fish, but they have adverse effects on aquatic flora and fauna. The accumulation is less in fish tissues and relatively less persistent in water. Hence, the plant derivatives are good fish poisons.

The best natural poisons are mahua oil cake, rotenone of derris root, quick lime (160 kg/ha), tea seed cake (150 kg/ha), camellia seed cake (50 to 200 kg/ha depending on water depth), tobacco waste (150-200 kg/ha) and powdered cotton seed (Table 6.1). Another safe chemical is saponin , which is a compound of tea seed cake and is applied at a dose of 0.5 ppm in the pond. Most of the natural poisons will degrade and disappear from the water in 7-12 days. Mahua *(Mahuca latifolia)* oil cake is an excellent poison, which breaks down after 10 days and is useful as a fertilizer. The chemicals like endrin, dialdrin and DDT should be avoided in ponds, as they can last in the ground for years and later kill all the pond fish.

Eradication of aquatic insects (Fig. 5.4) is discussed in nursery pond management.

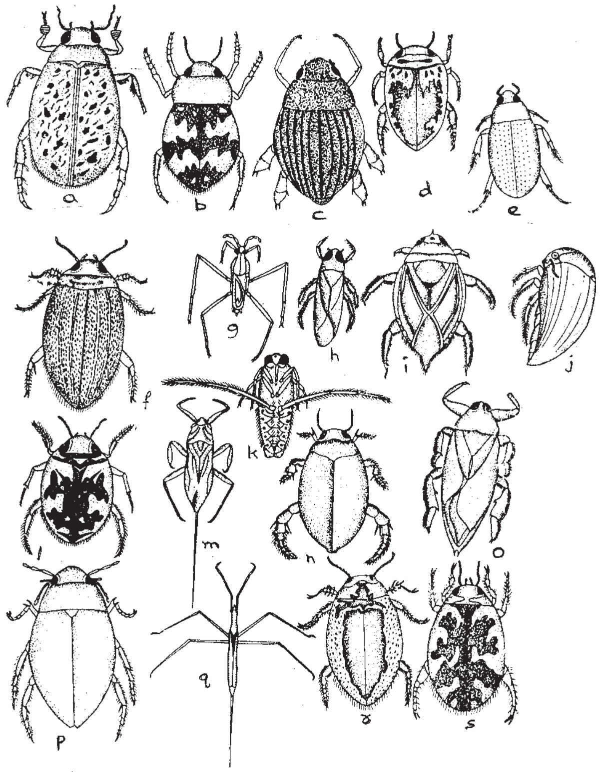


Fig. 5.4 Aquatic insects

a) Eretes b) Peschatius c) Dineutes d) Laccophilus e) Stemolophus f) Rhantaticus g) Limnometra h) Anisops i) Diplonychus j) Regimbartia k) Notonecta l) Hyphoporus m) Laccotrephes n) Cybister o) Lithocerus p) Hydrophilus q) Ranatra r) Hydaticus s) Sandracottus.

5.4.1.4 Liming:

Lime is frequently applied in aquaculture practices to improve water quality. After the pond is ploughed, cleared and smoothed, it should be conditioned with lime. Liming increases the productivity of a pond and improves sanitation. It is both prophylactic and theuraptic. The main uses of lime are;

Fig. 5.5 Aquatic weeds

a) Pistia b) Salvinia. c) Azolla d) Eichhornia
e) Lemna f) Ceratophyllum g) Chara

a) Naturalize the acidity of soil and water.
b) Increase carbonate and bicarbonate content in water.
c) Counteract the poisonous effects of excess Mg, K and Na ions.
d) Kills the bacteria, fish parasites and their developmental stages.
e) Build up alkaline reserve and effectively stops fluctuations of pH by its buffering action.
f) Neutralises Fe compounds, which are undesirable to pond biota.
g) Improve pond soil quality by promoting mineralisation.
h) Precipitates excess of dissolved organic matter and this reduces chances of oxygen depletion.

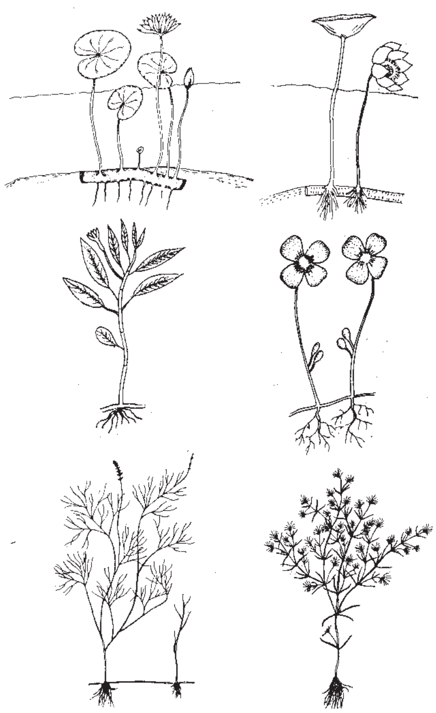


Fig. 5.6 Aquatic weeds

a) Nymphaea b) Nelumba c) Jussiaea d) Marsilia e) Potamogeton f) Najas

i) Acts as a general pond disinfectant for maintenance of pond hygiene.
j) Presence of Ca in lime speeds up composition of organic matter and releases CO2 from bottom sediment.
k) Lime makes non-availability of K to algae.

New ponds can be limed before they are filled with water. The limestone should be evenly spread over the dry pond bottom. In ponds with water, it is better to spread evenly on surface of water. Whether the pond is new or old, a layer of lime should be placed on the bottom of the pond. The lime should be added to the pond two weeks before the water is pumped into the pond. The best time for lime application is during the period when fertilization has been stopped. Lime should not be applied while the pond is being fertilized.

The highly acidic soils (pH 4-4.5) need a dose of 1000 kg/ha lime, whereas slightly acidic soils (pH 5.5-6.5) need about 500 kg/ha lime. Nearly neutral soils (6.5 to 7.5 pH) require only 200-250 kg/ha lime. The pH of the pond soil should be brought to nearly neutral for maximum benefits.

5.4.1.5 Watering:

After the lime has been applied to the pond bottom for at least two weeks, the water should be let in slowly. The water should fall from the water inlet into the pond, so that the water mixes with oxygen from the air as it falls into the pond. The water should not go in to the pond too quickly. If the water enters too fast, the pond bottom will get stirred up and thus make the water muddy. Screens should be used at inlets, so that the unwanted fishes and other organisms will not enter into the pond. The pond should be allowed to be free for a few days after it has been filled. The quality of water in the pond should be checked before the fish is released into it.

5.4.1.6 Manuring:

Fishes require certain elements to grow and reproduce. These elements are C, H2, O2, N2, K, P, S, Ca and Mg. Some other elements, called trace elements like Cu, Zn, Mn, Mo, B, etc., are needed only in small amounts. If these elements are missing or present in very low quantities, the fish will not grow well. Fish get these elements from the pond soil, the pond water and the food they eat. Some fish ponds lack elements that are necessary for fish growth and productivity. In these cases, it is necessary to add fertilizers to the water. The fertilizers are simple materials which contain the missing elements. The elements most often missing or in short supply in fish ponds are N2, P and K.

Fertilizers consisting these missing elements are added to the fish pond to help the growth of the fish and of the plankton, which the fish use as food.

A pond rich in phytoplankton is often bright green in colour. The colour indicates a bloom of algae. In a normal bloom, the secchi disc disappears at about 30 cm depth; when the secchi disc disappears at 20-40 cm depth, the pond is very productive and fertile. No fertilizer is needed in a pond under these conditions.

Sometimes a pond can become too fertile. If the secchi disc disappears at only 15 cm, the bloom is too thick. The thick layer of green blocks the sunlight in the pond and no oxygen can be released by the phytoplankton. In this case, there is too much fertilizer in the pond, and hence some of the thick layer of algae formed at the surface of the water should be removed. These ponds do not need any fertilizer.

If the secchi disc can still be seen at 43 cm depth, the plankton in the pond is not sufficient. It is, therefore, necessary to add fertilizer to the pond water in order to prepare a fertile pond. Another factor which determines the need for fertilizers is the quality of the soil. If the soil is highly productive, the need for fertilizers is less; if the soil is not so productive, the need for fertilizers is greater.

The choice of fertilizers can be decided on the basis of physical composition of soil. In sandy or sandy loamy soils with low organic matter, fertilization is carried out with organic manures. In loamy soils with medium organic matter, a combination of both organic and inorganic fertilizer should be applied. In highly clay soil with rich organic matter, fertilization is carried out with only inorganic fertilizers. Amount of fertilizers to be applied to ponds may be worked out on the basis of the productive potentiality of the pond. The ponds can be categorised on the basis of N, P, organic carbon and alkalinity (Table 5.1).

In case of deficiency of potash, it can be included at the rate of 25-50 kg/ha/yr. The NP ratio should be 2:1. In addition, cow dung may be applied at a rate of 10,000-15,000 kg/ha/yr. The best way to use this

Table 5.1. The compositionof organic manures

Manure	Nutrient contents		
	N	**P_2O_5**	**K_2O**
Cow dung	0.60	0.16	0.45
Pig dung	0.60	0.45	0.50
Sheep dung	0.95	0.34	1.00
Poultry dung	1.60	1.5-2.0	0.8-0.9
Farm yard manure	0.50	0.4-0.8	0.5-1.90

animal manure is to make a soup of it in a tank by mixing it with water. This soup should be spread in the pond. Fertilizer should be applied at a rate determined by the area of pond. Area is the length of the pond, multiplied by the width. For example, if a pond measures 20 m in length and 10 m in width, it has an area of 200 square metres (m2). This is equivalent to 2/100 of a hectare. To fertilize a 200 m2 fish pond with cow dung, at the rate of 1000 kg/ha, you must use only 20 kg.

Fertilization should be done 2 weeks prior to stocking the fish, so that, sufficient natural food is available in the pond. 1/5 of the total quantity of organic manure is required as an initial dose, and the rest is applied in 10 equal instalments. Organic and inorganic fertilizers may preferably be applied alternating with each other in fortnightly instalments. The amount of fertilizers required in general for fish ponds is 10,000 kg/ha/yr of cow dung, 250 kg/ha/yr of urea, 150 kg/ha/yr of single superphosphate and 40 kg/ha/yr of murate potash. In large ponds, fertilizers may be applied by using boats.

5.4.2 Stocking

Stocking is used to describe the act of placing the fish into the pond. The stocking density is used to describe the total number of fishes, which can be stocked in a pond. The stocking ponds are generally stocked with fingerlings which are about 75-100 mm in size. For increasing fish production, the selection of fish with desirable qualities is the most important biological factor. Since fish with the shortest food chain give the highest production, phytophagous, herbivores, omnivores and detritus feeders are preferred for culture in stocking ponds. For rearing of fish, either monoculture or polyculture in any species, combination may be carried out, most preferably the polyculture. The desirable stocking rate is 5,000 fishes per hectare. In a monoculture pond, the stocking rate is the same as the stocking density because there is only one kind of fish. There is enough food and room in a pond for a particular number of fish. Good growth of fish depends upon the right number of fish cultured in the pond.

The stocking rate depends on the volume of the water and on the oxygen balance of the pond rather than the size of the pond. The ratio of fish to the volume of water should not be less than 1 fish to 2 m3 of water where there is no forced aeration.

As far as possible each pond should be stocked with silver carp and catla, the surface feeders. This should not be more than 30 to 35%, otherwise it would affect their growth adversely. Rohu is a column feeder and it should not be stocked more than 15-20%. Bottom feeders such as mrigal and common carp together can be stocked to the extent of 45%. Availability of aquatic weeds in the pond decides the stocking density of grass carp. It should preferably be about 5-10%.

Rearing of fingerlings to table-size fish may continue for one year or only 6 months. In the latter case, the stocking density may be reduced. In this system, harvesting is done monthly and the number and species of harvested fish are replenished with a new stock of fingerlings. This is possible only where the supply of fingerlings is available throughout the year. Under these conditions the production is much higher than with the annual or 6 monthly stocking and harvesting.

In a polyculture of Chinese carp, the stocking density is about 20,000 fingerlings per hectare. The stocking rates are 5,000 grass carp, 5,000 bighead carp and 10,000 silver carp. If common carp is also included, then in a stocking density of 7 Chinese carps, 2 fish would be grass carp, 3 would be common carp, and there would be only one each of bighead and silver carp. In Malaysia, the ratio of carp stocking has been suggested at 2:1:1:3 for grass carp, bighead, silver carp and common carp.

If fishes are stocked in a pond, there should be enough oxygen, no temperature difference between the stocking water and the pond water. When the fingerlings are transported from a far away place, in order not to stress the fish, the bags with fingerlings are placed in the pond unopened until the water temperature inside the bags is about the same as the temperature in the pond. When it is same, the fingerlings are allowed to swim out of the container into the pond water by themselves. The fingerlings should not be poured into the pond water, as they die because of the shock of hitting the water.

5.4.3 Post-stocking management

5.4.3.1 Water quality Management

Water quality managment is discussed in detailed in 5.6

5.4.3.2 Feed Management

The feed management is discussed in detailed in chapter 6.

5.4.3.3 Health Management

The health managment is discussed in detailed in chapter 7

5.4.3.4 Hervesting

The fishes are harvested after a one year with the help of gill nets. Five to Six fisherman depending up on the size of the pond enter into the pond from one side, move to wards the other end with gill net and catch the fishes.

5.5 Aquatic weeds and their controle

Aquatic vegetation is described as aquatic weeds. Any undesirable vegetation which causes direct or indirect damage to the fishes or hamper the fishery operations may be described as weeds. In the tropical regions of the world, aquatic weeds grow luxuriantly causing nuisence to fisheries, water transportation and water supply systems, and provide conducive habitat for factors of several diseases. In India, ponds and tanks usually have fertile soil and water and so they invariably overgrow with all types of aquatic vegetation. For successful farm management, a strict watch on the growth of unwanted vegetation is necessary. With the presence of excess vegetation it becomes very difficult to net fishes in weed infested ponds.

5.5.1. Reasons for control of weeds

Uncontrolled vegetation growing excessively hinder fisheries interest in many ways. The weeds in the water reduce the yield of fish just as the weeds in the field reduce the yield of cultivated crop. It is necessary to control the weeds in fish ponds. Some of the reasons for this are quite obvious.

1. Due to the presence of aquatic weeds in the pond, the fishes cannot swim properly, thus restricting their ability to browse and hunt for food.
2. Weeds absorb nutrients for their growth and multiplication, thus absorbing nutrients essential for planktonic food of fishes which causes depletion offish food. Due to their presence, water loses its fertility to sustain fish stock.
3. Weeds offer shelter to unwanted predatory and weed fish, which hunt upon or compete with the cultivated varieties.
4. By profuse growth, weeds choke the entire water column, restrict netting and make navigation impossible.
5. The presence of weeds in water reduces the water holding capacity of the area and water loss due to evaporation through leaves occurs. In case of few weeds, the evaporation is much more than that from the open surface.
6. Weeds cause wide dirunal fluctuation in dissolved oxygen, temperature and other physico-chemical parameters to make the water inhospitable for fishes.

7. The weeds accelerate the process of siltation of the water area, ultimately turning it into a swamp.
8. Weeds harbour harmful insects, frogs, snakes and other predators enabling them to breed and multiply.
9. Weeds choke the gills of the tender young fishes.
10. The weeds interfere with the circulation and aeration of water, restrict the diffusion of sunlight and upset the normal chemical balance of the system.
11. The toxic gases in the pond bottom ooze produced by rotting organic matter cannot be easily eliminated into the atmosphere if the water surface is choked with weeds. In these conditions very few fish could survive in the water.
12. Aquatic weeds are responsible for minimising water depth and ultimately cutting down the soil-water interaction which is so essential for recycling of nutrients for the fishes.
13. Thick algal blooms deplete the oxygen in the water during dark hours or when they die or rot and cause sudden mortality of the fish stock.
14. Some kinds of algae cause allergic irritations on human skin and make it difficult for people to get into the pond.
15. The fish yield is reduced in weedy infested water bodies.
16. Weeds affect water irrigational potential.

5.5.2. Advantages of weeds

Weeds do not always have harmful effects. The weed mass can be turned to some productive use which will recoup 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 weed are advantageous and help in the development and maintenance of a balanced aquatic community. The advantages are:

1. Aquatic weeds produce oxygen during photosynthesis and this oxygen is utilized by the fishes.
2. Weeds provide shelters for small fishes.

3. Weeds provide shade for fishes.
4. Weeds provide additional space for attachment as well as food for aquatic invertebrates which in turn serve as food for fishes.
5. Weeds help in the precipitation of colloidal clays and other suspended matters.
6. Weeds, after removal, can be used as bio-fertilizers and even used in fish farms.
7. Aquatic weeds are used as food for fishes like grass carp.
8. Weeds are also used for pollution abatement.
9. Weeds are used as a source of energy production.

5.5.3. Weeds as food for fish

There are a number of herbivorous fishes which directly consume aquatic weeds. The grass carp is a fast growing fish that feeds on aquatic weeds. The fish utilize submerged weeds like *Hydrilla, Najas, Ceratophyllum, Ottelia, Nechamandra* and *Vallisnaria* in that order of preference. The young fish prefer smaller floating plants like *Wolffia. Lemna, Azolla* and *Spirodela.* In composite fish culture the production is greatly enhanced by inclusion of grass carp because of its fast growth. It also occupies an ecological niche, which otherwise remains unfilled with the fear that the grass carp may breed and compete with the native fish population in natural waters, only the triploid grass carp which is supported to sterile is being allowed to be introduced.

The other herbivorous fish which utilize aquatic weeds are *Pulchelluspulchellus, Oreochromis* and *Etroplus.* Though an omnivore, *Cyprinus carpio* feeds well on filamentous algae like *Pithophora* and *Cladophora.* The manatee, *Trichechus sp.,* a large air-breathing herbivore, is being utilized for the clearance of aquatic weeds in the canals of Guyana.

These advantages of water plants become negligible when they are present in excess and their control then, is essential. The methods to be adopted to control the aquatic vegetation can be formulated only after the plants are identified.

5.5.4. Factors contributing to profuse growth

A number of factors either individually or jointly influence favourable growth of weeds in cultivable waters. These are :

1. Climatic condition and geographical situation of the area.
2. Water depth - lesser the depth, more is the growth of vegetation especially the submerged rooted or emergent vegetation.
3. Clarity of water or turbidity - more suspended material adds more turbidity thus retarding penetration of light in the pond which has an effect on the growth of vegetation.
4. Silt deposition at the bottom, promotes excessive growth of aquatic weeds.
5. Quality of water - fertile condition of water has its impact on the propagation of vegetation.
6. Infestation from other sources - the minute generative vegetative components like spores and cysts may be carried through the water supply, wind, flood, birds, cattle, etc.

5.5.5 Types of aquatic weeds

The aquatic weeds (Fig. 5.5 and 5.6) are classified on the basis of habitat of plants - rooted weeds and floating weeds.

5.5.5.1 Rooted weeds

1. Bottom rooted weeds : Plants are rooted at the bottom of the water body and spread within the bottom layers of water. *Vallisneria, Ottelia*
2. Submerged rooted weeds : The plants are rooted in the bottom soil on the deeper margins of the pond and ramifying in the volume of water. e.g. *Hydrilla, Chara, Potamogeton*
3. Marginal rooted weeds : Plants are rooted on the marginal region of the surface layer of water and ramify on the surface of water and also on the adjoining land. e.g. *Marsilia, Ipomoea, Jussiaea*
4. Plants are marginally rooted and ramifying within the marginal region of the water volume. E.g. *Typha, Scirpus, Cyperus, Panium*

5. Emergent rooted weeds : Surface plants which are rooted in the bottom of the pond but their leaves float on the water surface or rise above the water level. They prefer shallow parts and shores of the pond. e.g. *Nymphea* (Lotus), *Nymphoides*, *Nelumbium*.

5.5.5.2 Floating weeds

1. Surface floating weeds : The plants are floating on the surface of water and with roots in the water. e.g. *Eichhornia* (water hyacinth), *Pistia*, *Lemma*, *Azolla*, *Spirodele*. Few surface plants, are floating on water but without roots e.g. *Wolffia*.
2. Submerged floating weeds : The plants are floating but submerged in the water e.g. *Ceratophyllum, Utricularia*.
3. We can also divide the aquatic weeds broadly as floating, emergent, submerged, marginal weeds and algal blooms and filamentous algae.

5.5.5.3. Methods of weed control

Based on the intensity of infestation and type of weeds, the aquatic weeds can be controlled by means of manual, chemical and biological methods.

a. Manual and mechanical method

When infestation is scanty and scattered, the weeds can be controlled manually only in small water bodies. This is an ancient method and is still practiced in most of the places. The pre-monsoon period (April-May) is more suitable for manual removal. In many parts of the country, advantage is taken of the drought to control the weeds as ponds and other water bodies dry up or register a sharp fall in the water area, and the plants can thus be removed. Where labour is cheap, manual labour is often employed to remove aquatic weeds. The weeds are controlled manually by hand picking, uprooting the emergent and marginal weeds and cutting the others with scythes.

Most of the floating plants like *Pistia*, *Lemna*, *Azolla*, *Wolfia* and *Eichhornia* can be effectively controlled by clearing manually with nets, whereas, the marginal weeds like grass, sedges, rushes, *Typha*, etc. may be controlled by repeated cutting. This method does not inflict any pollution and there remains no residual toxic effect as in the case of chemical treatment or shading. The weeds thus collected should be dumped far away, be converted into compost manure or burnt so as to have no chance of reinfestation.

Manual weed control is very expensive, time consuming and unsatisfactory. Therefore, mechanical devices have been developed. Cleaning of a weed infested water sheet through the mechanical method, becomes necessary where the water area is not shallow enough to walk through or small enough to uproot the weeds manually or cut them effectively with simple hand implements. Labour problem and an urgency of the work to eradicate the whole area of weeds within a stipulated time period before water level is raised, are the other factors which make it necessary to resort to mechanical methods for eradication of weeds.

A number of devices ranging from very simple barbed wire bottom rakers to sophisticated mechanical equipments like power winches with steel wire, under-water cutter, dredgers, mechanised removers, etc. are in vogue to use for the purpose. Broomfork, long fork, sickels or scythes, long knives, barbed wire netting, chaining and motor powered weed cutters are some of the specialised equipment used for this purpose.

Crusher boats are used to clear water bodies infested with water hyacinth. The rooted submerged weeds are dislodged mechanically by dragging with log weeders fitted with spikes and barbed wires. Mechanical winches are used for cutting and dragging of submerged weeds.

Another simple method of control of water hyacinth is to construct floating barriers which prevent water hyacinth from reaching other water bodies. The floating barriers reduce time, labour and cost as the accumulated weed is removed by draglines.

Laser rays are also used to control water hyacinth, usually of 10.6 nm wavelength. The irradiated plants are plasmolysed immediately.

Burning follows in proportion with the amount of laser energy applied. Many of the plants die within ten weeks. Daughter plants are stunted and turned pale due to destruction of chlorophyll.

b. Chemical control:

A large number of chemical weedicides are used for control of aquatic weeds. It is a very effective and cheap method. The weedicide is to be selected in such a way that it should be cheap and easily available, non-toxic to fish and man, should not pollute the water and should not involve the use of special and costly equipment. The lethal action of the weedicide is either by direct contact or by translocation of chemicals from the treated part of the plant to the other areas of its system resulting in both cases in the death of the plant.

Different type of chemicals are in use for eradication of weeds. Many of these are poisonous, toxic or harmful for human and other animals. Their mode of action on the weeds are also different. The same chemicals may not be useful for the eradication of different types of weeds.

Chemicals used for eradication of weeds are broadly classified under three categories.

1. Compounds of heavy metals. e.g. Copper sulphate, Sodium arsenate, etc.

2. Hormone weedicides e.g.2,4-D, 2,4,5-T, etc.

3. Fertilizers. e.g. Superphosphate, Urea, Ammonia, etc.

According to the mode of action, a weed killer chemical can also be grouped into two categories.

1. Contact weedicides – which kill plants on contact.
2. Translocated weedicides - which are absorbed by plants and are killed.

The contact weedicides may be selective or non-selective killer types. The selective killer type of chemicals are effective only on some specific weeds whereas the non-selective type chemicals kill all types of weeds. Besides weedicides, some chemicals are used as soil sterilants. It shows that all chemicals are not suitable for killing all types of weeds and all the chemicals may not have all the qualities required for commercial use. Some chemicals are extremely poisonous for animals and human beings. Some chemicals like fertilizers are required to be applied at a very high dose which is neither economical not easy to apply. Endothal, Endothal amine salt, 2,4-D are toxic to fish. Diquot is toxic to fish and not advocated to apply in muddy water.

c. Biological control:

Of all the weed controlling measures, biological control of weeds through stocking the water with weed-eating fish, such as grass carp, Ctenopharyngodon idella, is found to be an effective and satisfactory method. Grass carp is a voracious weed eater and possesses strong pharyngeal teeth, which enables it to grasp and nibble at soft weeds like Hydrilla. The nature of its gill rakers helps it to sieve large quantity of microvegetation from the water body. Because of its efficiency for weed consumption and convertibility into flesh it is preferred for stocking in weed infested waters.

Grass carp usually eat the soft parts of the aquatic plants leaving behind the harder parts like stem. It shows a certain preference for soft submerged weeds like *Hydrilla*, *Ceratophyllum*, *Najas*, *Vallisneria*. Its lower preference towards *Ipomea* is due to the hard nature of the weed. *Hydrilla verticellata* is the most preferred as it has soft leaves which could be easily nibbled and are easily digested.

Control of weeds, especially the soft submerged type of weeds, through biological control by stocking the water with grass carp has certain advantages. It is not only the most economical due to its low cost of operation and easy application but also does not contaminate the water with toxic substances unlike chemicals used for control. Moreover, it gives economical returns by increased fish production.

Common carp, *Cyprinus carpio* and Katti, *Acrossocheilus hexagonalepsis* and ducks are also used for biological control of aquatic weeds. Beatles and stemborers are also recommended for the purpose.

Biological control of weeds may be done by shading. Increasing turbidity, covering the surface by controllable floating weeds, shading the water area by canvas or coloured polythene sheets to cut down sunlight in order to check excessive growth and vegetation are some of the methods also in use.

Whichever method is used for the control of aquatic weeds, employment of manual labour is necessary. In the mechanical method labour is necessary for the clearance of the remains of the vegetative parts of the weeds. Even if the chemical method is resorted to, the dead weeds which sink to the bottom have to be removed. A rational utilization of all methods suitable according to the local condition and also economical is to be resorted to for eradication of weeds. However, checking of excessive weed growth at the proper time is also one of the effective and important factors to keep the weed under control. Control measures should be adopted before the flowering season of the weeds. The time for control of weeds given below has been found to be appropriate under Indian conditions.

January-February	-	*Eichhornia*, lotus
March-May	-	Duck weeds
June-July	-	*Utricularia, Ottelia*
July-August	-	*Jussiacea, Trapa, Nymphoides, Pistia, Nechamendra*
August-September	-	*Najas, Myriophyllum*
October-November	-	*Scrispus, Nymphaea*

5.6. Water Quality Management

Successful pond culture operations mainly depend on maintenance of a healthy aquatic environment and production of sufficient fish food organisms in ponds. Water is the primary requisite to support aquatic life. Physical, chemical and biological factors play an important role in governing the production of fish food organisms and fish production in the pond. Water not only plays an important role in the fish production, but also it helps in the survival and growth of the fish. Hence, fish farmers should take a lot of care to maintain hygienic conditions in the pond, so that they get more profits. If the water quality is maintained with utmost care, the farmers need not spend much money for curing the diseases. If the water quality is maintained, the fishes also have a good taste. Water quality is influenced by physical, chemical and biological factors.

5.6.1. Physical factors

The physical condition of water is greatly influenced with depth, temperature, turbidity, light and water colour.

5.6.1.1. Water depth

Pond depth has a vital bearing on the water quality. Depth determines the temperature, the circulation pattern of water and the extent of photosynthetic activity. In shallow ponds, sunlight penetration upto the pond bottom and facilitates an increase in the productivity. A depth of 1-2 metres is considered optimal for biological productivity of a pond. If the depth is very less, water gets overheated and thus has an adverse effect on the survival of the fish.

5.6.1.2. Water temperature

Temperature affects fish migration, reproduction and distribution. It depends on climate, sunlight and depth of the pond. Temperature varies vertically in the water body and also shows diurnal fluctuations. Fish posses well defined limits of temperature tolerance with the optimal being 20-32°C. Indian major carps can thrive well in the temperature range of 18-38°C. Wide fluctuations of water temperatures affect the survival of fish. In very low or very high temperatures, the fishes are strained, spend more energy and growth of the fish is affected. These temperatures also affect the chromatophores of prawns, and the prawns develop a red colour. If the temperature is maintained optimally, the red colour disappears. At low temperatures the food consumption offish and prawns decreases and gasses are produced at high temperatures. Hence, water temperature maintenance is very essential to obtain high yields. Fish and prawns or their seed have to be acclimatized whenever they are transferred from one pond to the other.

5.6.1.3. *Turbidity*

Water turbidity is mainly due to suspended inorganic substances like clay, silt, phyto - and zooplankton and sand grains. Ponds with a clay bottom are likely to have high turbidity. Turbidity reduces sunlight penetration and photosynthesis and hence acts as a limiting factor. If the turbidity is due to more suspended particles, they absorb nutrients in their ionic form, making them unavailable for plankton production. High turbidity also reduces the dissolved oxygen in the pond water. Turbidity is measured with the secchi disc. If the secchi disc disappears at 30-50 cm. the water is productive in nature. If it is not visible at a depth less than 25 cm, a dissolved oxygen problem could anse during the night. If it is more than 50 cm, the plankton produced is less in the pond water. In less turbid waters, the aquatic weeds growth is more. In highly turbid waters, the sand grains accumulate in the gills of the fish and prawns, causing suffocation and excessive secretion of mucous. High turbidity can be reduced by adding lime and alum. If the water is more turbid, it should be stored in sedimentation tanks and then used for fish culture. If the turbidity is more due to phytoplankton, water m the pond should be changed. Fertilizers have no effect in high turbid waters, hence fertilization of the pond should be stopped.

5.6.1.4. Light

Availability of light energy to a fish pond greatly influences its productivity and photosynthesis. In shallow ponds, light penetrates to the bottom and is responsible for luxuriant growth of aquatic weeds. In high turbid waters, the light will not penetrate to the bottom. Due to this, the vegetation at the bottom will decay and produce harmful gasses, which affect the fish and prawn life.

5.6.1.5. Water colour

Water gets its colour due to phytoplankton, zooplankton, sand particles, organic particles and metallic ions. Water used for fish or prawn culture should be clear, either colourless or light green or blue in colour. Water colour is golden or yellow brown if diatoms are more. This type of water is best for prawn culture. Brownish green, yellowish green and light green coloured waters are also good for prawn culture. Water becomes greenish in colour when phytoplankton is more, develops a brown colour due to zooplankton and mud colour due to more sand grains. Water with black, blackish green, dark brown, red, yellow colours are not good for culture. These colours are due to the presence of more phytoplankton, bad pond bottom and acids in the water. The red colour of water is due to the presence of high levels of iron and death of phytoplankton (phytoerythrin released).

5.6.2. Chemical factors

The chemical factors like pH, dissolved oxygen, alkalinity, hardness, phosphates and nitrates influence the productivity of the pond.

5.6.2.1 pH

pH is the hydrogen ion concentration, which ranges from 0-14. Water is slightly alkaline in condition, with the optimal range of 6.5-8. Less than 5 and more than 10 pH is lethal to fish and prawns. The pH of pond water undergoes a diurnal change, it is alkaline during the day time and slightly acidic just before day break. The fluctuations of pH are similar to dissolved oxygen. pH fluctuations are more in phytoplankton and weed infested waters and water with less hardness. No sudden pH fluctuations in brackish water and sea water occurs due to their buffering capacity. The difference in pH from morning to evening should not be more than 0.5. When pH increases, ammonia and nitrites become toxic, when it is reverse H_2S becomes more toxic. pH below 6.5 and above 8.5 is responsible for reduction of growth and resistance of parasitic infection increases in acidic waters. Whenever pH falls, lime should be added to the pond water. When pH is high, lime should not be used. Urea should not be used to reduce pH. This is because NH3 becomes toxic at high pH. It is always better to add new water to maintain an optimal pH. Alum or aluminum sulphate can be used to reduce the pH and turbidity. Alum removes phenolphthalin alkalinity. 1 ppm alum reduces 1 ppm phenolphtahlin alkalinity. Fish, prawns and their seed should be acclimatized to new water whenever they are transferred from one pond to another.

5.6.*2.2. Dissolved oxygen*

Dissolved oxygen is one of the most important chemical parameters, which has a great influence on the survival and growth of fishes and prawns. The pond water gets oxygen mainly through interaction of atmospheric air on the surface water of the pond and by photosynthesis. It is produced only during daytime, reaches a maximum at 3 PM, then gradually decreases upto early morning. During the night it decreases and it reaches a minimum during the early hours. It is due to nil production of dissolved oxygen at night and instead, consumption of oxygen by plankton, weeds, fishes and prawns. During overcast days, the production of dissolved oxygen during the day is less and during the subsequent nights it decreases drastically. When water temperature rises, oxygen is released into atmosphere. When salinity increases it is dissolved in water. The optimum dissolved oxygen is 5-8 ppm. If less than 5 ppm the growth rate decreases the fish and prawns are prone to get diseases and less than Ippm of dissolved oxygen results in death. More than 15 ppm results in gas bubble disease in fishes and prawns. Whenever the animals are under stress due to less dissolved oxygen the food consumption temporarily decreases. When oxygen decreases, prawns accumulate on the water surface and near the pond shores and are found stationary at one place or show weak movements. Fishes come to the surface and engulf the air. Prawns get milky white spots when dissolved oxygen is continuously less. It decreases gradually from the surface to the pond bottom and CO,, NH3 and other gases increases, hence prawns are under more stress. Farmers should take precautionary measures at nights, especially during the early hours to increase oxygen levels. If it is very less, the water surface should be disturbed by beating water with bamboo poles or by rumming boats or by using aerators.

5.6.2.3. Alkalinity

Alkalinity is caused by carbonates and bicarbonates or hydroxides of Ca, Mg, Na, K, NH4 and Fe. Alkalinity is less in acidic soils and in ponds with more organic load. Alkalinity is more in clay soil ponds and is increased if water is pot exchanged. The optimal level of total alkalinity is 40-150 ppm. Alkalinity has direct effect on the production of plankton. ‘

5.6.2.4. Hardness

Hardness is caused by Ca and Mg. Water with less than 40 ppm is soft and more than 40 ppm is hard water/ The pond water with a hardness of 15 ppm or more is satisfactory for growth of fishes and prawns and do not require additional lime. If water has less than 11 ppm hardness it requires liming for higher production. If it is less than 5 ppm, the growth rate is affected and causes eventual death of the fish.

5.6.2.5. *Salinity*

Na, C12, Ca, Mg, K, bicarbonates and sulphates are responsible for salinity of the water. Salinity is an important parameter for survival, growth and high production in brackishwater culture systems. Salinity ranges between 0-40 ppt in brackishxvater and 35 ppt in sea water. The optimal salinity for prawn culture is 15-20 ppt. The prawns can survive at 2 ppt and 40 ppt. but their growth rate decreases. If the salinity is high, the water should be exchanged. Due to heavy rains more freshwater enters into the ponds and sudden decrease is found in salinity levels which affect the life in the pond. To avoid this, two outlets (one at high level and other at low level) should be provided to send out freshwater and sea water separately from the pond. The animals should be acclimatised before introducing them into new water.

5.6.2.6. Carbondioxide

CO, is produced during respiration and consumed during photosynthesis. CO, is less during daytime and more at nights. The optimal level of CO, is 5 ppm. At high CO, levels, pH decreases, CO, is accumulated in the blood of the animals and water becomes acidic. The animals become sluggish, loss of resistance occurs, they cannot utilize dissolved oxygen and they ultimately die. Whenever CO, increases lime should be added to the pond. 1 ppm of lime reduces 0.9 ppm of CO,.

5.6.2.7. Dissolved ammonia and its compounds

NH3 is found in excreta and is also released due to decomposition of organic matter. It is an important compound influencing the growth of phytoplankton in the aquatic ecosystem. The optimal limit of NH3 is 0.3-1.3 ppm and less than 0.1 ppm is unproductive. Whenever NH3 increases pH also increases, but dissolved oxygen decreases. CO2 reduces the toxic effect of NH3. NH3 also increases with feed due to high protein levels and death of phytoplankton. When NH3 is more in water, animals may not get excreta with NH3. NH, accumulates in the blood and oxygen transport in the blood reduces. - Gills become black, biochemical tissue is damaged and gasous exchange is affected. NH3 levels can be reduced with good management like no excess feed, optimal stocking and water exchange. Lime should not be added when NH, is high. Optimal level of nitrites is 3.5 ppm.

5.6.2.8. Hydrogen sulphide

H2S is produced in anaerobic conditions by the action of-micro-organisms on sulphur compounds. H,S is toxic to fish and prawn. It should be less than 0.05 ppm in pond water. H2S is responsible for respiratory problems. When H,S increases, lime should be added.

5.6.3. Biological factors

The biological factors like plankton, weeds and disease causing agents also play a role in water quality maintenance.

5.6.3.1. Plankton-water quality

Plankton are free living smaller plants and animals, which move along with the waves. Plankton are natural fish food organisms, which consists of 60% easily digestible proteins. Phytoplankton produce food and O, by photosynthesis. Plankton density variations depend upon the fertilizers used and fish species cultured. Carbon, oxygen, H,, P, N,, S, Fe, K, Na, Mn, Mo, Zn, B and Cl, are essential for plankton production. Out of these, N, P, K, are most important elements for plankton production.

To increase plankton production, organic and inorganic fertilizers should be used. Lime is also essential for plankton production. Fertilizers and lime should be used at regular intervals. This helps in production of plankton in sufficient quantities. Excess production of plankton, especially myxophyceae members settle on the water surface and form algal blooms. This hampers photosynthesis and oxygen depletion is observed, esp£Cially during nights. CO, levels increase in the pond and affect water quality.

5.6.3.2. Disease causing agents — water quality

The most important aspect of water quality management in the culture system is to maintain fish without disease causing agents and under hygienic conditions. The diseases in fishes and prawns are caused by bacteria, virus, fungi, protozoa, helminth, and crustacean parasites. These parasites enter into the pond along with water, fish or prawn seed and nets from other infected ponds. Due to the unhygienic conditions these parasites cause diseases in fish and prawns, and the fish and prawns become less resistant to diseases. Due to the parasitic infection the growth rate reduces and finally they die. To avoid these bad effects, use good and healthy material and fish and prawns should be examined once in 15 days. Abnormal behaviour offish and prawns is observed in infected ponds. These should be observed and immediate action should be taken, otherwise, whole crop could be wasted / destroyed.

5.6.3.3. Aquatic weeds - water quality

Excess growth of aquatic weeds in fish pond is not a good sign in aquaculture systems. Weeds utilize the nutrients and compete with desirable organisms. Weeds also compete for oxygen, especially during nights and space with fishes. They obstruct the netting operations too. Hence, the weeds should be removed from ponds by mechanical, chemical or biological methods. Application of lime, fertilizers and feed are some of the important measures to maintain the water quality. These should be applied whenever required. Excess application leads to the poor condition of water quality.

5.6.4. Role of aerators in the water quality management

Atmospheric oxygen dissolves in the water at water surface. In this layer, dissolved oxygen increases quickly, but not at the pond bottom./To get oxygen even in the bottom layer, the pond water should be disturbed. To gedhis aerators are very essential. Aerators produce the air bubbles, which disturb the water in the pond, so that more oxygen dissolves in the water. Aerators, therefore play a vital role in aquaculture to increase fish and prawn production.

Different types of aerators are in operation to increase aeration in the ponds. Diffused, air lift pumps, U-tube and splashers are some of the common aerators (Fig 5.7) in operation in aquaculture.

In diffused type, the blower or compressor is arranged on the dyke, and this is connected to a porous tube, which is arranged on the pond bottom. Compressor produces air, which comes out of the porous tube in the form of air bubbles and disturbs the water to produce more dissolved oxygen. The capacity of the aerator depends upon the compressor energy and pond depth.

In air lift pump aerator, air is sent into a tube, which opens on surface of the water. Air bubbles travel through the tube and enhances the dissolved oxygen. This aerated water falls on water surface and increases dissolved oxygen water further.

In U-tube aerator, the U-tube has 12-18 metres depth. At one end. air is pumped with the help of blower and the air bubbles travel to the other end i.e., air bubbles have more contact time with water. These aerators are more efficient, but need more expenditure for construction.Splasher type of aerators are also known as surface aerators. Propeller of the aerator is arranged near the water surface and water is sprinkled which helps in enhancing the oxygen in the pond. Paddle wheel surface aerators are also used in fish ponds. Sprinklers are used in fish ponds where porous pipes are arranged on the water surface and pump the air is pumped with engines into the pipes. This gives good aeration in the pond and produces successful results (such as those obtained in Kolleru area).

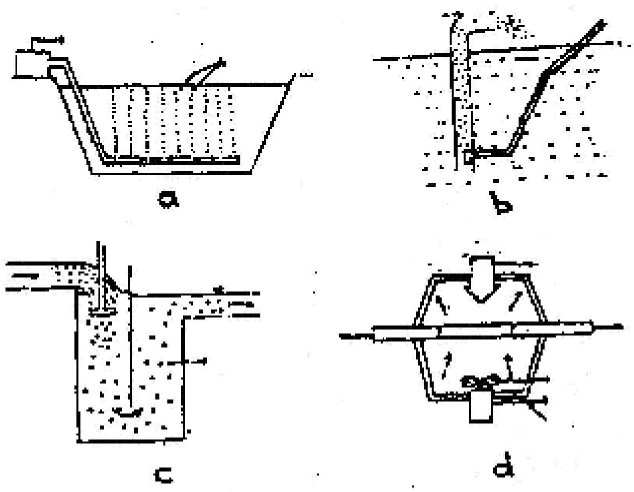


Fig. 5.7. Aerators

a) Diffused type b) Air lift type c) U-tube type d) Splasher type

5.6.5. Role of filters in the water quality management

Aquatic culture systems contain living organisms in water. These organisms require inputs, such as food and they excrete other materials. The inputs must be mixed with or dissolved in water to be available to the organisms, whose outputs will also become mixed with or dissolved in water. Excessive output and/or input can become toxic if the concentration is allowed to increase in the culture water. The process of removing excess materials is called filtration. It consists of passing the

water through a thick layer of sand and gravel which act as strainers. Suspended and colloidal matter in the water and also a large number of bacteria are caught in the interstices of the sand during its passage.
The mechanical, biological and airlift filters are generally adopted in aquaculture practices to manage and control the water quality for intensive rearing and culture.

5.6. 5.1- Mechanical filter

A mechanical filter (Fig 5.8 a) is an under drained water tight basin in which the filtering materials are placed. The size of a mechanical slow sand filter unit may be about 30 to 60 m x 15 to 30 m or more and about 2.5 m to 3.5 m deep according to desired flow. Water after passing through the filter is collected in an outlet chamber, which is equipped with a flow regulating arrangement. The filtering material about 90 cm to 150 cm of which about 60 cm to 90 cm is fine sand, is laid on top of the under drainage system in five or six layers in progressively smaller sizes towards the top.

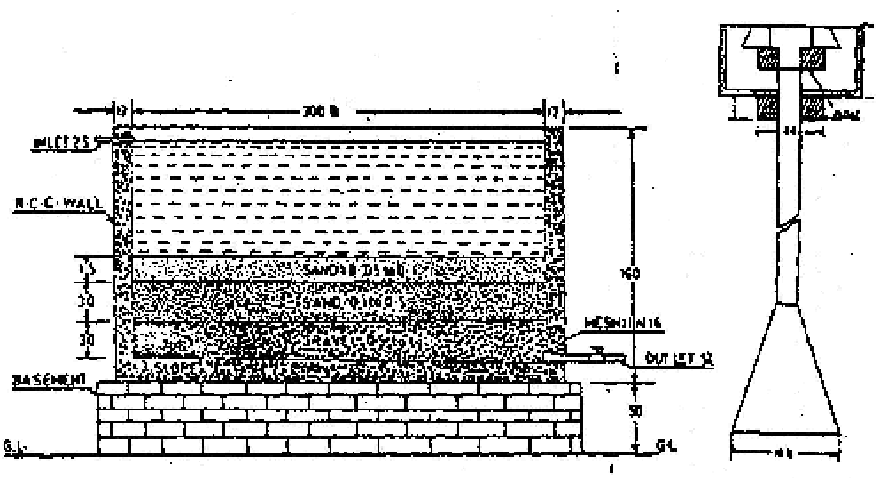


Fig. 5.8. Filters

a) Mechanical filter b) Airlift filter.

The sand is supported on two or three layers of graded gravel, with the finest layer immediately below the sand and the coarsest material at the bottom of the filter, packed around the drains. The gravel layers must be graded sufficient to prevent the material from mixing and the sand being drawn down.

The following thickness may be taken for the filtering materials from the bottom towards the top.

1. 10 cm to 15 cm of broken stone 40 mm to 65 mm size
2. 8 cm to 15 cm of gravel 20 mm to 40 mm size ,-
3. 5 cm to 10 cm of gravel 3 mm to 6 mm size
4. 15 cm of coarse sand and
5. 60 cm to 90 cm of fairly uniform fine sand.

When the resistance in the filter (due to sand and clogging) i.e., loss of head, is equal to the total depth of water on the filter, the operation will stop. The loss of head should not be greater than the depth of the filtering sand. When it becomes excessive and before a negative head is formed the filter should be cleaned. The level of the filtered water at the outlet chamber should not be below the level of the surface of the filter sand.

The rate of filtration is 120 litre per minute when the graded layers are 1' sand of 0.05 to 0.1 mm, 6" sand of 0.1 to 0.5 mm, 6" gravel 2 to 5 mm and 1' metal 5 to 10 mm at the total filtering surface area of 144 square feet.

5.6.5.2. Biological filter

It comprises the mineralisation of organic nitrogenous compounds, nitrification and dentrification by bacteria suspended in the water and attached to the gravel in the filter bed.

Heterotrophic and autotrophic bacteria are the major groups present in culture systems. Heterotrophic species utilize organic nitrogenous compounds excreted by the animals as energy sources and convert them into simple compounds, such as ammonia. The mineralisation of these organics is the first stage in biological filtration. It is accomplished in two steps; ammonification, which is the chemical breakdown of proteins and nucleic acids producing amino acids, and organic nitrogenous base and deamination in which a portion of organics and some of the products of ammonification are converted to inorganic compounds.

Once organics have been mineralised by heterotrophs, biological filtration shifts to the second stage which is nitrification, it is the biological oxidation of ammonia to nitrite and then to nitrate by autotrophic bacteria. Those organisms unlike heterotrophs require an inorganic substrate as energy source and utilise carbondioxide as their only source of carbon. *Nitrosomonas* and *Nitrobacter* sp. are the principal nitrifying bacteria in culture systems. *Nitrosomonas* oxidises ammonia to nitrite, *Nitrobacter* oxidises nitrite to nitrate.

The third and last stage in biological filtration is dentrification. This process is a biological reduction of nitrate to nitrite to either nitrous oxide or free nitrogen. Dentrification can apparently be carried out by both heterotrophic and autotrophic bacteria.

5.6.5.3. Air lift filter

It is the most trouble free means of filtering water through synthetic sponge layer by pumping the water with air lift (fig 5.8b). In culture applications, lift pipe extends below water level and the filter chamber rests above the top water surface. The suspended or colloidal impurities upto the size of 0.002 mm can be filtered out through this system. By pumping 5 cm3 air /sec/. 2 litres of water per minute can be filtered when the diameter of the lift pipe is 1 cm.

Summary

Fish culture is practised in ponds. These are small shallow bodies of water in natural conditions and completely drainable, usually constructed artificially. The natural ponds differ from the lakes in having a relatively large littoral zone and a small profundal zone. Their source of water may also vary.

Nursery ponds are also called transplantation ponds. These are seasonal ponds and are constructed near the spawning and rearing ponds. The main object is to create a suitable condition of food availability and growth of fry because at this stage they are most susceptible to hazards like the wave action and predators. These should be small and shallow ponds 0.02-0.06 ha. in size and 1-1.5 m. in depth. In the nurseries, the spawn (5-6 mm) are reared to fry stage (25-30 mm) for about 15 days. These ponds are usually rectangular in size. Extra care should taken for rearing the young stages, otherwise heavy mortality may occur. Sometimes the spawn are cultured for 30 days also. The pond bottom should gently slope towards the outlet to facilitate easy netting operations. Small and seasonal nurseries are preferred as they help in effective control of the environmental conditions. In practice about 10 million spawn per hectare are stocked in nursery ponds.

Rearing ponds should be slightly larger but not proportionally deep. These should be located near the nursery pond and their number may vary depending upon culture. They should preferably be 0.08-0.10 ha in size and 1.5-2.0 m in depth. The fry (25-30 mm) are reared here upto the fingerling (100-150 mm) stage for about 3-4 months. Carp fry grown in nursery ponds are relatively small in size and not fit enough for their direct transfer into stocking ponds. In stocking ponds bigger fishes are likely to be present which may prey upon the fry. Hence, it is desirable to grow the fry in rearing ponds under proper management practices upto fingerling size so that their ability to resist predation will be improved.

Stocking ponds are the largest ponds and are more deep, with a depth of about 2-2.5 m. The size of the pond may vary from 0.2-2.0 ha., but these should preferably be 0.4-0.5 ha in size. These are rectangular in shape. The fingerlings and advance fingerlings are reared upto marketable size for about 6 months. One year old fishes may grow upto 1 kg. or more in weight.

The pond management consists of pre-stocking, stocking and post stocking management phases.

Pre-stocking pond management involves site selection, eradication of weeds, insects and predators, liming, manuring, etc.

Post-stocking pond management involves water quality management, feed and health management and harvesting.

Based on the intensity of infestation and type of weeds, the aquatic weeds can be controlled by means of manual, chemical and biological methods.

Questions

1. Discribe the nursery pond management.

2. Discribe the stocking pond management.

3. Discuss the types and controlling mesures of aquatic weeds.

4. Discuss the water quality managment.

5. Write the following
   a. Aerators
   b. Filters
   c. Liming
   d. Manuring

6. FEED MANAGEMENT

One of the most important features offish culture is that the fish should have good food. Feeding and fertilization together make the pond culture successful. The growth offish in the ponds is directly related to the amount of food available in the pond. The pond must provide all the food and nutrients that the fish need. But all fishes do not need the same kind of food, for different species feed on different types of food, fish also feed on different foods depending on the stage of their life cycle.

Newly hatched hatchlings absorb feed from their yolk sac until the yolk in the yolk sacs is exhausted. The fry eat the smallest phytoplankton in the pond. Adult fish feed on a particular kind of food that fish enjoy plankton, aquatic weeds, worms, insect larvae, etc.

As the aquaculture technology evolved, there has been a trend towards high yields and faster growth of fish. It is necessary to enhance the food supply by fertilization, supplementing the food with artificial feed or providing all the nutrients to the fish in a cultivating field. As the fish becomes less dependent on natural food organisms and more dependent on artificial food, the need for nutritional artificial feed becomes necessary.

With the advancement offish culture technology, the extensive carp farming method has gradually shifted towards intensive culture method. The fish originally lived solely on the natural products of the pond for growth, reproduction and health. In the farming habitat, feeding of stocked population with nutritionally balanced and quality test diet is of critical importance to ensure optimal biological and physiological processes as well as production. However, test diets are either dried, semi-dried, moist, encapsulated or particulate diets. Dried diets includes the diets of pure plant origin, animal tissue meal, compounded or formulated meals.

Compounded diets should contain adequate level of nutrients to meet the physiological requirements of the organisms such as energy, body building, repair or maintaining cells, tissues and regulating body processes. According to Halver (1976), any nutritionally balanced compounded diet must include an energy source with sufficient essential amino acids, essential fatty acids and non-energy nutrients to maintain and promote growth. Any imbalance in these nutrients may show sparing action that would affect the efficacy of conversion of food by the organisms. The specific nutritional requirements offish vary greatly with species, size, physiological condition, temperature, stress, nutrient balance of the diet and environmental factors. Therefore, programming of nutrient constituents must be done in order to have most economic compounded ration for fish.

The knowledge relating to basic nutritional requirements of fishes stems from man's endeavers to raise fishes for food and for stocking in lakes and rivers. In intensive fish culture practices the objective is to maintain optimum density of fish per unit area of water by adopting techniques relating to polyculture, multiple stocking, stock manipulation etc. Under such conditions of fish culture, the natural protein component of food organisms present in the environment will not meet the needs of the growing fish biomass, thereby necesciating supplementation with protein rich feeds. Since there is heavy competition of protein foods mainly for human consumption the idea of feeding such type of foods to all cultivated species. Of fishes does not sound very economic. There are certain foods which are not consumed by the human beings such as plant proteins, condemned grains straw, hay, scrap or human food, by products and wastes from industries, single cell proteins etc. To achieve progressive development of the fish farming industry such substances could be utilized for the preparation of artificial fish feeds after conducting proper experiments.

The development of artificial feeds mainly depend on the studies relating to basic nutrition and physiology. For economic reasons such investigations should aim to find out the minimum level of protein which satisfies the amino acid requirements of the species for optimum inherent capacity for growth, adequate supplementation by carbohydrates to serve as dietary calories and luxurious supply of vitamins and minerals for necessary stimulation of protein digestion.

Information regarding the nutritional requirements of warm water fishes is not available excepting the channel cat fish for which complete ration has been formulated and dietic requirements have been studied. However, the importance of giving protein rich diets to carps has been realized in view of the high yields obtained. It has been established that the natural food plays only and insignificant role. Results obtained by feeding carps in running and confined water practices, in cages and floats have revealed that carp can grow well even without natural food by feeding with different types of supplementary feeds.

6.1. Natural fish food organism

A variety of natural fish food organisms are found in a waterbody, which depend on the nutritive nature of the waterbody. The natural food provides the constituents of a complete and balanced diet. The demand of natural food varies from species to species and age group of individuals. For example catla prefers zooplankton and silver carp prefers phytoplankton. At a younger stage; the fish may feed on plankton, and the same fish may prefer animal food as an adult Fishes feed on different natural food organisms at all the different trophic levels. Natural feeds have high protein and fat contents, which promote the growth of the fish. Hence, it is necessary to increase the live food in the aquatic ecosystem to improve the growth of the fish.

6.1.1. Classification of food and feeding habits of fishes

Different authors have classified natural food and feeding habits of the fishes (Schaprclas, 1933).

1. Main food : It is the most preferred food on which the fish will thrive best
2. Occasional food : It has relatively high nutritive values and is liked and consumed by fish whenever the opportunity presents itself.
3. Eniergency food: It is fed upon/ accepted when other food material is not available.

Nikolsky (1963) recognised 4 main categories of food on the basis of their importance in the diets of fishes.

Basic food: It is normally eaten by the fish and comprises most of the gut contents.

1. Secondary food : It is frequently consumed in smaller quantities.
2.. Incidental food : It is consumed rarely.
3. Obligatory food : The fish consumes this food in the absence of basic food.

Based on the nature of food, Das and Moitra (1963) classified the fishes into 3 primary groups. x

1. Herbivorous fishes : They feed on plant material, which forms more than 75% of gut contents.
2. Omnivorous fishes : They consume both plant and animal food.
3. Carnivorous fishes : They feed on animal food, which comprises of more than 80% of the diet.

Herbivores are divided into 2 sub-groups.

a. Planktophagous fishes : They consume only phyto- and zooplankton
b. Detritophagous fishes : They feed on detritus.
Omnivores can also be grouped into 2 categories.

a. Herbi-omnivores : Fishes feed more on plant material than animal food, b. Cami-omnivores : Fishes feed more on animal food than plant material.

Carnivores are also classified into insectivores (feed on insects), carcinophagous (feed on crustaceans), malacophagous (feed on molluscans), piscivorous (feed on other fishes), and larvivorous (feed on larvae). Some fishes are cannibalistic.

The fishes consume a variety of food material, such as phytoplankton, zooplankton, aquatic weeds, animals like annelids, arthropods, molluscs, other fishes and amphibians.

6.1.2. Plankton

Fish production in a waterbody is directly or indirectly dependant on the abundance of plankton. The physico-chemical properties of water determines the quality and quantity of plankton. Thus, during the study of plankton, a link in the food chain is a pre-requisite to understand the capacity of the waterbody to support the fisheries and the need for introduction of additional selected species of commercially important fishes. Other two categories of life in an ecosystem are benthos and neckton. Benthos is the term given to life at the bottom, like aquatic earthworms, insect larvae and certain fishes. Neckton includes the larger swimming animals like fishes. Plankton is most essential for many fishes as food. The growth of plankton feeding fishes mostly depends on plankton dynamics of the waterbody. The plankton is further divided into two main categories - phytoplankton and zooplankton.

6.1.2.1. Phytoplankton :

Fishes consume the phytoplankton, which is found abundantly in well managed ponds. Phytoplankton gives green colour to the water due to the presence of chlorophyll. Phytoplankton are generally made up of mostly unicellular algae which are either solitary or colonial. Phytoplankton are autotrophs, i.e., they fix solar energy by photosynthesis using CO2, nutrients and water. Phytoplankton occupy the base of the food chain and produce the food material on which other organisms in the ecosystem sustain themselves. The phytoplankton drift about at the mercy of the wind and water movements. Algae consist of three major classes which form the main food in phytoplankton (Fig. 6.1) . These are chlorophyceae, cyanophyceae and bacillariophyceae.

a. Chlorophyceae:

These are called green algae due to the presence of chlorophyll. Many chlorophyceae members are useful as food to fishes. These organisms are distributed all over the pond. The chlorophyceae members useful as fish food are *Chlamydomonas. Volvox*, *Eudorina*, *Pandorina*, *Chlorella*. filamentous algae like *Ulothrix*, *Oedogonium*, *Spirogyra*, *Pediastrum*, *Microspora*, *Cladophora*, *Clostredium*, *Scenedesmus*, *Cosmarium*. etc.

b. Cyanophyceae: These are also called as myxophyceae and are commonly known as blue green algae. This colour is due to the varying proportions of chlorophyll a. carotenoids and biliproteins. The product of photosynthesis is cyanophycean starch, present in granular form. The cell wall lacks cellulose and instead comprises mainly of aminoacids and amino sugars. Many cyanophycean members are consumed by fishes. These are *Nostoc, Oscillotoria, Anabaena, Microcystis, Spirulma. Merismopedia, Arthrospira,* etc. *1.2.1.3. Bacillariophyceae* .-These are called diatoms. They are unicellular organisms with different shapes and sizes. These may be yellow or golden brown or olive green in colour. Golden brawn diatomin pigment is present in diatoms. The reserve food materials are fat or volutin. The diatoms consumed by fish are *Diatoma. Navicula. Cocconies, Synedra, Tabellaria, Meridian, Fragilaria, Nitzschia, Pleurosigma, Amphifileura, Rhizosolenia, Cyclotella, Amphora, Melosira, Aclwanthes,* etc.

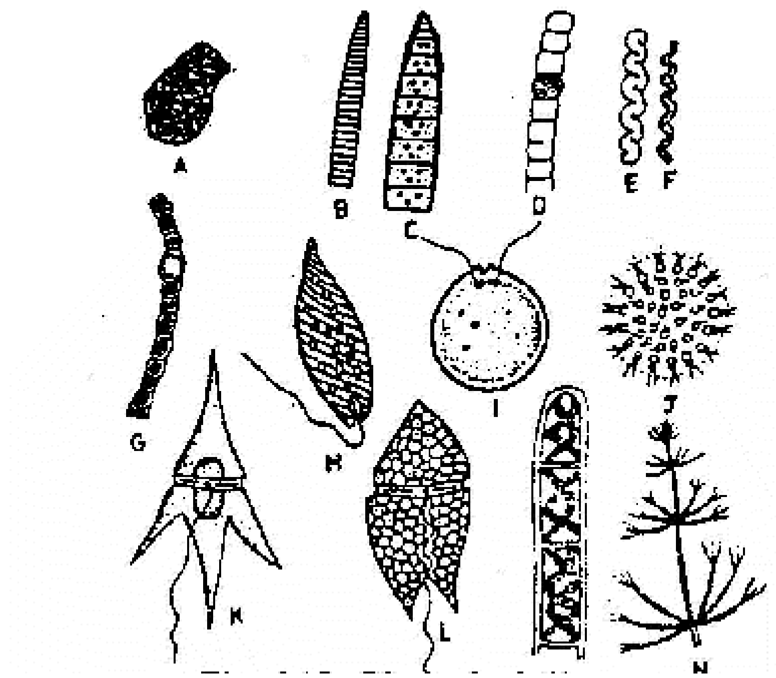


Fig. 6.1. Phytoplankton

a)Microcystisb&c) Oscillator,!, d) *Anabaena*e & f) *Spirulna b) Nostoc* h) *Euglena* i) *Chlomydomonas* j) Volvox k) *Spirogyra* 1) *Nitella.*

6.1.2.2 Zooplankton :

Plankton consisting of animals is called zooplankton. .Zooplankton is abundant in the shallow areas of a waterbody. The zooplankton unlike phytoplankton are particularly distributed horizontally and vertically in an ecosystem. They also undergo diurnal vertical migrations. The zooplankton forms an important group as it occupies an intermediate position in the food web, many of them feeding on algae and bacteria and in turn being fed upon by fishes. They also indicate the trophic status of a waterbody. Their abundance increases in eutrophic waters. They are also sensitive to pollution and many species are recognised as indicators of pollution. Among zooplankton, some of the organisms occasionally occur in appreciable numbers forming swarms. These swarms occur in freshwater ponds forming bands or streaks, or are arranged into areas of thick and thin concentration. Simulating cloud effect, they may give the water a strikingly different colour in the region of the swarm. The most common organisms in zooplankton are protozoans, crustaceans and rotifiers (Fig. 6.2).

a. Protozoa:

Protozoans are most primitive, unicellular and microscopic animals. These organisms are provided with locomotory organellae like pseudopodia, flagella and cilia. These organisms are found abundantly in fish ponds and are useful as natural fish food. Generally protozoans dominate in the zooplankton communities. Protozoans in general, are solitary single celled organisms. In some dinoflagellates and ciliates the daughter individuals do not separate and together form pseudo-colonies during repeated fission. These colonies are called catenoid colonies. The protozoans belonging to the classes sarcodina, flagellata and ciliata are useful as food items to fishes.

The protozoans with pseudopodia are included in the class sacrodina or rhizopoda. *Amoeba* and *Actinophrys* are common sarcodines found in fish ponds and are also used as food by fishes and prawns occationally.

The protozoans with flagella are included under the class flagellata or mastigophora. *Euglena* is the most common fish food organism found in fish and prawn ponds. *E. viridis*, *E. spirogyra* and *E. minuta* are some important species used as fish food. *Ceratium*, *Chilomonas* and *Phacus* are also used as fish food.

The protozoans with cilia are included in the class Ciliata. Here the cilia persist throughout life. The ciliates like *Paramecium, Vorticella. Coleps*, *Colpoda. Metropus*, *Euplotes. Oxytricha*, etc. are fish food organisms. The ciliates are the dominating organisms among the zooplankton.

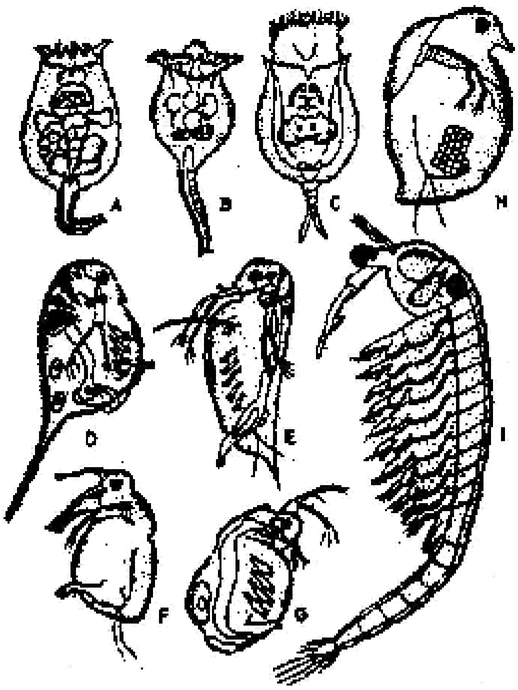


Fig. 6.2 Fish food organisms

a) Brachionus plicatilis 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) *Artemia salina.*

b. Crustacea : The aquatic animals with 19 pairs of appendages and branchial respiration are included in the class Crustacea. The crustaceans vary form microscopic to large animals. Crustaceans form a major component of zooplankton. In zooplankton, the microcrustaceans are useful as food to fish and prawns. The important microcrustaceans are copepodes and cladocerans. The crustacean nauplii also constitute good food material for many fishes and prawns. For example, nauplei *ofArtemia* are used in prawn hatcheries.

a) Copepoda : These are animals with 5 pairs of thoracic appendages, abdomen without appendages, forked telson, two pairs of antennae and body with head, thorax, and abdomen. The copepodes inhabit many of the freshwater habitats such as lakes, reservoirs, ponds, etc. Many of the copepodes are pelagic and so are abundant in the plankton of both limnetic as well as littoral regions of the water. Only the harpacticoids are mostly benthic or bottom living. The size of the body of the copepods is 0.3 to 3.5 mm. Copepods such as *Cyclops, Mesocyclops, Diaptomus, Canthocamptus,* etc. are useful as fish food organisms.

b) Cladocera": The animals which are bivalved, shield shaped with or without shell, flattened trunk appendages and leaf-like caudal styles which may be unjointed or jointed are included in cladocera. The greatest abundance of cladocerans is found near the vegetation in lakes, ponds, etc. The size of these shelled crustaceans varies from 0.2 to 3.0 mm. The cladocerans like *Daphnia, Ceriodaphnia, Moina, Sinocephalus, Scapholebris, Sida, Eurycents, Chydorus, Daphniosoma, Polyphemus, Macroihrix. Leydigia, etc.* are useful as fish food organisms.

c) Ostracoda : The animals with bivalved carapace, which encloses the entire body, 4-6 trunk appendages and reduced trunk are included in ostracoda. These forms are well represented in both the standing and running waters. These are exclusively planktonic forms. Occasionally the ostracods like *Cypris, Stenocypris,* etc.. are consumed by fish.

c. *Rotifera :* Rotifers are readily identifiable from other planktonic materials by the presence of their anterior ciliated wheel-like structure called corona and hence they are called wheel animalcules. Rotifers live in a variety of aquatic habitats. They are microscopic, ranging from 40 microns to 2.5 mm in size. Usually rotifers like, *Keratella, Phlodina, Rotaria. Hexanhra, Filinia, Brachionus Epiphanes*, etc., are useful as food organisms. Rotifers offer several advantages as fish feed organisms. They are

1. They reproduce quickly, it is estimated that a population under favourable conditions can double every one to five days. Under intensive laboratory conditions, they have recently been reported to have a doubling rate of less than 9 hours.
2. Rotifers are small and therefore are accepted as food by some organisms that cannot ingest larger zooplankton: thus they are an important first food for many fishes and prawns.
3. They are nutritious and their actual nutritional value can be improved, as can be done for other zooplankton, by packing the rotifers with specific strains of algae or other feed.

6.1.3. Aquatic weeds

Though the aquatic weeds form undesirable vegetation, which cause damage to the fisheries, these are helpful as food for a few fishes. Many herbivorous fishes consume aquatic weeds. The grass carp is a fast growing fish that feeds on aquatic weeds. This fish utilizes submerged weeds like *Hydrilla. Najas, Ceratophyllum, Ottelia, Nechamandra. Vallisneria* in that order of preference. The young fish prefer smaller floating plants like *Wolffla, Lemna, Azolla* and *Spirodela*, the other herbivorous fish utilize aquatic weeds are *Pulchellus pulchellus, Tilapia* and *Etroplus.* Though an omnivore, common carp feeds well on filamentous algae like *Pithophora* and *Cladophora. Trichechus* sp., a large air-breathing herbivore, is being utilized for clearance of aquatic weeds in the canals of Guyana. The detailed account of aquatic weeds is given in chapter 5.

6.1.4. Annelids

Animals with metameric segmentation, eucoel, nephridia and setae are included in the phylum annelida. The animals which belong to classes polychaeta and oligochaeta are useful as fish food organisms. These are found at the bottom of the waterbody and are generally consumed by bottom-dwelling fish, common carp, catfishes, murrels, etc. *Tubiflex, Glycera* and earthworms are the common fish food oligochaetes.

6.1.5. *Insecta*

Animals with 3 pairs of legs, 2pairs of wings, jointed appendages and a chitinous body wall are included in class insecta. Insects and their larvae form the main food item of many fishes. Aquatic insects are often preyed upon by fish like trout, catfishes, murrels, etc. Hemiptera, diptera, coleoptera, ephemeroptera and plecoptera insects dominate as fish food among the insects. Belostomatidae and notonectidae and nymphs of odonata are good fish food organisms. Larvae of mayflies, dragonflies, chironomid larvae, chaoborus larvae and mosquito larvae are also found commonly in fish diets. When mayflies constitute the diet of trouts, it has been observed that the trout are fatter and better flavoured.

6.1.6. Mollusca

The animals with a soft body, shell and foot are included in the phylum mollusca. The molluscans are found at the bottom of waterbody. Hence, only bottom-dwelling fish consume them. The gastropodes are found in the diets of carnivorous and omnivorous fishes.

6.1.7. *Amphibia*

Amphibians are tetrapodes, terrestrial as well as aquatic. The fishes consume only anuran larvae, the tadpoles among amphibians. The consumption of tadpole larvae is not frequently found.

6.1.8. Fishes

Carnivorous (piscivorous) fishes feed on a variety of other adult fishes, fish eggs. fry and fingerlings. Fishes like murrels, freshwater shark, seenghala, etc. feed on other fishes. The small fishes like

Salmostoma, Amblypharyngodon, Puntius, Labeo. Chanda. Nuria, Lebistis, Gambusia. Esomus, etc. are consumed as food by larger fishes. Some fishes are cannibalistic in nature.

Fishes also feed on decapods (prawns). The carnivorous and omnivorous fishes feed on small prawns. For example, *Macrobrachium kitsuensis* is found in the gut of many fishes. *Acetus* prawn suspension is given as food to the larvae and post-larvae of prawns in the hatcheries.

The bryozoans or ectoprocta are also found in the gut of fishes. They enter accidentally into the mouth of fishes. Generally bryozoans inhabit the aquatic weeds, stones and pebbles. When aquatic weed are taken as food by fish, along with the weeds the bryozoans enter into the mouth of the fish. Adult bryozoans and statoblasts *ofBugula* and *Hyalinella* are found in fish gut. Natural food of different stages of carps like fry, fingerlings, yearlings and adults are discussed in the later part of this chapter.

6.2 Significance of Plankton inAquaculture

In temperate countries, because of low-temperature regime, in the place of fertiliser-based fish culture, feed-based intensive fish culture is followed, despite (he heavy expense involved. In the waters of the tropics, *a* food pyramid exists with bacterioplankton at the base and fish at the top. Plankton provides about 50% of total food required for the fish which can be broadly classified as live food and formulated feed. Live organ-ferns, essentially microorganisms, those drift or are visibly mobile, are referred to as plankton or live fish food organisms in a pond ecosystem. Due to their balanced nutritional content, plank-ters are referred to as ‘*living capsules of nutrition.* These fish food organisms are broadly catagorised as phytoplankton land zooplankton. The former is com-ijwsed of bacteria and single and multi-• cellular algae. The members of the later ‘. belong to phyla protozoa and metazoa. iSome phytoplankton of interest that iierve as fish food are those of chlorophyceae, cynophyceae, bacillariophyceae, euglenineae and di-noflagellates, and those amongst the zooplankton are protozoans, crustaceans and other aquatic larvae. Plankton, in *a* pond system, is distributed non-un’rformly and horizontally as well as vertically. Though basically these are surface dwellers, thi.ir daily shrinkage losses are fairly hicjh. Many forms of zooplankters such t.s rotifers, cladocer-ans and copepods, for example, exhibit diurnal vertical migration in response to variation in light intensity.

Thus, plankton can be regarded as a heterogenous group of saline and freshwater organisms, essentially microorganisms, showing no or only vertical movement, drifting helplessly with ;| the water current, i hey are microscopic |; to submicroscopic in size, classified as I euplankton (or hnloplankton; plankton -”: throughout life cycic), pseudoplankton and meroplanklon ipi.iriklon lor a poriod of their life cycles). Some plankton terminology swch as, nekton, neuston, pleuston, etc. baffle a general reader at times. Therefore, these have been elaborated lucidly in the course of the presentation.

This contribution encompasses various aspects of several freshwater fish-food organisms but with the deliberate omission of *Artemia* as it cannot be regarded as a strictly freshwater species. However, as *Tubifex* is a conventional aquarium fish-food, some aspects about its culture are touched upon.

Some facts about plankton biology:

1) Transparency optima with reference to plankton in an aquaculture pond are : a) 35-40 cm for 1.2 m deep pond, and b) 25-35 cm for 0.8-1.0 m deep pond;
2) Cat/a adults feed preferably on zooplankton as also almost all fry;
3) Rohu, common carp, silver carp and grass carp feed preferably on phytoplankton;
4) Rohu shows preference to chlorophyceae, as also the crustacean zooplankters;
5) Mrigal feeds on bottom dwellers including plankton, benthos and detritus (neuston);
6) Shrimp feeds upon both zoo- and phytoplankton;
7) Phytoplankton supercedes zooplankton in riverine water as also in a productive pond at a ratio of upto 10:1;

8) Rotifers prefer Cy-anophyceae;
9) Cyanophycean members have a greater adaptability to different environmental parameters, and hence are found in abundance in any water body followed by Chlorophyceae;
10) Some malodour-forming and toxic Cyanophycean members are generally unpreferred diet of certain zooplankters and fish;
11) Some other Cyanophyceans *viz., Spirulina, Arthrospira,* form the most desired food for all the zooplankters, shrimps and carps;
12) Dominant phytoplankters in a pond system are Chlorophyceae and Cyanophyceae;
13) Similarly, dominant /oopl.mktors are rotifers, copepods and nauplii;
14) *Ichthyo-eutrophication:* A phenomenon marked by the dominance of phytoplankton in a fish pond system due to overgrazing of zooplankton particularly by catla and other such zooplanktivores as bighead carp *(Aristichthys nobilis)* and Thai magur *(Clarias gariepinus);*
15) *Cyclomorphosis'.* A phenomenon where the same organism exhibits a number of morphological characteristics as the seasons change. For example, *Daph-nia,* in summer, exhibits a sharp-pointing head and in winter, a round one;
16) In temperate regions, phytoplankton usually grows in a series of flushes or blooms, the first in spring by the increase in sunlight, and in autumn growth is terminated. In tropical regions, growth is nearly uninterrupted subject to continuous availability of nutrients;
17) There may be a seasonal abundance of forms. In summer blue-green algae usually predominate while diatoms are the most abundant in winter;
18) Case study shows that Cyanophycean members dominate from April to November, Chlorophyceans in December and January, Dinophyceans in February, and Euglinineae in March;
19) Plankton blooms may lead to oxygen depletion;
20) Plankton death (senility) leads to ammonia accumulation; and
21) A popular practice to control bloom formation is to add copper sulphate (CuSo4) and citric acid in the ratio of 1:2, and then apply the mixture at 1-2 ppm (10-20 kg/ ha-m depth).

6.2.1 Classification:

Though there are many classifications of plankton made by several taxonomists, one of them is as au-totrophs (phytoplankton; chemo- and photo-) and heterotrophs (zooplankton; herbivores, “carnivores, detritivores, om-nivores) and as bacteria, a specialised group, that includes both auto- as well as heterotrophs.

According to another widely accepted classification, the three groups are, bacteria, phytoplankton (macroplankton: >3 mm; nannoplank-ton: <0.03 mm; picoplankton: <0.003 mm) and zooplankton (macro: visible to the naked eye, e.g., *Anemia'*, micro: seen under a microscope; nanno: sub-microscopic; ultraceston: 0.0005-0.05 mm; picoplankton: <0.0005 mm). The last two types of the former and the last three types of the later are commonly collected by centrifugation technique because of their minute size.

Primarily, classification of various types is based on one or the other consideration. Algae, for example, are divided into different divisions on the basis of pigment composition, maintenance of energy reserve, cell wall composition, locomotory organs and their general structures. These contain two main groups of pigments, chlorophylls and carotenoids. The cell wall of algae is composed of cellulose and polysachharides, silica, proteins and lip-ids in various proportions, which also serve as the basis for taxonomic classification.

Thus, the three main groups of plankton are bacterioplankton (a special submicroscopic bacterial-algal group representing mainly the bacteria, nannoplankton and some filamentous algae), phytoplankton (plankton with photosynthetic pigment, of plant origin), and zooplankton (plankton without photosynthetic pigment, of animal origin).

Some of the divisions of phytoplankton (algae) are: euglenophyta *(Colacium, Euglena* and *Phacus)*, chlorophyta - presence of chlorophyll a and b, cellulosic cell wall, may be unicellular or multicellular (e.g., unicellular: *Chlamydomonas'*, colonised: *Volvox, Pandorina;* filamentous: *Spirogyra, Ulothrix'*, thalloid: *Ulva, Monostroma)*, Chrysophyta (Xanthophyceae - yellow-green algae, chrysophyceae:

golden or yellow-brown algae and bacillariophyceae (diatoms) - presence of chlorophyll a and c, xanthophylls pigments, pectin and silica-rich cell wall, cell is covered with a frustule (two overlapping valves connective bands to laterally form a band)), phaeophyta (brown algae); pynrophyta (desmocontae and dinophyceae), rhodophyceae (red algae) and cyanophyceae (myxophyceae or BGA; *Anabaena, Nostoc* and *Spirulina).*

Some of the divisions of zooplankton are: protozoa - not a food of choice, indirectly involved in the basic fish-food cycle, unicellular or ncellulnr animals of minute size, usually microscopic, fln-gella and/ or cilia may be present as feeble locomotory organs (e.g., *Vorti-ce/la, Actinophrys, Arcella, Diffusia),* rotifera (wheel animalcules) *(Brachionus, Keratella, Asplanchna, Polyarthra, Fillinia),* cladocera - (minute crustaceans of 0.2-0.3 mm) (e.g., *Ceriodaphnia, Daphnia, Moina, Simocephalus, Bosmina, Diaphanosoma),* Ostracods - small, bi-valved crustaceans (e.g., *Cypris, Stenocypris),* Copepoda - longest division of Crustacea, body separated into head, thorax and abdomen (e.g., *Mesocyclops, Microcyclops, Heliodiaptomus).*

Again, based on occurrence, plankton are classified as limnoplankton (occurring in lake), rheoplankton (in running water), haleoplankton (in pond), halioplankton (in salt water), hypalmyroplankton (in brackishwater), and so on. Similarly, based on hydrogrnphical distribution, plnnklon i<; classified as hypopl.'inklon (bottom dwellers), epiplankton (euphotic-zone dwellers), bathyplankton (aphotic-zone dwellers) and mosoplnnklon (dispholic zone dwellers).

6.2.2 Characteristics of plankton as fish food

A pianktonic fish food organism normally has all the required physical trails of an ideal fish-food (or feed), such as a) It has easy availability ; b) it is easy to handle ; c) It performs as a feed; d) Its production cost to serve as feed is low and the rate of capital return is viable; e) It has particle size of 10-500µm dia; f) It stays suspended in the water column for a considerable period (suspendability/water stability); g) It does not pollute the water system; h) It possesses attractability as a feed for the fish; i) It is acceptable, palatable and ‘digestible; j) It possesses a low BOD, reducing any chance of rapid microbial degradation; k) It has an appreciable shelf-life; and I) It is easy for culture/rapid propagation.

Other roles of plankton: Plankton regulates transparency and dissolved oxygen thereby regulating sun’s ray penetration and temperature, and decreasing accumulation of CO,, NHr NO, H,S etc. in water. Pond with a definite phytoplankton is observed to keep prawns calm and reportedly minimize cannibalism. They consume phytoplankton and thereby regulate NH4+ and tieup with heavy metals.

Planton’s role as a bioindicator is worth mentioning. Because of their short life cycle, plankton responds quickly to environmental changes. Hence, the standing planktonic crop and species composition indicate the quality of water mass in which they are found (density>1 lakh in nos/ml water indicates future algal collapse; density <1 lak in nos/ml water indicates future algal collapse; density <50,000 nos/ml water indicates weak algal density; Vorticella microstomata indicates a re-purification zone in a polluted water body; Microcystis bloom indicates a dilapidated water mass). Higher zooplankton population indicates higher organix loading. Planton Plays a significant role in stabilizing the whole pond ecosystem and in minimizing the fluctuations in water quality. Maintenance of proper phytoplankton growth prevents the growth of lab-lab, a bottom meance after its death. Plankton serves as a shelter for a large number of small to smaller creatures when an algal mat (periphyton, and even sewage fungus) is formed.

Indication of algal collaps

Increase in water colour intensity –Clusters of colour on water suface – Milk clouds on water column with foaming/frothing – Water clear-up – Dramatic increase in transparency.

6.2.3 Procedure for enhancing pond plankton population

During preparation of the following procedure is suggested:

Water may be filled upto 50 cm depth – Fertilisation may be done with 9 kg urea and 0.9 kg TP (Total phosphorus) – Pond may be temporarily sealed till dark brown colour with yellowish colouration appears- Water may be filled upto 80% of the operational level and 14kg urea and 1.4kg TP may be applied – Pond kept undisturbed for 2/3 days- (If no colouration develops 50-100kg/ha CaCo3 may be applied) – Pond filled to operational level – 19 kg urea and 3kg TP per ha may be applied – If yellowish-brown coloration does not appear water level may be dropped by 10cm and refertilised with 6.8 kg urea and 0.7 kg TP.

After 5 days, a Secchi disc reading of 25-35 cm and a yellowish-brown water coloration confirm optimal condition for best stocking results.

Nutritional value of plankton (fish food organisms): As discussed earlier, due to their balanced nutritional aspects, fish food organisms are rightly referred to as 'living capsules of nutrition' and more often so as single cell protein. However, the nutritional values of each organism greatly vary according to the culture conditions as well as the phase of growth during the harvest. As for example, harvest at prime phase of microalgae contains high protein and at stationary phase, higher carbohydrate. The proximate composition and nutritional details of some natural food groups of the plankton species (Table 1 at P.56) are discussed.

Microalgae: The nutritional status depends on the cell size, digestibility, production of toxic compounds and biochemical composition. Although marked differences are exhibited, the range for the level of protein, lipid and carbohydrate are 12.0-35.0%, 7.2-23.0% and 4.6-23.0%, respectively on dry weight basis. Microalgae could be considered as a rich source of highly unsaturated fatty acids (HUFA) and ascorbic acid (0.11-1.62% dry wt).

Cladocerans: It has low essential fatty acid contents, particularly HUFA. *Daphnia* contains broad spectra of digestive enzymes, such as, proteinases, pepti-dases, amylases, lipases and even cel-lulases, which ultimately facilitate extrinsic digestion in the predator fish.

Copepods: these contain 44-52% protein and a good amino-acid profile with the exception of methionine and histi-dine.

6.2.4 Dangers to fish food organisms:

The various danger elements that fish food organisms in particular and plankton in general encounter in a pond system include predators such as protozo- fans, rotifers, crustaceans, bacterioph-"fages, vibrios, and even microplanktonic flarvae of benthic organisms, opportunistic pathogenesis by viruses, bacte-fria and fungi, physico-chemical factors f^such as the pH, temperature regime, tur-fbidity, nutrient status of the water and fsediment, as also some of the hydro-fbiological factors such as excessive feeding of one type of the plankton by fish that may, as discussed earlier, lead to ichthyo-eutrophication, etc.

Some cyanobacteria and other plankton reportedly produce toxin, which endanger aquatic life in general and fish in particular. One such example is microcystin production by *Microcystis* sp.

In India, though the case has not yet been alarming, its potential as a hazard cannot be ruled out. Sometimes, the algal culture may get contaminated with toxic substances such as heavy metals and non (or low) biodegradable pesticides, which may lead to further complications, including algal collapse, oxygen depletion and fish kill.

6.3. Food and feeding of cultivable fishes

Thorough knowledge of food and feeding habits of culturable fish is essential for successful fish farming. Mixed farming of compatible species of fish in suitable proportion is practiced for full utilization of food habits of cultured fishes. It is necessary to determine the stocking rate of fishes in ponds. We should also be familiar with food preferences and acceptable food in an emergency for individual species. Frequent feeding zone of individual species and availability of food in each zone of ponds provide important information necessary for successful fish farming.

The food and feeding habits of major carp also differ as availability of different kinds of food in ponds varies. Food habits also van- with season, size and age. We have a very meagre knowledge of the food requirements of our culturable species of major carps. Major carps are non-predatory fishes. They have toothless jaws and cannot, therefore, bite their food unlike predatory fishes which have strong teeth to catch the prey. They can, however, swallow food which is crushed with a set of pharyngeal teeth at the throat before it is passed down into the stomach. Their non-predatory habit of feeding is also reflected by a highly coiled intestine as compared to a very short bag like stomach of predatory fishes. Food components of major carps vary in different stages of their life cycle.

6.3.1. Food of carp fry

Newly hatched larvae of about 5 mm have a yolk sac, on which they subsist for at least two days, when they start feeding on organisms found in water. Three to four days old carp fry measuring about 7 mm feed primarily on zooplankton.

Food habits of all the species of major carps are identical at the fry stage. They all start feeding on cladocerans and the animalcules. Cladocerans and rotifiers form the bulk of the food consumed by these young fish. Cladocerans are the most preferred food of carp fry. They are voracious feeders at this stage. A single fry may consume as many as 150 cladocerans within 24 hours. As the yolk sac absorption differs somewhat from one fry to the other, the number of organisms consumed by them varies accordingly.

Carp fry have the ability to choose and eat only selective food. Generally they discriminate plankton and prefer zooplankton as food. Species of *Daphnia, Moina. Cyclops, Diaptomus, Brachionus, Keretella,* Fi/i/niaandNauplius larvae form the most important components of zooplankton food. When these organisms are scarce, carp fry may consume plankton algae like *Pandorina, Volvox,* and *Microcystis* as an emergency food. Carp fry raised on phytoplankton alone is very weak and the survival is very poor. Phytoplankton have very little food value so far as carps are concerned. Phytoplankton organisms have a resistant cell wall, which is indigestible by tender fry. Zooplankton specially cladocerans are consumed eagerly and also digested quickly.

6.3.2. Food of carp fingerlings

As the young fry of major carps approach toward fingerlings size, there is definite change in their food and feeding habits. Also food of fingerlings differ from one species to the other. Each species of major carps at this stage have a choice for its own preferential food. However, there is only little change in food habits of catla fingerlings which continue to feed largely as before on cladocerans and other animalcules, making very little, use of microscopic plants floating in water. Rohu fingerlings on the other hand start feeding on microscopic plants, vegetable debris, deritus and mud in addition to few cladocerans. The food of mrigal fingerlings is more or less same as that of rohu. but they consume relatively larger quantities of decaying vegetable debris, phytoplankton organisms, sand and mud. Kalbasu fingerlings mainly feed on vegetable debris and microscopic.plants in addition to few cladocerans, detritus and mud.

6.3.*3. Food of carp yearling and adults*

Catla do not exhibit any marked change in food and feeding habits even at the yearling and adult stage. At all stages of their growth, their preferred food is largely composed of cladocerans, copepods and rotifiers, although they do swallow algae, vegetable debris and other organisms floating in the water. Rohu consume, at this stage, considerable quantity of bottom sand, mud, vegetable debris and planktonic algae but have very little proportion of cladocerans and other animalcules in their diet. Mrigal at fingerling and adult stages have a common diet as that of rohu of the same size and age, but consume more quantities of organic and vegetable debris, microscopic plants sand and mud. Mrigal feeds mostly on debris and decaying matter. The proportion of animal food in their diet is very poor. Kalbasu at fingerling stage consume more or less same food as that of mrigal of the same size and age. Kalbasu prefers feeding on snails and worms at the bottom of pond in addition to their usual food. Some of the submerged plants like *Vallisneria, Potamogewn, Ceratophyllum, Hydrilla* and *Ottelid* at least in the decaying condition are utilized to a limited extent by rohu and mrigal. Of all these plants, *Potamogeton,* is best relished by carps. Catla, however, does not eat submerged plants to any appreciable extent. Rohu, mrigal and kalbasu may casually include these larger aquatic plants in fresh or decaying condition, but carp raised on these plants do not show satisfactory growth.

6.3.4. Food and feeding habits of prawns

A wide range of feeding habits have been noticed in prawns in nature during their developing stages. The nauplius larvae do not feed at all as they depend on yolk reserves. But protozoea larvae feed voraciously on minute food organisms, mainly phytoplankton viz. *Skeletoneria, Chaetoceres,* etc. as their oral appendages are not fully developed for the capture of larger food organisms, and they have a simple alimentary system. The mysis stage starts feeding on small animal food organisms, occuring plenty in the ecosystem. During the post larval stages, which follow the mysis stage the mouth parts and chelate legs are fully developed, and from now on, the prawn larvae are capable of feeding on a variety of animals as well as vegetable matter. They then settle down to the bottom and browse on the substratum. *Penaeus indicus* has been reported to feed on plant material in the younger stages while the older ones prefer predominantly crustacean diet. Algal filaments also form part of the food of this species. *P. monodon* feed on molluscs, crustaceans, polychaetes and fish remains. *P. semisulactus* consume large quantities of animal matter viz. polychaetes, crustacean, molluscs, foraminiferans and fishes. Controlled fertilization of culture ponds stimulates the growth of algae and zooplankton and inturn some of the bottom dwelling animals, which are known to be the food of prawns.

The natural food of larvae, from mysis stage onwards, consists mainly of zooplankton such as veliger, trochophore, rotifers, copepodes, very small worms and larval stages of various aquatic invertebrates. In the absence of live food, minute pieces of organic material especially those of animal origin (fish, prawn, crab, molluscs, etc.) are readily eaten.

6.4. *Non-conventional feeds*

In aquaculture. supplementary feeds constitute 50 % of the cost offish production. The cost of available feeds is high and generally, these feeds do not meet the actual protein requirements of growing fish or prawns. Hence, it is imperative to make use of the protein rich and locally available non-conventional feeds.

A number of non-conventional materials suitable in the preparation offish feeds have been identified. The blue-green algae, *Spirulinaplatensis.* grown in sewage water contain 40-70% protein (on dry weight basis) and sufficient quantities of essential amino acids such as lysine and tryptophan, vitamin BI2, unsaturated fatty acids, carbohydrate and minerals. Unlike the cellulose cell wall of green algae, the mucoproteic constituents of the cell wall of *Spirulina platensis* are easily digestible. Tapioca leaves have 20-40% protein and a good amount of minerals and vitamin A. The toxic constituent linamarin likely to be present in these leaves, may however, be removed by drying and boiling them. Air-dried leaves of Subabul *(Leucaena lecocephald)*, a recent addition to India contain 33 % crude protein and a variety of amino acids similar to those in prawn waste and fish meal. The toxic mimosine content of the leaves is removed by heating the leaves at 80°C for two days. Aquatic fern, *Azollapinnata* fixes atmospheric nitrogen at the rate of 2-3 kg/ha/day owing to its symbiotic blue-green algae viz., *Anabena azollae.* The dried Azolla which has a crude protein content of 27% also finds application in the feeds of pigs and poultry. Mangrove leaves contain 8-18 % of protein in the decomposing state. The associated bacteria of the leaves are also known to increase the protein content besides making them easily digestible. Further, the bacterial flora may also improve the quality of food by providing essential amino acids lacking as such in healthy leaves. Seaweeds such as. *Ulva fasciata*, *Enteromorpha intestinalis* and *E. compressa* (green algae); *Gracilaria corticata* and *G.follifera* (red algae) and *Sargassum ilicifolium* (brown algae) have 15-25 percent protein and a number of minerals which should be included in fish feeds.

Other vegetable components are leguminous seed kernels, groundnut oil cake, rice bran, wheat bran, tapioca flour. Non-conventional animal components include silk worm pupae, trashfish meal, prawn waste, squilla meal, squid meal, chank meat, clam meat, pila meat and slaughter house waste. These have high protein content (50-70 %) and the inclusion of any one or two of these components is essential to enhance the protein content of feeds.

For optimal growth, juvenile and adult fish and prawns need 30-40 % and 40 % protein respectively. A prawn feed containing 35 % protein may be prepared using the animal component (50 %), groundnut oil cake (30 %) and tapioca flour (20 %) and a fish feed of 40 % protein with rice bran (15 %), groundnut oil cake (15 %), animal component (60 %) and tapioca flour (10 %). Cheaper feeds of varying protein levels could also be formulated and prepared with non-conventional components making use of their protein contents.

The dried and powdered feed components are mixed and the mixture kneaded well adding about 30-50 % of water to form a soft dough. The dough is cooked for 30 minutes in steam under pressure at 1 kg/cm2. The cooked dough is then fed through a pelletiser.

6.5. Bioenriched feeds

Bioenrichment is the process involved in improving the nutritional status of live feed organisms either by feeding or incorporating within them various kinds of materials such as microdiets, microencapsulated diets, genetically engineered baker’s yeast and emulsified lipids rich in w3HUFA (Highly Unsaturated Fatty Acid) together with fat soluble vitamins.

6.5.1. Factors to be considered prior to bioenrichment

a) Selection of the carrier or biofeed : This is a very important aspect taking into account the acceptability of the organism and its size. Commonly used carriers and their size ranges are listed as under :

1	Microalgae	: 2 - 20 u	4.	Moina	:	400 - 1000 u
2	Rotifers	: 50 - 200 u	5.	Daphnia	:	200- 400 u
3	Artemia	: 200 - 400 u				

b) Nutritional quality, digestibility and acceptability before and after enrichment. This requires extensive studies on all commercial species. This study will form a baseline to conclude upon whether to go in for bioenrichment or not.

c) Fixing up the level of the enriching media to be incorporated into the carrier organism. This depends on the nutritional quality of the carrier before incorporation and is also based on the feeding trials conducted in the laboratory.

d) Economic feasibility of enrichment.

e) Purity of the culture of the carrier organism.

f) The other criteria that the carrier should satisfy include,

  i) It should be easily procurable.
  ii) Culture should be economically viable.
  iii) Catchability of the carrier by the target species.
  iv) It should be easily reproducible.

6.5.2. Techniques of bioenrichment:

There are essentially two methods which are widely used for bioenrichment, - the direct method, and the indirect method.

1. The indirect method : It is based on the fact that baker' s yeastcontains a fairly high amount of monoethylenic fatty acids and no w3HUFA, and that the fatty acid composition of rotifers is readily affected by the fatty acids of the culture organisms. A new type of yeast has been developed as a culture organism for rotifers in order to improve upon the nutritional value for fish larvae of rotifers cultured on baker's yeast (Imada et al, 1979). This new type of yeast designed as co-yeast, was produced by adding fish oil or cuttle fish liver oil as a supplement to the culture medium of baker's yeast, resulting in higher levels of lipids and w-SHUFA, the essential fatty acid for both marine and freshwater finfish and shellfish larvae. In a similar manner *Anemia* nauplii and *Moina* are

also enriched with W-3HUFA. This method is so called because live feeds are enriched with w-3 HUFA together with the lipid.

2. The direct method: This method was first developed by Watanabe et al (1982). wherein a homogenate prepared by an emulsion of lipids containing W-3HUFA. raw egg yolk and water is directly fed to the carrier organisms to enrich them directly.

The use of both the methods, direct and indirect will significantly improve the dietary value of live feeds by allowing them to take up from the culture medium not only w-3 HUFA, but also fat soluble vitamins together with lipids (Watanable et al, 1982). Temperature and density of the carriers too dictate the incorporation.

6.5.3. Preparation of enrichment media :

For the preparation of emulsified lipids. the w-3 HUFA concentration in the lipid source should be very high. In an ordinary preparation about 5 gm. of the fish oil is homogenized for 2-3 minutes in a homogenizer or mixer or by vigorous shaking. Proper emulsification is ensured by observing the emulsion under a microscope. The preparation may be stored under refrigeration until use. Ermilsifiers may be added to maintain the emulsion. If not, a violent shaking prior to use reforms the emulsion. The enrichment media may be supplemented with water and fat soluble vitamins like A, D, E and K prior to homogenisation.

Enrichment of *Artemia* nauplii and rotifers with w-3 HUFA is dictated by two factors - lipid content in the emulsion, and type of lipid source. The amount of lipid source depends on the population density of the carriers, their feeding activity and the water temperature. The nauplii or rotifers are harvested using a plankton net of 60 u mesh size washed with clean sea water or freshwater and fed to the larvae of finfish or shell fish in adequate numbers.

6.6 Nutritional Requirements

Carps being the fast growing varieties of fishes are mostly chosen for culture practices in India in fresh waters. The general practice is to provide some starchy foods to these carps to serve as dietary calories. As a result of series of experiments conducted in the country certain balanced artificial feeds have been formulated. To meet the dietary demand of fishes one should know the nutritional requirements of fishes such as proteins, carbohydrates, fats, micronutrients, vitamins etc., besides the knowledge relating to digestibility and utilization of the compounded feeds by the fish for yielding protein as the final metabolized product in intensive fish culture practices.

6.6.1 Proteins

Fishes are efficient converters of vegetable proteins into tasty proteins of high biological value and are able to utilize high levels ofdietary proteins for synthesis, as comparedto other organisms. It has been reported that at 470F Chinnok salmon require 40% casin, whereas the requirement was 55% and 580F. It has also been observed that high protein level (53%) is less effective in comparison to lower level (26.67%) when fed to fry and fingerlings of carps. Level of protein depends upon quality of protein for obtaining optimum growth.

Amino acids which are indispensable in human nutrition have been found to be essential for certain fishes and since their composition is known to the primary factor influencing protein digestion, need for their quantitative requirements by the cultivable fishes could be measured by the qualitative and quantitative distribution of amino acids so that limiting ones can be supplemented by synthetic preparations of complementary proteins resulting in a proper mixture of dietary amino acids for better utilization of dietary proteins. Composition of amino acids in fish flesh which can offer guide lines for their levels in artificial feeds is given in Table - 6.1.

Table 6.1 Amino acid composition of Fish and other animal proteins (From the Wealth of India)

Amino Acid	Fish muscle	Fish myosin	Egg	Beef	Milk	Chicken
Arginine	7.4	4.8	6.6	7.2	4.2	7.1
Histidine	2.6	2.7	2.4	2.9	2.6	2.3
Lysine	9.0	15.0	7.0	8.1	8.7	8.4
Tyrosine	3.8	2.7	4.5	3.4	6.0	4.3
Tryptophan	1.2	0.9	1.5	1.3	1.5	1.2
Phenyl-alanine	4.4	4.4	6.3	4.9	5.5	4.6
Cystine	1.2	—	2.4	1.3	1.0	1.3
Methione	3.2	2.3	4.0	3.3	3.2	3/2
Threonine	4.7	5.8	4.3	4.6	4.7	4.7
Leucine	9.5	10.2	9.2	7.7	11.0	-
Isoleucine	6.5	7.7	7.7	6.3	7.5	-
Valine	6.0	6.6	7.2	5.8	7.0	-

6.6.1.1. Animal Proteins

Fish Meal: Fish meal is the ideal protein item having all the essential amino acids required in fish feeds. It has been reported that fishes feed with fish meal have yielded better results when compared to the fishes fed with soyabeen.

Silkworm pupae: In Japan intensive farming of carps in cages and floats is achived by feeding with silkworm pupae and the conversion rate worked out to 2. It has been revealed that fishes fed on silkworm pupae have yielded better growth when compared to the fishes fed on a mixture of rice bran and mustard oil cake in the ratio 1 : 1. It has been observed that a mixture of animal proteins gave better weight grain and feed conversion than a mixture of plant proteins or any of the proteins tested alone. It has also been reported that plant proteins mixed with 10 to

15% of animal proteins could be utilized as the basic ingredients in formulating the artificial feeds under intensive fish farming.

6.6.1.2.Plant Proteins

They are deficient in lysine and methionine content, and to avoid aminoacid imbalance need supplementation with animal protein. The most favoured items generally used for carp feeding are different oil cakes, and grain fodders. It has been reported that in the composite fish culture of Indian major carps and exotic carps high fish production has been achieved by using a mixture of rice bran and mustard oil cake in the ratio 1 : 1. The nutritive value of oil cakes and grain feeder is dependent on their quality. The quality of prepared feeds will be reduced when their fact content is 10-20%. The overall protein content will be used when the solvent extracted oil cake and rice bran are used as feeds.

Leaf Proteins: Information regarding the use of leaf proteins in fish nutrition is, as yet, negligible except for somevegetable eating species, but because of their high production and competitive economy in agricultural industries, they may in the near future occupy a prominent place in fish feeds after adequate processing involving separation of pigments, flavour and toxins.

Algae Proteins: Algae constitutes the feed of certain varieties of Cultivable fishes. *Chlorella* spp. have been found to contain all the essential amino acids and protein of desired nutritional and functional and functional quality can be obtained by selecting the suitable media for their culture and adjusting the harvesting time. It has been noticed that feed pellets made of *Chlorella* resulted in the higher yields of *Oreochromis mossambica.*

Single Cell Proteins: the proteins derived from yeast, bacteria, fungi or algae grown on a variety of substrata, which include hydrocarbons like crude oil, gas oil, natural gas, coal, carbohydrates such as cellulose, grain, sulfite liquor, molasses and organic wastes constitute yet another source of protein. It has been reported that satisfactory results are achieved when yeast is grown on liquid hydrocarbons as a substitute for a part of fish meal.

6.6.2 Carbohydrates

They are diets of starch and serve as a major source of dietary calories in artificial feeds. Most of the cultivable fishes like carps and mullets are omnivorous taking in considerable amount of vegetable matter and are therefore, well adapted physiologically to digest starch. Digestibility of starch is reported to be 30-90%. Rice bran and wheat bran which are the main starchy diets used for cultivable fishes are found to the highly digestible. Potatoes can be used as substitute for grain. It has been reported that the digestability of potato starch, xylan and algin as 85, 66 and 53% respectively. The ratio of protein to carbohydrate in the feeding of 1 : 7 or 1 : 8 which gives a wide scope to utilize feeding of cheap carbohydrate diets as long as protein in the natural food is sufficient for growth. While formulating the balance diets, carbohydrate and protein ratio needs a careful manipulation so as to spare the proteins for growth and carbohydrate to serve supplying the dietary calories. The diet of certain fishes is said to be nutritionally complete when it contains 39.9% of proteins and 18.2% carbohydrates with food conversion rate of 1. 4-2. 4:1.

6.6.3.Fats

The fishes cultivated in warm waters utilize the fats in a better way. Stimulation has been noticed in the growth of fishes when cod liver oil is added to the diet. But it is known whether lipids or other components of the oil are responsible for such a type of stimulation of growth. As excess fats get deposited in liver, trout ration is usually prepated with less than 10% fat content. It has been reported that in order to yield better results of growth and to reduce mortality in rainbow trout fatty acids with Omega-3 configuration between 3-10% are required. The increased fish yield was found maily due to accumulation of body fat in sorghum fed fish as long as protein was not a limiting factor. Therefore it is clear that provided the protein component in the diet is sufficient, fats can be advantageously used in carp feeds for gaining added yields as well as sparing proteins for growth.

6.6.4 Micronutrients

The growth stimulating micronutrients cannot be substitute for food but their presence in general required to formulate a balanced diet for improving the protein assimilation. In spite of the presence of proteins, growth rate may be slow due to the absence of micronutrients.

6.6.5.Vitamins

Salmon and trout require all the seven vitamins for their growth. Cultivae carps need pyridoxine riboflavin and pantothenic acid. The carps indicated better results when they werefed with 0.8 mg/kg/day of cobalt, which is a part of vitamin B12 concerned with nitrogen assimilation and synthesis of haemoglobin and muscular protein and addition of 4% fodder yeast. Addition of cobalt chloride increases the survival and growth of cultivable fishes.

6.6.6.Antibiotics

The intensive fish farming results in causing diseases to fishes. The role of antibiotics in stimulating protein metabolism depends upon the quality of diet and best results have been obtained by feeding 20,000 units of terramycin to carps every three days resulting in the growth increase by 9.5% and a fodder saving of 10.5%.

6.6.7. Digestibility

Natural food items of fishes are highly nutritious, reflecting a simple and regular relation between protein, fat, carbohydrate and their utilization, but in case of artificial feed stuff, elaborate experimental analysis have to be carried out to know their digestibility and utilization co-efficients. Digestion co-efficients are generally measured in terms of nitrogen and calories.

6.7 Relationship Between Food and Growth

Food supply is the most potent factor affecting the growth of fishes and with sufficient quantity and adequate quality of food, fish attain the maximum size. It is not easy to measure accurately the food intake of fishes.

Some of the food is used to replace the tissues broken down in catabolic processes i.e., to provide for basal metabolism. Basal metabolic rates can be measured by studying the respiration of anaesthetized fish. The activities of fish is influenced by the environmental conditions and requires energy. The energy for these activities is obtained from food. Fish can gain weight only when they eat more food than is necessary to satisfy their basal metabolism and to provide energy for their activity. The fish require particular ration for the upkeep of the routine metabolism known as maintenance requirement. Fish only gain weight from surplus food after fulfilling the maintenance requirements. In case of food shortage, fish lose weight, and in case of starvation the metabolic activities are lowered to some extent.

The use of vitamin B12, cobalt nitrate and extract of ruminant stomach give good results in survival of the major carp fry. It is found that 50 kg B12 and cobalt nitrate in combination with extract of goat stomach enhance the survival of carp fry upto 5%. Addition of yeast, also promotes growth. Yeast along with vitamin B12 and B-complex also enhance the survival rate significantly. The knowledge of conversion rate is very essential for the selection of fish feed. The conversion rate is expressed as a ratio between food consumed for increase per unit weight gained by the body discounting the food requirement by the for its maintenance and energy requirement.

$$\text{Conversion rate} = \frac{\text{Quality of feed}}{\text{Weight increase (flesh)}}$$

6.8 Supplementary Feeding

In the raising of stable fishery, there is a need for regular supply of sustained and balanced food for growin fish. Suitable food has to be provided for healthy growth of fish. Special food arrangement is required for raising good crop of quality often very necessary. However, artificial feeding of fish in rearing and stocking ponds may not be economical in

India at present. Some fattening food may, however, be desirable a few days before the harvesting and marketing of fish. To ensure sustained growth, artificial food has to be supplemented at times of natural food scarcity in ponds.

The food which is added in the pond for better growth of fish is supplementary food. The typical supplementary foods are rice bran, groundnut oil cake, bread crumbs, fish meal, maize power, broken rice, soyabean cake, peanut cake, corn meal, cottonseed oil cake, oats, barley, rye, potatoes, coconut cake, sweet potatoes, guinea grass, napier grass, wheat, silkworm pupae, left-over animal feeds and animal manures.

The kind of extra food depends on the type of fish. For example tilapia eat almost anything including all types of supplementary foods. The silver carp eat only phytoplankton, even at the marketable size.

Supplementary feeds given to different cultivated fishes of diverse feeding habits are:

1) Vegetable feeds such as leaves, grasses tubers and roots starches.
2) Oil cakes such as mustard, groundnut, til, coconut etc., and other residues.
3) Grain fodders like wheat bran, rice, lupine, soyabean, maize, rye, barely etc.
4) Feeds of animals origin such as fish flour, fish meal, fresh meat from warm blooded animals blood, poultry eggs shrimps, crabs, mussels, snails etc.,
5) Additives such as vitamins and minerals.

Fish may also feed directly on dung applied as manure in ponds. The selection of supplementary feed depends on number of factors such as:

1) Ready acceptability to fish
2) Easy digestibility
3) High conversion value
4) Easy transportability
5) Abundant availability

Of all these, ready acceptability by the fish and its conversion ration and the involved costs are the most important. It should be a balanced one with adequate protein, fat, carbohydrate, mineral and vitamin contents. The rate of food conversion depends on:

1) quality of supplementary feed
2) stocking density of fish
3) size and age of the fish stock
4) environmental factors such as temperature, oxygen tension, water etc.
5) the method of feeding (the spreading and frequency of distribution etc.)

In the raising of stable fishery, there is a need for regular supply of sustained and balanced food for growing fish. Suitable food has to be provided for healthy growth of fish. Special food arrangement is required for raising good crop of quality often very necessary. However, artificial feeding of fish in rearing and stocking ponds may not be economical in India at present. Some fattening food may however, be desirable a few days before the harvesting and marketing of fish. To ensure sustained growth, artificial food has to be supplemented at times of natural food scarcity in ponds.

The food which is added in the pond for better growth of fish is supplementary food. The typical supplementary foods are rice bran, groundnut oil cake, bread crumbs, fish meal, maize powder, broken rice, soyabean cake, peanut cake, corn meal, cottonseed oil cake, oats, barley, rye, potatoes, coconut cake, sweet potatoes, guinea grass, napier grass, wheat, silkworm pupae, left-over animal feeds and animal manures.

6.8.1 Relationship between supplementary feed and fish production in different culture systems

In the natural environment, when the growing fish number and natural fish food organisms are in equilibrium, it is need not necessary to provide supplementary feed. When the culture system is intended to go in for more fish production, fertilizers and supplementary feeds should be supplied. In the extensive culture system, the fish production can be

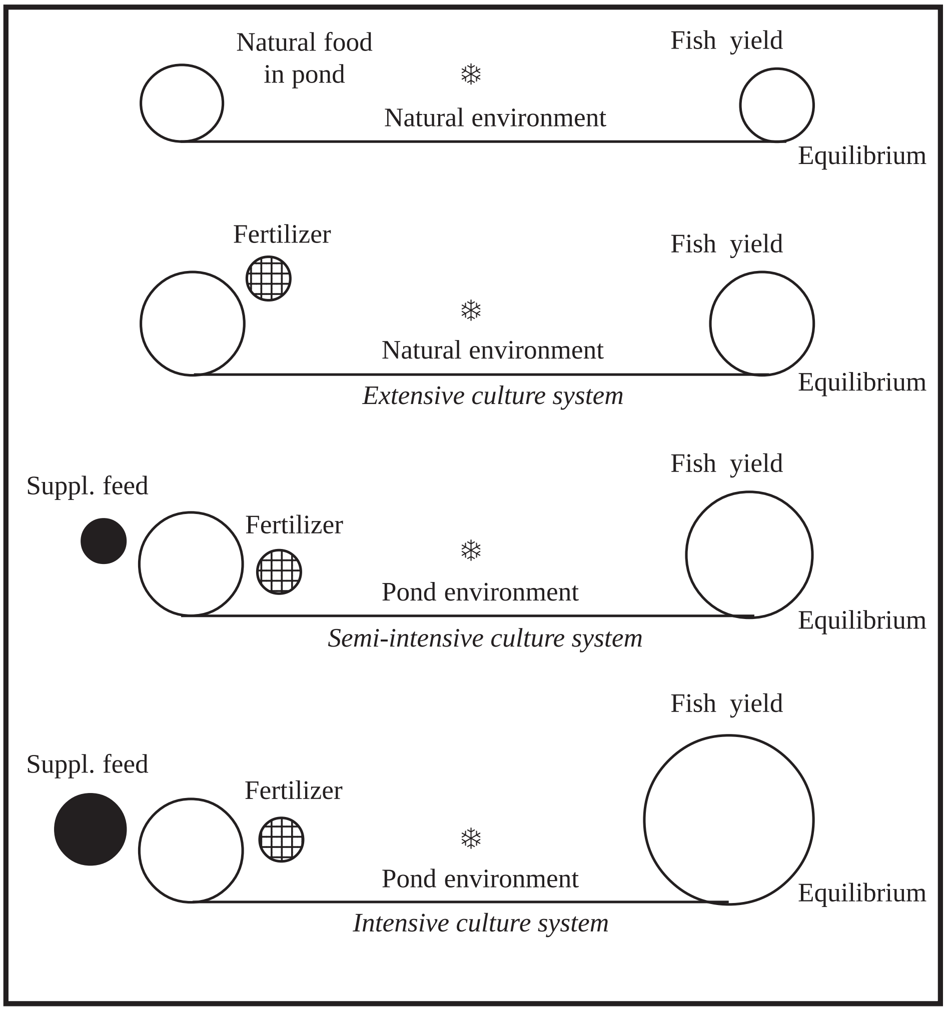
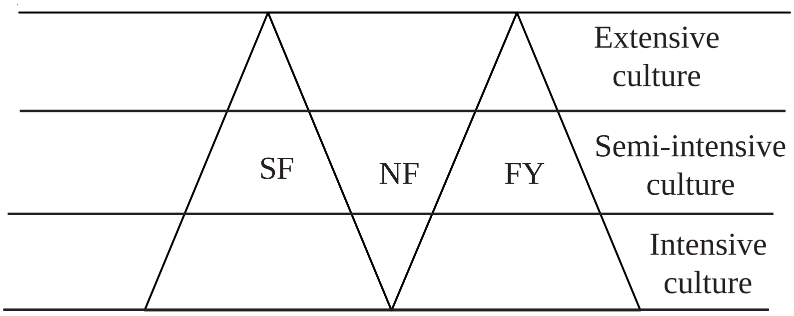


Fig. 6.3 Relationship between supplementary feed and fish yield.

enhanced by adding little amount of organic and inorganic fertilizers, whereas in semi-intensive culture systems the fish production can be enhanced by adding the fertilizers along with sufficient amount of supplementary feed. In intensive culture systems the fish production can be enhanced more by using large amount of supplementary feeds (Fig.6.3).

The fish yield can be enhanced by increasing the supplementary feed from the extensive to intensive culture practices (Fig. 6.4).



6.4 The relationship between supplementary feeds SF, natural food NF and fish yields FY in different culture systems

6.8.2.Formulated feed

Rearing of spawn, fry and fingerlings until they become stockable size and their subsequent culture in grow out ponds require appropriate and nutritionally balanced diet for enhancing production. This has been one of the essential requisites in the development of aquaculture. The advantages of formulated feeds are:

1. Proper formulated feeds are a replica of exact nutritional requirement of fish. Therefore, by understanding the nutritionally well balanced feeds which could be formulated using low cost feed stuff availability locally.

2. Ingredients of formulated feeds can complement one another and raise the food utilization rate.

3. Proteins can supplement one another so as to satisfactorily improve most of the essential amino acid content of the feed, thereby raising the protein utilization.

4. Large quantities of feeds can be prepared at a time with good shelf-life so as to be convenient to preserve, which can be used at the time of supplementary feeding.

5. Feed ingredient sources can be broadened with preferred and less preferred ingredients along with additives like antibiotics and drugs to control fish diseases.

6. High efficiency of feed can be achieved by judicious manipulation of feed ingredients and can be made commercially feasible.

7. By adding a binding agent to produce pelleted feeds, the leaching of nutrients in water is diminished and wastage is reduced.

8. Dispersing over large farm areas is quite possible as formulated feeds are convenient to transport. These are suitable for automatic feeding, for which automatic feed dispensing devices could be successfully employed.

Formulated feed are mainly of two types. They are:

a) Suspension – It is liquid feed, prepared with *Acetes*, *Squilla* and clams. Its preparation is discussed in chapter VG.

b) Pelletised feed – This is a nutritionally well balanced solid feed and can be used off the shelf as and when required. This type of feed contains only ingredients of precisely known composition and for this reason such diets are very expensive.

6.8.3 Formulation of feeds:

Though natural fish food is available to fish, supplementary feeds are required to get more yield. The supplementary feed is a combination of different ingredients both from plant and animal origin and it can be administered in different forms. The conventional method is by broadcasting the feed in dry powder form in the fish pond. Broadcasting has its own disadvantages. Much of the feed is likely to be wasted by getting dissipated in water due to the disturbance causes during the feeding of fish. Further, supplementary feed in powder form can not be stored for a longer period. Alternatively, the feed is given in paste form. To avoid the instability of these ingredients, the feeds are now prepared into dry type of pelleted feeds. Dry pellets are easy to handle and store, have longer shelf-life and are free from accumulation of lethal toxic materials like alpha-toxins. Further, such pellets reduce wastage on feeding and ensure uniform composition of the various nutritional components. Owing to these advantages, the fish culturists are assured of maximum return when they use dry pellets.

The ingredients used for formulating fish-feed should be based on their qualities such as protein content, energy level, type of amino acids, etc. Major ingredients commonly used are corn meal, groundnut oil cake or mustard oil cake, soyabean powder, rice bran, wheat bran, fish meal, fish offal, shrimp meal, crab meal, blood meal, slaughter-house waste, tannery waste, silk worm pupae, cow dung, tapioca flour, wheat flour, wild leguminous seed kernels, dried algae, molasses, etc. Besides, dried yeast in the form of flour also serves as a rich food ingredient with protein and many B-group vitamins.

In many fish feeds, protein is the most expensive portion and is invariably the primary substance. The energy level of the diet is adjusted to a desired level by the addition of high energy supplements, which are less expensive than protein supplements. The rectangle method is an easy way to determine the proper dietary proportions of high and low-protein feeds for use in the dietary requirements of fish. For example, if rice bran and groundnut oil cake are to be used as chief ingredients to prepare fish feed with 40% protein, the procedure is as follows: A rectangle is designed and the above mentioned ingredients are put on the two left corners along with their protein contents.

The desired protein level of feed is placed in the middle of the rectangle. Next, the protein level of the feed is subtracted from that of the already used ingredients placing the answer in the opposite corner from the feed. This could be elucidated by an example. That is, for the preparation of 36.8 kg of fish feed with 40 percent protein, 3.5 kg of rice bran and 33.3 kg of groundnut oil cake are added. In other words, for the preparation of 100 kg of fish feed with 40 percent protein, 9.5 kg of rice bran and 90.5 kg of groundnut oil cake are needed.

6.8.4 Preparation of pelleted fish feeds:

The required quantities of the various components are dried, powdered and mixed. The mixture is kneaded well adding minimum quantity of water to form a soft dough. The dough is then cooked for 30 minutes in steam under pressure at 1 kg/cm2 (15 lbs/inch2). The dough after cooking is allowed to cool in a spacious tray and the prescribed quantities of chap fish oil or vegetable oil and vitamin and mineral mixture are thoroughly mixed in the dough. Finally, it is pressed through a hand pelletiser having a perforated disc with 2 mm or larger holes depending on the size requirement for different finfish and shellfish. A semi-automatic pelletiser powered by a 0.25 HP electric motor suitable for the production of pelleted fish feed having a rated output of 10 kg/hr has been designed. The noodles are dried in the sun and broken into pieces of about one cm, Care should be taken to see that the pelleted feeds are free from moisture. However, a maximum moisture content of 15% may be allowed in the pellets. Sun-dried pellets can be stored for a period of even one year.

6.9. Management of feeding

Proper management of feeding in aquaculture practice is important for resulting in maximum yield, feed utilisation efficiency and to reduce the waste of feed as well as the cost incurred for feed to a certain extent. The management of feeding involves the feeding rate as well as the frequency of feeding at a fixed place and fixed time. These feeding rates and feeding frequencies vary with the species, size of fish, water temperature and dietary energy levels in the feed (Chiu, 1989). Usually the feeding rate is adjusted either at a given percent of body weight. The former feeding rate is very common and prevalent. Feeding frequency is also positively related to the growth of fish. Fish either at short food chain at low trophic niche or at the higher feeding regime naturally grow faster although there is a maximum ingestive limit at which the increase in growth is negligible. This is defined as the optimal feeding frequency which differs from size offish, sex, gut morphology of the species and meal size of the artificial feed.

The feeding management concept of fixed quantity and quality is to be oriented as the daily food consumption in fish is variable. Such daily variations in feed intake is bound to influence the digestibility of the fish. Hence, the management of feeding schedule should match with the diurnal variations of digestibility of the fish for proper feed utilization and assimilation efficiency. Therefore, mixed dietary regimes of low and high protein in feeding can provide a means of reducing feed costs and marginal cost of fish yield.

6.9.1. Supplementary feeding in nursery ponds

Though carp hatchlings predominantly feed on minute plankton, yet the supply of supplementary feed in the form of finely powdered 1:1 ratio of groundnut oil cake and rice bran to the hatchlings or fry results in better growth in nursery pond. The nursery ponds are supplied with supplementary feed equal to double the weight of spawn from the first to fifth day and then the amount is doubled till fifteenth day. Feeding should be stopped a day before harvesting. The feed should contain 40-45% protein, 25-30% carbohydrate. Cobalt in minute quantities of 0.01 mg/fish/day along with supplementary feed enhances the survival and growth rate of hatchlings. The mixture of silk worm pupae, groundnut oil cake and wheat bran in rohu and mrigal, and soyabean in catla cultures gave good results.

6.9.2. Supplementary feeding in rearing ponds

The fry are provided with supplementary feed in the form of groundnut oil cake and rice bran at the rate of 1% of the body weight till they grow to fingerlings.

6.9.3. Supplementary feeding in stocking ponds

The supplementary feeds like oil cake and rice bran must be supplied to the fish in stocking ponds. Oil cakes like mustard or groundnut and rice bran in 1:1 ratio should be given to fish daily at the rate of 1-3% of the body weight. Aquatic weeds are given to grass carp. Feeding is carried out preferably in the morning hours. It is always better to assess the density of plankton before feed is supplied. If the plankton is below 2 ml/50 1, only then the supplementary feed should be given. The feed should be supplied at a fixed place in a tray suspended in the water. The grass carp should be given aquatic weeds on a bamboo platform.

Summary

A variety of natural fish food organisms are found in a waterbody, which depend on the nutritive nature of the waterbody. The natural food provides the constituents of a complete and balanced diet.

The natural fish food organizims are plankton, oligochaetes, insects larvae, molluscs, tadpoles, weeds, etc.

The plankton is divided into two main categories - phytoplankton and zooplankton.

The phytoplankton drift about at the mercy of the wind and water movements. Algae consist of three major classes which form the main food in phytoplankton. These are chlorophyceae, cyanophyceae and bacillariophyceae.

The most common organisms in zooplankton are protozoans, crustaceans and rotifiers

Bioenrichment is the process involved in improving the nutritional status of live feed organisms either by feeding or incorporating within them various kinds of materials such as microdiets, microencapsulated diets, genetically engineered baker’s yeast and emulsified lipids rich in w3HUFA (Highly Unsaturated Fatty Acid) together with fat soluble vitamins.

Food supply is the most potent factor affecting the growth of fishes and with sufficient quantity and adequate quality of food, fish attain the maximum size.

The food which is added in the pond for better growth of fish is supplementary food. The typical supplementary foods are rice bran, groundnut oil cake, bread crumbs, fish meal, maize powder, broken rice, soyabean cake, peanut cake, corn meal, cottonseed oil cake, oats, barley, rye, potatoes, coconut cake, sweet potatoes, guinea grass, napier grass, wheat, silkworm pupae, left-over animal feeds and animal manures.

Formulated feed are mainly of two types. They are:

a) Suspension – It is liquid feed, prepared with *Acetes*, *Squilla* and clams. Its preparation is discussed in chapter VG.

b) Pelletised feed – This is a nutritionally well balanced solid feed and can be used off the shelf as and when required. This type of feed contains only ingredients of precisely known composition and for this reason such diets are very expensive.

Questions

1. Discribe the natural fish food organizems.

2. Write the significance of plankton in aquaculture.

3. What are the nutritional requirements.

4. Discuss the suplementary feeding in fishes.

7. Heatlth Management

Fish are prone to hundreds of parasitic and non-parasitic diseases, especially when grown under controlled conditions. Adverse hydrological conditions often precede parasitic attacks, as the resistance of fish is thereby lowered. Mechanical injuries sustained by a fish when handled carelessly during fishing and transport may also facilitate parasitic infection.

The prevalence of fish diseases is very much dependent on the intensity of stocking. So when a farmer decides to raise the stocking rate, he not only has to provide extra food, but also has to take special care to prevent and cure outbreaks of diseases. Diseases are more common in freshwater environments, as it has been found that susceptible freshwater fish are significantly free from disease when grown in slightly brackishwater.

Properly managed ponds usually remain free from disease. Carelessness in stocking and feeding may result in serious parasitism and mortality. Prevention is better than cure. Care should be taken to prevent parasites gaining access to the culture ponds from any nearby infected source. Even though several curative methods are available, treatment is difficult and often impracticable in ponds containing large number of fish.

Preventing the spread of disease by quick removal and destruction of infected fish is probably the most effective method of control. Disease-resistant fish should, as far as possible, be selected for stocking.

7.1 Methods for disease diagonsis

Fishes are poikilotherms, hence the environmental impact is more in fishes when compared to warm-blooded animals. The following aspects are useful for the identification of diseased fishes.

1. Disease can be diagonised only in freshly killed fishes and live fishes. If it is late after the death of fish, diagnosis is very difficult due to

the chemical changes in the body at normal temperatures.
2. Slime production is more in diseased fishes.
3. After death, the fish settle on the bottom of pond. Then come to the water surface due to the gases produced by chemical changes in the body.
4. Mucus samples should be collected from body surface and gills and examine them under the microscope.
5. Change of body colouration.
6. Abnormal behaviour of the fish.
7. Examine the external features, then go for internal examination.
8. Examine the size, colour and shape of the internal organs like liver, kidney and spleen.
9. Examine the fluid accumulation, hemorrhages and inflammations in the body cavity of fish.
10. Take out the samples from vital organs and go for bacteriology, virology and histological studies.
11. Examine for tumors or swelling in the body.

7.2 Types of Fish Diseases

The diseases of fishes are classified as parasitic diseases and non-parasitic diseases.

7.2.1 *Parasitic Diseases in Fishes*

Parasitic diseases are also called as pathogenic diseases or infectious diseases or communicable diseases. The important parasitic diseases are viral, bacterial, fungal, protozoan, helminthic, annelid and crustacean. The loss of fish production from infectious diseases accounts for about 60% of all diseased cases. Hence, the study of infectious diseases is of primary significance to the development of aquaculture.

The parasites are mainly of two types:

1. Ectoparasites: These are found on the body surface, fins and gills. Ex. *Argulus*, *Lernaea*, *Ergasilus*, leaches.

2. Endoparasites: These are found inside the body. These are further divided into 3 types.
   a) Cytozoic parasites: These are found in the cells. Ex.*Microsporidia, Glugia.*
   b) Histozoic parasites: These are found in the tissues.
   c) Coenozoic parasites: These are found in the body cavity or inside the alimentary canal. Ex. *Diphyllobothrium,* nematodes.

7.2.1.1. Viral diseases in fishes:

Viruses are transmitted from one host to the other through a structure called virion. Viruses are classified mainly based on external structure, shape, size, capsid structure, RNA and DNA nucleic acids. Viruses cause disease by weakening the host tissue or by forming tumors in the host tissues. There is no treatment for viral diseases, only prophylactic measures have to be taken.

a. Lymphocystis:

Woodcock (1904) identified this disease in fishes. Marine, freshwater and aquarium fishes are susceptible to this disease. Turnor formation is the important character of this viral disease. The external lesions are raised, and made up of the growing of granular, nodular tissue which is composed of many greatly enlarged host cells. Matured lesions may become slightly hemorrhagic. Within 6-15 days of infection the tumors grow to 50 thousand times. It caused a lot of damage in the Baltic Sea area in America.

b. Viral Hemorrhagic Septicemia (VHS):

This disease is caused by an unequal shaped fish virus with RNA. This disease occur in salmon fishes. Transmission of the disease occurs through the water by a flagellate. This disease is also called as infectious kidney swelling and liver degeneration in German and pernicious anaemia, infectious or entero-hepatic renal syndrome in France. The symptoms are kidney swelling, reduced appetite, obvious distress, erratic spiral swimming, multiple hemorrhages in skeletal muscles, change in body colour, reddish fins. The only control measure is prevention.

c. Infectious Pancreatic Necrosis (IPN):

This disease is found in trouts. This disease causing high mortality of fry, fingerlings and occasionally larger fish. The symptoms are darkening distention and at time, hermorrhages in ventral areas including bases of fins. There is pronounced pancreatic necrosis. 200 ppm. Of chlorine is effective for treatment.

d. Infective Haemopoitic Necrosis (IHN):

IHN was observed for the first time in trouts in British Columbia (Canada) in 1967. Necrosis is observed in the haemopoitic tissue of kidney in infected fish. This disease occurs more in fry and fingerlings, and occasionally in adults. The symptoms are pale gills, reddish fins, black colouration of the body, abdomen swelling, and huge mortality. The symptoms are clear in 12-45 days after the entry of virus into the host body.

e. ***Chinook disease:***

A small size virus is responsible for this disease in Chinook salmon *(Oncorhychus tshawytscha)* fingerlings. The symptoms are exophthalmus, distended abdomen, a dull red areas on the dorsal surface anterior to dorsal fin. The liver, spleen, kidney, gills and heart are pale. The disease is transmitted by the egg from the carrier female. No treatment.

f. Channel cat fish virus disease:

This disease occurs in fingerling of cat fish *(Iactalurus punctatus)*. The symptoms are that the fish show abnormal swimming and rotating, hemorrhagic areas on fins and abdomen, fluid accumulation in abdomen and pale gills. There is no treatment for this disease. Destruction of infected fish may prevent spread of the disease.

7.2.1.2 Bacterial diseases in fishes:

Bacteria are responsible for many fatal diseases in fishes like furunculosis, columnaris, fin or tail rot, vibriosis, dropsy, cotton mouth disease and tuberculosis.

a. Furunculosis:

Furuculosis disease is caused by *Aeromona salmonicida* in salmon fishes. It is a non-motile, gram-negative bacterium. This disease frequently appears to infect fishes living in the dirty waters containing a large amount of decaying matter. This disease is also observed in few other fishes. The first symptoms of this disease is appearance of boil-like lesions. Others symptoms are blood-shot fins, blood discharge from the vent, haemorrhages in muscles and other tissues and necrosis of the kidney. Bursting of boils allow the spread of this disease among other fishes and also offer suitable areas for fungus growth. In acute forms it is systemic bacterial infection, a septicemia with bacteria present in the blood, all tissues and lesions. Fishes severely infected with the bacteria die in good number.

Remove the severely infected fishes from the pond and supply food containing antibiotics like sulphonamides or nitrofurans. Sulfonamides like sulfadiozine or sulfaguanidine are given orally with food at the rate of 22 gms/100kg. Of fish/day. Other antibiotics like chloromycetin and tetramycin are most effective at a dose of 5-7.5gm/100kg of fish/day. Disinfect the eggs with 0.015% solution of metthiolate or 0.185% acriflavin.

b. Columnaris disease:

Columnaris disease is caused by *Chondroccus columnaris and Cytophaga columnaris* in many freshwater aquarium fish. It is a long, thin, flexible, gram-negative slime bacterium (myxobacteriales). This disease is often associated with low oxygen level. Initially it is marked by appearance of grayish-white or yellowish-white patches on the body. The skin lesions change to ulcerations and fins may become frayed. Gill filaments are destroyed and eventually lead to the death of the fish.

Addition of 1 ppm copper sulphate in the pond to control this disease is effective. Tetramycin administered orally with food at a rate of 3 gm/100 pounds of fish/day for 10 days is very effective. Dip treatment in malachite green (1:15000) for 10-30 seconds and one hour bath in 1 ppm furanase is very effective to control this disease.

c. Fin or tail rot:

Tail or fin rot disease is caused by *Aeromonas salmonicid and A.liquefaciens.* However, protozoans and fungi may also be involved. It is characterized by appearance of white lines along the margins of fins, the opacity usually progresses towards the base eroding them, and causing hemorrhage. The fin rays become brittle first and later break, leading to the complete destruction of the fins. The infection may also spread on the body surface. Fin and tail rot are associated with poor sanitary conditions in fish ponds and with water pollution in nature.

The fin or tail rot may be checked at an early stage by keeping fishes in 0.5% copper sulphate solution for 2 minutes. Control may be achieved with 10-50 ppm tetramycin and 1-2 ppm of benzalkonium chloride. In severe infections the affected parts are surgically removed and the fishes are then kept in 0.04% potassium dichromate.

d. Vibriosis:

Vibrio bacteria are the causative agents of vibriosis disease in salmon and many other fishes. This disease may occur in waters with low oxygen. These bacteria are small gram-negative bacilli, characteristically curved. Diseased fishes show large, bright coloured, bloody lesions in the skin and muscles, hemorrhages in eyes, gills may bleed with slight pressure, and inflammation of the intestinal tract. Sulfamethazine at a rate of 2 gm/100 pounds of fish / day gives good results. 3 – 4 gm/100 pounds of fish/day for 10 days of terramycin also give satisfactory results.

e. Dropsy:

Pseudomonas punctata is the causative agent of this disease. It is characterized by accumulation of yellow coloured fluid inside the

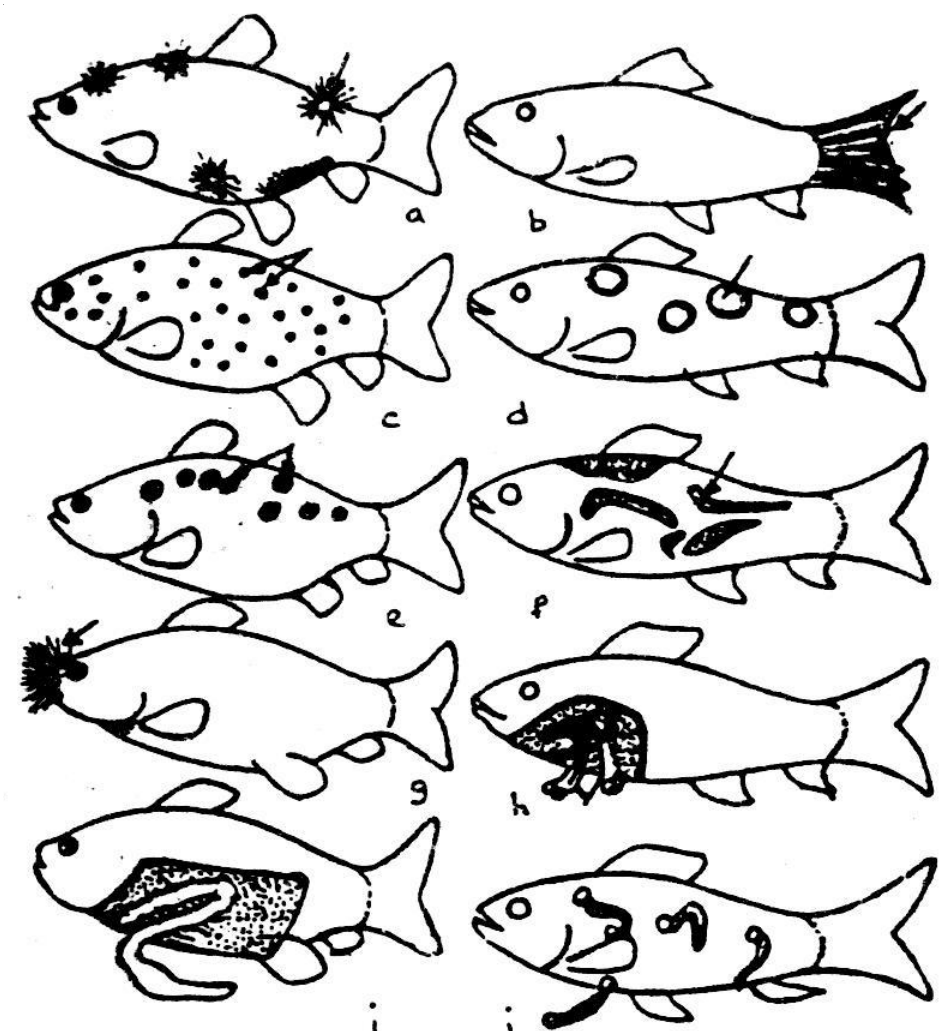


Fig. 7.1 Common diseases of fish

a)	Cotton wool disease	b)	Tail rot
c)	Ich diseased	d)	Boil disease
e)	Dropsy disease	f)	Costiasis
g)	Cotton mouth disease	h)	Dactylogyrosis
i)	Nematode infection	j)	Leech infection

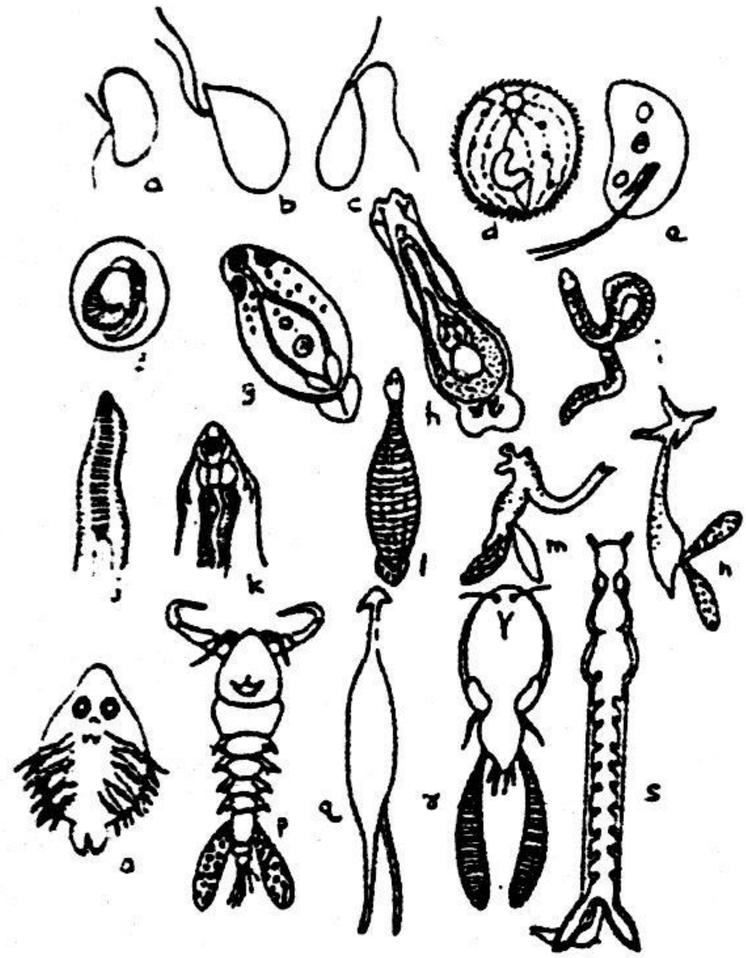


Fig. 7.2 Common fish parasites

a) *Achlya*
b) *Aphanomyces*
c) *Saprolegnia*
d) *Ichthyophthirius*
e) *Costia*
f) *Trichodina*
g) *Diplostomum*
h) *Dactylogyrus*
i) *Ligula*
j) *Philometra*
k) *Camallanus*
l) *Hemiclepsis*
m) *Clavellisa*
n) *Lernaea*
o) *Argulus*
p) *Ergasilus*
q) *Larnaenicus*
r) *Caligus*
s) *Pseudocyonus*

body cavity, protruding scales and pronounced exopthalmic conditions. This is known as intestinal dropsy. In case of ulcerative dropsy, ulcers appear on the skin, deformation of back bone takes place and show abnormal jumping. This is a fatal disease in culture systems.

Removal and destruction of fishes, followed by draining, drying and disinfecting the pond with lime are preventive measures to control the disease. The infected fishes may be cured with 5 ppm potassium permanganate for 2 minutes dip bath. Streptomycin and oxytetracyclin give good results.

f. Cotton mouth disease:

The filamentous bacteria, *Flexibacteria* is the causative agent of this disease. The main symptom is appearance of fungus like tuft around the mouth. This can be treated with antibiotics like 10 ppm chloramphenicol for 2-5 days and 0.3 ppm furanace for long term bath (Fig.7.1).

g. Tuberculosis:

Mycobacterium is a disease causing agent which is difficult to diagnose without pathological examinations. The symptoms are ulcers on body, nodules in internal organs, fin or tail rot, loss of appetite and loss of weight of fish. This can be cured with dip treatment in 1:2000 copper sulphate for 1 minute for 3-4 days. Antibiotics are not successful. The fishes should be destroyed and potassium permanganate or lime used in the pond.

h. Bacterial gill disease:

This disease is caused by Myxobacteria in salmon fish. Many bacteria are found in swollen gill lamellae which show proliferation of the epithelium, and symptoms are lack of appetite. This disease is transmitted through water from infected fish. It can be treated with 1-2 ppm timsan or 1 ppm copper sulphate.

7.2.1.3. Fungal diseases

a. Saproligniasis:

This disease is also called as cotton wool or water mould disease. This disease is caused by *Saprolignia parasitica*. It is the most common fungus affecting fishes, especially major carps. The fry and fingerlings, when transported over long distances get bruises on the body, and unless properly disinfected, become sites of infection, resulting in large scalemortality. Whenever fish get injuries the fungal infection may occur. The infected fish becomes weak and lethargic or exfoliation of the skin followed by hemorrhage, exposure of jaw bones, blindness and inflammation of liver and intestine. This can be treated with 1-3 ppm malachite green for one hour or 1:500 formalin for 15 minutes.

b. Branchiomycosis:

This is also called as gill rot. This disease is caused by *Byanchiomyces demigrans* and *B.sanguinis*. It is reported to be common on cultivated fishes in ponds having abundant decaying organic matter. The tubules of fungus grow into the respiratory epithelium of the gills, causing inflammation and damage to their blood vessels. The blood supply is stopped to the infected area, as a result of which it becomes necrotic. It can be controlled with 5% common salt for 5-10 minutes.

c. Ichthyophonosis:

It is also known as reeling disease. It is characterized by swinging movement of the infected fish. It is caused by *Ichthyophonus hoferi*. It enters into the host along with the food. The spores spread to the various organs and in severe cases spread out to the skin which may rupture and become ulcerative at several places. It is extremely difficult to control this disease. The infected fishes are isolated from the stock and kept for treatment in separate ponds. Medicines like sulfamethanis, terramycin, erythromycin and calomel are useful to treat the infected fish.

7.2.1.4 Protozoan diseases

a. Whirling disease:

This disease is caused by a myxosporidian protozoan, *Myxosoma cerebralis* only in salmon fishes. The symptoms are pancreatic necrosis, lesions and disintegration of the cartilaginous skeletal support of the organ of equilibrium. Rapid tail-chasing type of whirling is often seen when the fish is frightened or trying to feed. The typical symptoms usually appear at 1-2 months after exposure to the disease. If the pond contains all infected fish, it is better to destroy them by deep burial. Then the pond should be cleaned thoroughly and disinfected with calcium cyanamide, quick lime or sodium hypochlorite.

b. Costiasis:

This is caused by a mastigophore, *Costia necatrix* in culture fishes. This is a common disease in ponds where fishes live densely in water with a low pH and poor condition food. The parasites live in large numbers on fish skin, fins and gills. The symptoms are appearance of grey blue film on the skin, which turns to red patches in severely affected cases. The infected fish becomes weak, loss of appetite occurs and finally die. They can be treated with 3% common salt for 10 minute or 1:2500 formalin solution.

c. Ichthyophthiriasis:

This caused by a ciliate, *Ichthyophthirius multifilis.* This disease is also called as ich or white spot disease. The young parasites moving in water get attached to the skin of the fish. They grow between the epidermis and dermis and after becoming large in size fall to the bottom of the pond. Infected fish develop small white spots on the skin and the fins. These parasites attack the gills also. Fish respond by jumping in the water and rubbing their body against the water objects. Respiration gets affected and they finally die. Dip treatment in 1.5 ppm of malachite green or in 10 ppm of acriflavin gives good results. 3% salt solution, 1:4000 formalin, 1:100000 quinine hydrochloride, 1:500000 methyl blue are also useful to treat the fish.

7.2.1.5 Helminthic diseases

a. Dactylogyrosis:

The monogenic trematode, *Dactylogyrus* is reported to cause serious infection in fishes. *D. exitensis, D. vastator and D. lamellatus* are found in carps. These are found on the body, fins and gills. The parasites start appearing in the ponds during the rains, but their prolific multiplication takes place during winter, when the intensity of infection on carp fry may reach as high as 94%. The most infected size group is 61-100mm, irrespective of species. Infected fishes rest near the surface of the pond margin, swim very slowly, feel suffocation, are more slimy, dropping, and folding of fins and pale gills. Alternative baths with 1:2000 acetic acid and 2% sodium chloride are effective. 10 ppm of potassium permanganate bath for 1-2 hours and 5 ppm in the pond may give good results. Bromex – 50 (0.18 ppm) and Dylox (0.25 ppm) are effective to control the disease.

b. Gyrodactylosis:

Another monotreme trematode, *Gyrodactylus* also causes disease in culture ponds. This also lives on fins and on the body of the fish. The symptoms are production of more slime, damage of fins and fading of the body colour. The medicines used in control of dactylogyrosis are also effective to control this disease.

c. Other helminthes

Like *Diphyllobothrium, Bothriocephallus, Diplostomum, Clinostomum*, and spring headed worms (Acanthocephala) cause diseases in fishes. Nematodes also cause diseases in fishes of which some of the common nematodes are *Phillometra* and *Camallanus.*

7.2.1.6 Leeches diseases

Leeches belonging to the gnathobdella and rhynchobdella attack the fishes. Leeches like *Piscicola, Myzobdella and Hemiclepsis* hold the skin of the fish and suck fish blood. After the blood meal they detach themselves, leaving the wound open for secondary fungal infections. The growth of fish is affected and they become weak. A popular control method is dip treatment in 2.5% sodium chloride for 30 minutes. This helps to detach the parasite from the body of the host. Use 1 ppm dylox for 5 days. Remove the infected fishes from the pond for treatment, and drain and disinfect the pond with lime to destroy the eggs and adult leeches.

7.2.1.7 Crustacean diseases

a. Argulosis:

Argulus or fish lice is a common copepode parasite in fishes. It is a large ectoparasite and can move over the body surface of the fish. *Argulus* puncture the skin and inject cytolytic toxin through the oral sting to feed on the blood. The feeding site becomes a wound and hemorrhagic, providing ready access to secondary infection of other parasites, bacteria, virus and fungi. *Argulus* transmits dropsy in fishes. In advanced stages, fish swim erratically, show growth loss and loss of equilibrium.

To control *Argulus*, remove the submerged vegetation, wooden lattices placed in the pond will serve as artificial substrate to deposit its eggs, which can be removed at intervals to kill the eggs. 500 ppm of ammonium chloride, 410 ppm of balsam, 10 ppm of DDT for 25 seconds dip, 0.25 ppm of dylox and 2000 ppm of Lysol for 15 second dip are effective to kill *Argulus*.

b. Lernaeasis:

It is caused by a copepode parasite, *Lernaea* or anchor worm. This disease is mostly caused by *L.cyprinacea*. The larval stages are temporary parasites that feed on mucous and blood of fish. The adult female is a specialized fish parasite, worm like, which burrows into the fish flesh, keeping its eggs cases protruding out of the fish body. Male *Lernaea* do not attack the fish and are not specialized for parasitic life. Early infected fish swim erratically, flashing against the sides and bottom of ponds. Heavily infected fish swim upside down or hang vertically in the water.

Only partial control of *Lernaea* is possible with chemicals, because the head is buried in the fish tissues and there are no exposed respiratory organs. Hence, prevention is more effective than control. 1% common salt eliminates larvae in 3 days, 250 ppm formalin for 30 to 60 minutes. 0.2 ppm gammexane for 72 hours, 2 ppm of lexone, 0.1 ppm lindane for 72 hours and 1 ppm chlorine for 3 days may give good results.

c. ***Ergasillus and salmincola:***

These two parasites are responsible for huge mortality of fishes in the culture systems. These two parasites are found attached to the gill filaments and feed on blood and epithelium. Later they may also be found on the fins and body. The infection results in impaired respiration, epithelial hyperatrophy, anaemia, retarded growth, restlessness and finally death. The fish becomes susceptible to secondary infection, especially fungus.

Ergasilus can be treated successfully with a combination of 0.5 ppm copper sulphate and 0.2 ppm ferric sulphate for 6 to 9 days. *Salmonicola* can be controlled with 0.85% calcium chloride, 0.2% copper sulphate, 1.7% magnesium sulphate, 0.2% potassium chloride and 1.2% sodium chloride for 3-4 days.

Achtheres is a common parasite attached to the gill rakers of fishes, but does not damage gill filaments. It can also be controlled by the above chemicals.

7.2.1.8 Algal disease:

Cyanophyceae member, *Oscillatoria* is responsible for fish mortality. It is found on gills and fish body in large numbers and produce toxic substances, which are responsible for fish kill. *Chlorella* and *Pharmidium* also cause discomfort in fishes.

7.2.1.9 Epizoic Ulcerative Syndrome (EUS):

Epizoic Ulcerative Syndrome, popularly known as EUS, has caused severe damage to India's aquaculture, especially at the moment when the Indian fisheries industry is poised for a great leap forward with high input based hitech production systems. Widespread outbreaks of the disease, occur suddenly and often cause mass mortality in freshwater and brackishwater fishes causing anxiety and tremendous concern. Although the disease has been known in the Asia-Pacific region since the seventies, it appeared for the first time in India in 1988 and has now covered almost the entire length and breadth of the country. Barring a few states like Jammu and Kashmir, Punjab, Himachal Pradesh and the Union Territory of Delhi, the disease has been reported from every state by now.

One common feature of the disease is that it initially affects the bottom-dwelling species like murrels, followed by catfishes and weedfishes. Subsequently, the Indian major carps also get affected. There is a growing concern about the disease now since it has also been found to affect several species of fishes in brackishwater bodies like Chilka lake and estuarine waters of Paradeep of Orissa. Auari and Mandovi estuaries of Goa and Vembanad lake of Kerala.

Unlike other diseases, this syndrome has been disturbingly found to affect a variety of fish species, both wild and culturable, resulting in large scale mortalities. The most severely affected ones are *Channa sp., Puntius sp., Clarias batrachus, Heteropneusters fossilis and Mastacembelus sp.*, Other species which are affected are *Glossogobius sp., Trichogaster sp., Gadusia sp., Amphpipnous cuchia, Wallago attu, Anaba testudineus, Salmostoma bacaila*, etc. Among the major carps, it has been recorded in catla, mrigal, rohu and kalbasu. Common carp, grass carp and silver carp are also affected.

Among the brackishwater fishes, it has been seen in *Mugil subvirdis, M. cephalus, Liza bornensis, Etrophus suratensis* and *Channa striatus*. Fishes of all sizes are affected. However, the incidence of infection is more in the younger ones.

Clinical signs and gross pathology in the affected fishes are similar in almost all the species with moderate to severe ulcerative skin lesions. The lesions start as small grain to pea-sized hermorrhagic spots over the body which ultimately turn into big ulcers of the size of a coin, with grayish, slimy central necrotic area surrounded by a zone of hyperemia. The disease affects the fish to such an extent that they start rotating while still alive, and eventually die.

Affected fishes with mild lesion may not show any clinical sign, whereas those with marked ulcerative lesions exhibit distinct abnormal swimming behaviour with frequent surfacing. The internal organs of most of the clinical and sub-clinical cases do not show any gross lesions. In severe cases, hemorrhages have been noticed over the surface of the liver and kidney. Clinical symptoms can be categorized in three stages: 1) Initial stage characterized by localized hemorrhages on scale pockets, 2) Advanced stage showing sloughing off of scales with degeneration of epidermal tissue and the ulceration, and 3) Final stage characterized by deep and large ulcers on various parts of the body.

Till date, several methods have been tried or are being tried to control the disease. Many antibiotics, sulfonamides, herbal preparations and chemicals have been advocated as preventive and curative measures. Yet, lime is the most accepted therapeutic agent. These reagents which help in controlling this disease to some extent are either costly in their application and are not favoured by the farmers who are generally poor.

The success of any developmental planning depends on the identifications of anticipated maladies and provision of suitable remedies. Ultimately, they have been successful in formulating a chemical mixture which has proved to be very effective as a curative as well as a preventive measure against EUS. The chemical mixture has gained immense popularity and affordable price. This mixture has been named Cifax. The yellowish brown liquid is advised to be diluted in a sufficient quantity of water before being sprayed over the waterbody evenly for a thorough mixing. Appreciable changes are noticed in the affected fish within 3-4 days and marked improvement of the ulcerative condition is noticed within 7 days.

7.2.1.10. Health management

The principles of fish health management incorporates minimizing stress in cultivated fishes, confinement of disease outbreak to affected ponds and minimizing losses from disease outbreak. This could be achieved through prophylaxis and positive treatment to the outbreak of epidemics. Because of the aquatic ambience, it is not easy to be aware of the activities of fish. It is difficult to conduct a correct diagnosis and timely treatment. This necessitates prevention of fish diseases which is more important than control of fish diseases. This signifies the importance of the statement "Prevention is better than cure".

i. Prevention of fish disease

a) Importance: It is difficult to identify the appearance of disease in its initial stage on account of the gregarious nature of fish in water which causes difficulties in observation, diagnosis and timely treatment. Apart from this, some effective drugs and measures to cure certain fish diseases are still not known well. Therefore, perfect preventive measures must be taken since this is a key link in fish disease control.

b) General preventive measures: Increasing the internal resistance of fish is important in the prevention of diseases. Therefore, some important points in fish culture should be special attention.

1. Selection of healthy fish seed.
2. Proper density and rational culture.
3. Careful management
4. Qualitatively uniform ration and fresh food.
5. Good water quality.
6. Prevention of fish body from injury.

ii. Abolishing pathogens and controlling its spreading:

Existence of pathogen is one among three factors (host, causative agent and environment) in outbreak of fish disease. To abolish the pathogen and control its spreading the following measures can be taken.

1. Thorough pond cleaning and disinfection. Bleaching powder (chlorinated lime) should be applied at the rate of 50 ppm in the pond. It readily kills all the wild fish species, molluses, tadpoles, crabs and disinfects pond soil and water. In nursery and rearing ponds it is desirable to use malathion at the rate of 0.25 ppm 4-5 days prior to stocking of fish seeds.
2. Disinfection of appliances: Nets, gears, plastic wares and hapas should be sun-dried or immersed in a disinfected solution.
3. Disinfection of fingerlings and feeding platform: Disinfection with mild concentration of potassium permanganate solution is helpful during the transfer of the fingerling to stocking tanks. The feeding platform can be disinfected by hanging bleaching powder cloth bags with mixture of copper sulphate and ferrous sulphate (ratio 5:2) near the feeding place. When fish come to the feeding place for feeding purpose, their skin will be automatically disinfected.
4. Proper feeding: Fixed quality, quantity, time and place has to be followed for proper feeding. Any reduction in quality and quantity and variations in feed application and place may cause not only deficiency disease but also will increase the susceptibility to many infectious diseases.
5. Segregation of year class fish population: Brood and older fish may serve as carriers of disease causing organisms without exhibiting any clinical symptoms. To avoid such risk, young fish should be segregated from the brood and older fish.
6. Spot removal of dead fish from the pond: Dead and sick fish should be removed as soon as it is located. The daily loss of fish should be recorded to provide valuable insight to the intensity of disease problem.
7. Chemoprophylaxis: Effective and inexpensive prophylactic measures against wide range of parasitic and microbial diseases are advisable as chemoprophylaxis (Table.7.1) Occasional pond treatment with potassium permanganate at the rate of 2-3 ppm and dip treatments with potassium permanganate at the rate of 500-1000 ppm for 1-2 minutes or short bath in 2-3% common salt solution is safe. Some of the chemoprophylactics used in culture practices are given in Table 7.1 Besides, oral administration can be given for preventing systemic infections.

8. Immunoprophylaxis: Immunisation programme is gradually emerging as one of the most important measures for preventing infectious disease. Vaccine to combat bacterial diseases of carps are available in developed countries. Vaccine against *Aeromonas hydrophila, Plexibacter columnaris, Edwardsiella tarda, E.ictaluri, Aerononas salmonicida, Yoreinia ruckeri, Vibrio angullaram* and several viral pathogens such as IPNV (infectious pancreatic necrosis virus). CCVD (channel catfish virus disease), VHSV (viral hemorrhagic septicemia virus), IHNV (infectious haemopoitic necrosis virus), etc. are being tried on large scale. Serodiagnostic methods that included Fluorescent antibody test (FAT), Enzyme immuno assay (EIA) and passive haemagglutination (PHA) are employed. Study of virus, viral vaccine preparations, incubating temperature and pH are the determining factors for fish cell culture. "Formalin inactivated vaccine" for hemorrhagic septicemia in grass carp is adopted in China.

Chemotherapy:

The term chemotherapy was introduced by Paul Ehrlich (1854-1915) cited by Smith, 1967; who was a pioneer in the development of chemotherapeutic agents (Table.7.2). It is a procedure employed to restore normal health condition of fish. Therapy is applied in 3 ways – external treatment, systematic treatment through diet and parentreal treatment.

Table 7.1. Chemoprophylactics

	Disinfectants	*Treatment*	*Control*
1.	Acriflavin	3-10 ppm for pond treatment. Bath in 500 ppm for 30 minutes	Protozoan and egg disinfection
2.	Calcium hydroxide	Sprinkle in drained out pond. In perennial ponds apply 1-2tons/ acre	Pond disinfection
3.	CaCI	25-1800mg/litre of water depending on situation	Pond disinfectant
4.	Calcium oxide	46-60 ppm or 2000 kg/ha in drained wet ponds	Pond disinfectant

5.	Malachite green	(i) Dip treatment in 66 ppm for 10-30 seconds (ii) 1-5 ppm bath for 1 hour	Fungus prevention in eggs
6.	Malathion	0.25.3 ppm in nursery pond application	Killing of copepods
7.	Potassium permanganate	(i) 5 ppm to be used in alternative days (ii) 500-1000 ppm as dip bath for 10-30 seconds	Prophylaxis against external protozoa, fungi, etc. Ulcerative diseases
8.	Lime and KMnO4	Bath 5 ppm for short time	Bacteria, Hemorrhagic diseases, fungal infections
9.	Quarternary Ammonium Alkyldimethylbenzyl – NH4Cl	1-2 ppm (100% concentration) product	Fungus, parasites compounds.
10.	Trichlorphon and	Mild dose dichlorvus	Ectoparasites, Argulus Learnea
11.	Copper sulphate	Concentration depending on	Forectoparasites the hardness of water (0.8 – 1 ppm)
12.	Sodium chloride	Bath for 3 days	As hauling prophylactics
13.	Formaldehyde	Mild dose	Egg disinfectant
14.	Iodine and Iodophors	Use Iodine for 10 – 15 minutes	Egg disinfectant
15.	Soap and oil application	18 kg soap + 56 kg diesel oil/ha	Insect control
16.	Dipterex	0.3 ppm	Argulus and ectoparasites

Antibacterial agents or antibactics include Sulfonamides, nitrofurans, furanace, tetracycline. 4-quinolones, erythromycine, chloramphenicol which are being used to combat fish diseases (Table.7.2). In 1941, the term “antibiotic” was defined by Waksman (1946) as a chemical substance produced by microorganisms which have the capacity to inhibit the growth of bacteria and even destroy bacteria and other microorganisms in dilute solution.

Table 7.2. Chemotherapy

	Antibiotics	Dose	Disease
1.	Sulfamergine and sulfamethazine	As feed for 2 to 3 weeks	Columnaris, Furunculosis, Gram+ve bacteria, *Vibrio angullarum*, vibrio sp., Bacteria diseases, sporozoan diseases, viral (vibrio), Gill rot, Bacterial septicemia, protozoan disease
2.	Nitrofurans (feroxone, Nitrofurazone, funrazolidone furazone etc.)	(i) 50-75 mg/kg as feed for 20 days 1 ppm solution bath for (ii) 5-10 minutes	
3.	Oxytetracycline	(iii) 50-75 mg/kg as feed for for 10-15 days (iv) intraperitoneal injection -- 20-30 mg/kg of fish (v) Long duration bath in 10-20 ppm solution	Bacterial diseases, Fungal *diseases, Vibrio anguillarum*
4.	Streptomycin	20-25 mg/kg of fish as intraperetoneal injection in combination with pencillin 20,0000 IU/kg of fish	Columnaris, Bacterial septicemia
5.	Erythromycin	25-50 mg/kg per day as feed for 4-7 days	Streptococcus
6.	Chloramphenicol	(i) 50-100 mg/kg fish/day for 5-10 days (ii) intraperitoneal 1 injection at 12 mg/kg body weight	*Aeromonas liquifaciens Aeromonas*
7.	PVP-Iodine	Injection	IPN virus

7.2.2 Non-parasitic diseases

Non-parasitic diseases are classified into environmental and nutrietional fish diseases.

7.2.2.1 Environmental Fish Diseases

Environmental diseases are belongs to non-paracitic diseases.

The environment, in which the fish live and grow plays an important role for fish health. Any deterioration in the environmental qualities often creates stress to fish and favour multiplication of pathogens. Though the fish has defensive mechanism against pathogens in the form of scales, epithelial cells, acid and alkali media of alimentary canal, which offers resistance to pathogens, and finally the defense mechanisms regulated by immune system and phage cells, the pathogens predominate and diseases occur in fish farming systems.

Stress response from the environment leads to fish mortality in extreme cases. At sub-lethal level, there may be several other responses like changes in fish behaviour, reduce growth/food conversion efficiency, reduced reproductive potential, reduced tolerance to disease, and reduced ability to tolerate further stress.

The environmental diseases diagnosed are

a) Depletion of oxygen – The mouth remains open. Gills look pale with wide opercle. Bigger fishes die first.
b) Excess of carbondioxide – Excessive secretion of mucus or high pH level in pond by epithelial cells.
c) Nitrogenous waters and ammonia accumulation – Gills look dark red due to formation of methaemoglobin, a combination of nitrogen and haemoglobin.
d) Supersaturation of oxygen or nitrogen – Accumulation of gas bubbles within the body cavity of fish spawn.
e) Excess of hydrogen sulphide gas – Pond muck smells like rotten eggs. The bottom dwelling fish come up to the surface and die first.
f) Organic pollution – Dropping of pectoral fins in case of organo-phosphorus pesticide. Oozing of blood from eyes in some cases.
g) Algal toxicosis – Algal bloom may appear in ponds due to accumulation of plenty of organic matter; or due to excessive chemical fertilizers. Toxins released by blue-green algae like *Microsystic*, *Aanabaena* and *Aphanizomenon* kill other phytoplankton and cause surfacing of fish stock. Persistence of the bloom will cause toxicosis for the fish stock showing symptoms like convulsions leading to death.

h) High temperature of water – The fish on crossing tolerance limit shows the alarm syndrome initially i.e., coming up to the surface, splashing water and finally exhausted and swimming to the bottom. Indian minor carps die when the temperature is 390C and air breathing cat fishes get exhausted at 420C.

i) Europhication – Water body looks pea-soup green in colour due to bloom of blue green algae.

a. Prevention against environmental diseases:

Proper sanitation by removing muck from pond bottom regularly and exposing the bottom soil to the sun. During summer months, when water level in perennial pond remains at its lowest, lime and potassium permanganate can be used in maintaining sanitation. Liming of ponds has become a must in maintaining sanitation in nursery, rearing and stock ponds. Through restricted use of manure, fertilizer and fish feed, both primary producer (algae) and primary consumer (zooplankton) need to be kept under control, or else the supersaturation or depletion of oxygen will create problems.

b. Acidosis and alkalosis:

A great majority of fish live in pH 7-8. However, if the pH of water goes down drastically owing to reduction of calcium salts or release of humic acids from the soil, a phenomenon known as acidosis results, when the fish may show very rapid swimming movements and a tendency to jump out of water. In the gills of carps, acidosis causes dark-greyish deposits, darkening of the edges and mucous secretion. In the event of mortalities in ponds due to acidosis. The pH must be normalized with powdered calcium carbonate and not with quicklime.

Aquatic plants present in high densities liberate enormous quantities of oxygen during photosynthesis which is responsible for the formation of insoluble calcium carbonate from calcium bicarbonate followed by the formation of calcium oxide with the elimination of carbon dioxide. This phenomenon is known as alkalosis. Excessive alkaline condition leads to the corrosion of bronchial epithelium and fins. Alkalosis can be prevented by buffering the medium by means of suitable calcification. Excessive plant growth in ponds should also be avoided. The lethal acid and alkaline ranges are <4.8 and >9.2 in trout, <5.0 and >10.8 in carps and <4.0 and >9.2 in perches respectively.

c. Gas bubble disease:

When nitrogen of the water is higher than 125 percent saturation due to rapid temperature change, gas bubble disease may result and fish fry particularly, die in large numbers. Fish affected by this disease often swim at an angle of 450 with their head pointing down. Other symptoms are the presence of bubbles beneath the skin, on fins, around the eyes, in the stomach and intestine or in blood capillaries. In such conditions, water should be well agitated to bring down the nitrogen saturation below110 per cent or affected fish should be transferred to other ponds. Besides nitrogen, supersaturated levels of oxygen (>350 percent air saturation) have also been reported to cause gas bubble disease in fishes.

7.2.2.2. Nutritional disease

Nutritional fish diseases can be attributed to deficiency, excess or improper balance of components present in the food available. Symptoms appear gradually when one or more components in the diet drop below the critical level of the body reserves. Nutrition diseases are presented in Table 7.3.

Table 7.3. Nutritional diseases in fishes

Nutritional components	Symptoms
1. Protein	Reduce growth rate and body deformities
2. Carbohydrate	Depress the digestion, symptoms are similar to that of *diabetes millitis* in warm blooded animals. Enlarge livers. Sikoki disease in carp similar to diabetic symptoms
3. Lipids	W3 deficiency (linolenic series) causes discoloration, hypersensitivity to shock and large liver. Fat oxidised diet causes muscular destrophy, poor growth. Lipoid liver degeneration is characterised when liver glycogen is replaced by lipoid and ceroid produced from liver lipid

		through fat metabolism. Visceral granuloma is due to auto xidation of lipid in diet. Enteritis and hepatoma are due to aflatoxin in diet.
4.	Minerals	Thyroid hyperlasia or goiter caused by iodine deficiency. Dicalcium phosphate deficiency cause scoliosis in carps.
5.	Vitamins (water soluble)	1. Thiamine (vit-B1) deficiency resulted in poor appetite, muscle atrophy, loss of equilibrium similar to that of whirling disease symptoms in trout, odema and poor growth. 2. Riboflavin (vit-B2) corneal vascularisation, cloudylens, hemorrhagic eye, photophobia, dim vision, incoordination, discoloration, poor growth and anemia. 3. Pyridoxine ((vit-B6) Nervous disorders hyper irritability, aemia serous fluid, rapid gasping and breathing. 4. Panthothenic acid. Loss of appetite, necrosis and scarring, cellular atrophy, exudates on gills, sluggishness, cubbed gills, poor growth 5. Inositol. Fin necrosis anaemia, distended stomach, skin lesions and poor growth. 6. Biotin. Blue slime patch on body, loss of appetite, muscle atrophy, fragmentation of erythrocytes, skin lesion and poor growth. 7. Folic acid. Poor growth, lethargy, fragility of caudal fin, dark colouration, macrocytic anaemia, decreased appetite. 8. Choline. Anaemia, hemorrhagic kidney and intestine, poor growth. 9. Nicotinic acid. Loss of appetite, photophobia, swollen gills, reduced cooridation, lethargy 10. Vitamin (B12) cobalamin derivative. Erratic haemoglobin level, erythrocyte counts and cell fragmentation. 11. Ascorbic acid. Lordosis and scoliosis eroded caudal fin, deformed gill operculum, impaired collagen formation.

Fat soluble vitamins

Vit-A - Vit-A causes expthalmos, ascite, odema, hemmorhagic kidney. Hypervitaminosis (A) cause necrotic caudal fin

Vit-D - Necrotic appearance in the kidney

Vit-K - Mild cutaneous hemorrhages due to ineffectiveness of blood clotting

Vit-E - Exophthalmia, distended abdomen, anemia with reduced RBC numbers and haemoglobin content. Accumulation of ceroid in fish liver.

7.3 Therapeutic Methods

In recent years, prawns and fishes have gained considerable attention as they form much sought after candidate species in semi-intensive and intensive culture systems. One of the principal factors limiting their productions from natural sources, hatcheries and culture operations have been outbreaks of various disease which cause severe mortalities of the valuable shrimp and fish stock and bring forth considerable economic and production losses. According to a more conservative estimate the farmers of Andhra Pradesh alone have suffered about 500 crores rupees losses by the recent outbreak of white spot disease epizootic of *Penaeus monodon* in the last quarter of 1994 and first quarter of 1995. These great losses suffered by the aquaculture-industry due to outbreak of diseases underlines the need to focus more attention on this aspect of aquaculture arid to divise suitable trtera-; peutic measures for the treatment and control of shrimp diseases:.

7.3.1 METHODS OF THERAPY IN fish DISEASES

The shrimps are pokilothermic invertebrates. They are highly delicate animals. Any fluctuation in their aquatic habitat cause significant effects on their physiology leading to outbreak of diseases and subsequent mortalities. These variables have a direct bearing on the use of therapeutic agents in combating different diseases. There are many methods of administering therapeutic agents some common among them are as follows

7.3.1. Pond treatment

This technique is frequently used in ponds where shrimps can not be easily removed or concentrated and where the ponds are undrainable. But this method of treatment is effective only in small water bodies, aquaria, cisterns and pools. Moreover, only low concentrations of chernotherapeut i cs can be used as they must be dispersed by natural processes. Acute and advanced diseases can bot be treated effectively by this method as the chemical concentrations are too low to work rapidly. However, this is a very effective method of prophylactic treatment of shrimps for external parasites.

7.3.1.2 Bath treatment

This method is useful in culture facilities having sions for rapid flow of water. Alternatively, aquaria, sized plastic or aluminium vessels may also be useful and. The bath treatment is essentially of short duration lasting minites to a maximum of one hour only. In this case the re dose of therapeutic agents are mixed thoroughly in the ve<r.s affected shrimps are put into it. Care must be taken to gau stress levels and oxygen depletion due to high population.

7.3.1.3 Dip treatment

In this method the shrimps are placed in a hand net arid dipped into a concentrated solution of chemotherapeutant for one minute or less. This method has been found highly effective in treatment of acute diseases, but it may cause additional stress on the affected shrimps. Thus' care should be taken to immediately release them back into the pond water once treatment is over.

7.3.1.4 Flush treatment

In this technique, the entire doses of the chemical is added at the inlet and allowed to pass through the flow of water into the pond. This method is more applicable in raceways or recircu— latory systems. It has an advantage of using relatively high concentrations of chemicals with virtually no stress due to handling or oxygen depletion. But in this method the distribution of drug depends greatly on the flow pattern of water. Dead spots such as corners may recieve little or no chemical.. Shrimps in those areas are not treated properaly and may die or serve as reservoir of infection.

7.3.1.5 Constant flow treatment

This method is useful where the water supply is contaminat ed. The shrimps are constantly exposed to pathogens under these conditions and constant presence of drugs may be necessary to prevent outbreaks. Here a constant flow siphon or metering pump is used to monitor the drug to give a constant low concentration of therapeutant. This method is used in ponds having constant flow of water or in large commercial aquaria with recirculatory or running water facility.

7.3.1.6 Feed treatment

This technique is highly popular tp administer drugs to shrimps for systemic infection. Here, the required drugs -are mixed with the diet and pellets are prepared. The drugs are mixed with the vegetable oil, gelatin or methyl re1lulose and dry feed pellets are coated with it. Mi croencapsulated feed are also prepared combining choiced medications and the same is fed to the affected shrimp. Both these methods prevent leaching of valuable drugs into the water. It should be ensured to have even and uniformly mixing of drugs in the feed and effective utilization of medicated Feed by the affected shrimps. Underdose will *be* ineffective, while overdose may be toxic.

7.3.1.7 Paranteral treatment

Paranteral injections are applicable only in the case of valuable broodstock, berried spawners, etc. In smaller size shrimps, it is not practicable. Intramuscular injections ventral-ly in the lower abdominal region can be administered conveniently. Care should be taken to employ small sized needle otherwise it will peirce the whole body and drug may also be leaked. However, the injection method is time consuming and the required handling is highly stressful to shrimps.

7.3.1.8 Topical treatment

Shrimps and fishes suffer from many external parasite, fungal and bacterial infections, which respond to topical application of drugs. The lesions, ulcers and localized injections of valuable shrimps may be treated with topical application of concentrated chemicals, antiboiotics etc.,

Summary

Fish are prone to hundreds of parasitic and non-parasitic diseases, especially when grown under controlled conditions. Adverse hydrological conditions often precede parasitic attacks, as the resistance of fish is thereby lowered. Mechanical injuries sustained by a fish when handled carelessly during fishing and transport may also facilitate parasitic infection.

The diseases of fishes are classified as parasitic diseases and non-parasitic diseases.

Viruses are transmitted from one host to the other through a structure called virion. Viruses are classified mainly based on external structure, shape, size, capsid structure, RNA and DNA nucleic acids. Viruses cause disease by weakening the host tissue or by forming tumors in the host tissues. There is no treatment for viral diseases, only prophylactic measures have to be taken.

Bacteria are responsible for many fatal diseases in fishes like furunculosis, columnaris, fin or tail rot, vibriosis, dropsy, cotton mouth disease and tuberculosis.

The fungal diseases in fishes are Saproligniasis, Branchiomycosis and Ichthyophonosis.

The protozoan diseases in fishes are Whirling disease, Costiasis and Ichthyophthiriasis.

The helminthic diseases in fishes are Dactylogyrus and Gyrodactylosis.

The crustacean diseases in fhish are Argulosis, Lernaeasis, Ergasillus and salmincola.

Cyanophyceae member, *Oscillatoria* is responsible for fish mortality. It is found on gills and fish body in large numbers and produce toxic substances, which are responsible for fish kill. *Chlorella* and *Pharmidium* also cause discomfort in fishes.

Epizoic Ulcerative Syndrome, popularly known as EUS, has caused severe damage to India's aquaculture, especially at the moment when the Indian fisheries industry is poised for a great leap forward with high input based hitech production systems. Widespread outbreaks of the disease, occur suddenly and often cause mass mortality in freshwater and brackishwater fishes causing anxiety and tremendous concern.

One common feature of the disease is that it initially affects the bottom-dwelling species like murrels, followed by catfishes and weedfishes.

This syndrome has been disturbingly found to affect a variety of fish species, both wild and culturable, resulting in large scale mortalities. The most severely affected ones are *Channa sp., Puntius sp., Clarias batrachus, Heteropneusters fossilis and Mastacembelus.*

Therapeutic methods are pond, bath, dip, flush, constant flow and feed treatments

Questions

1. Discribe the parasitic disease in fishes.
2. Discribe the non-parasitic disease in fishes.
3. Discuss the health management in fishes.
4. Discribe the nutritional diseases in fishes.

8. COMPOSITE AND INTEGRATED FISH FARMING

The basic principle of composite fish culture system is the stocking of various fast-growing, compatible species of fish with complementary feeding habits to utilize efficiently the natural food present at different ecological niches in the pond for maximising fish production. Composite fish culture technology in brief involves the eradication of aquatic weeds and predatory fishes, liming: application of fertilizers on the basis of pond soil and water quality, stocking with 100 mm size fingerlings of Indian major carps-catla, rohu, mrigal, exotic carps, silver carp, grass carp and common carp in judicious combination and density; regular supplementary feeding and harvesting of fish at a suitable time. Composite fish culture system is conducted by adopting three types of combinations viz., culture of Indian major caps alone, culture of exotic carps alone, and culture of Indian and exotic carps together. Fish production ranging between 3,000 to 6,000 Kg. per hectare per year is obtained normally through composite fish culture system. Development of intensive pond management measures have led to increase the fish yield further. Integated fish and animal husbandry systems evolved recently are the fish-cum-duck culture, fish-cum-poultry culture, fish-cum-pig culture, utilization of cattle farm yard wastes and recycling of biogas plant slurry for fish production.

Advantages of the combined culture systems, number of birds/ animals, quantity of manure required and fish production potentiality of the recycling systems are described. Fish culture in paddy fields is an important integrated fish cum agriculture system. Essential requirements of paddy fields to conduct fish culture, characteristic features suitable for culture in rice fields, constraints to culture fish in paddy fields due to recent agrarian practices, and improved fish-paddy farming methodologies are discussed. Freshwater prawn culture is a recent practice. Giant freshwater prawn *Macrobrachium rosenbergii* and Indian riverine prawn *M. malcolmsonii* are the two most favoured species for farming purposes in India. Breeding, hatchery management, seed productio, culture systems and production potentialities of the freshwater prawns are presented. Commercially important air-breathing fishes of India are the murrels, climbing perch, singhi and magur. Techniques of their seed production and culture systems are described.

8.1 Composite fish Culture

The main aim of fish culture is to achieve the highest possible fish production from ponds and water resources. The techniques of fish cultivation involve both management of soil, water and husbandry of fish. Two criteria, less consumption of water by fish and high fecundity, go very much in favour of fish cultivation. Fish provide high quality food rich in protein, vitamins and other nutrients necessary for human health and growth.

Population explosion results in the area of cultivable land getting reduced, and consequently, animal protein is likely to be less in future due to limitations of space and food. This indicates that more and more animal proteins will have to be procured from the waters. We have to think as to how to produce more animal protein. The fish is a very good source of protein. We have to consider the production of more fish under controlled conditions in ponds as these offer the greatest potential of all.

The fish pond is a complex ecosystem. The surface is occupied by floating organisms like phytoplankton and zooplankton. The column region has live and dead organic matter sunk from the surface and the bottom is enriched with detritus or dead organic matter. The marginal areas have a variety of aquatic vegetation. The different tropic levels of a pond are utilized for increasing the profitability of fish culture. In view of this a recent concept in fish culture has been formulated called composite fish culture. It is also known as polyculture or mixed farming. The main objective of this intensive fish culture is to select and grow competable species of fish of different feeding habits to exploit all the types of available food in the different regions or niches of the fish pond to get maximum fish production.

In olden days, the average yield of fish from ponds was as low as 500 kg/ha/yr. This quantity is considered as very poor. In composite fish culture more than 10,000/kg/ha/yr fish yield can be obtained in different agro-climatic regions of our country.

8.1.2 Superiority over the monoculture

Monoculture is the culture of a single species of fish in a pond. If only one species is introduced into a pond, due to the same dietary habits, all the fish congregate at one place. Naturally, when monoculture is preferred, more number of fish of one species are introduced. This results in high competition for food and space. Due to the fights, heavy mortality of fish will occur. Because insufficient amount of food, the fish will not grow to good size and the yield is affected. In monoculture systems other niches are vacant and in that area and the available food in these niches remains wasted.

Composite fish culture is undoubtedly more superior over monoculture. In composite fish culture, the above problems will not be found. Six varieties of fishes utilize food of all niches of the pond, get good amount of food, grow well without any competition and the yield is also very high. The mortality rate in composite fish culture is negligible. In monoculture a yield of about 500/kg/ha/yr is difficult, but in polyculture system the yield is about 20 times more than that of monoculture with scientific management.

8.1.3 Principles of composite fish culture

The scientific based technology of composite fish culture aims at maximum utilization of the pond's productivity. Fast growing, non-predatory, non-competable species of food fishes are cultured together with complementary feeding habits and capable of utilizing both the natural and supplementary fish food. At the same time one fish is useful to the other. For example the excreta of grass carp is useful for growing fish food organisms, on which other fishes feed. The fishes never face any competition for space and food. Bottom feeders like common carp and mrigal subsist partly on the faecal matter of grass carp. If the bottom feeders are absent in a culture pond the excessive faecal matter of the grass carp may pollute the water. Stocking optimum number of each kind of fish adequately utilizes the different ecological niches. The productive potential or carrying capacity of the pond can be increased by stimulating natural fish food production through fertilization and the use of supplementary feed to provide adequate food for the large number of fish stocked.

8.1.4 Fishes used in composite fish culture

All over the world, the major cultivable fishes, especially for polyculture belong to the carp family. There are three major systems of carp culture in the world. These are:

1. Chinese system :- The Chinese carps are cultured together. These are silver carp - *Hypophthalamichthys molitrix*, grass carp - *Ctenopharyngodon idella* and common carp - *Cyprinus carpio*. These are also called as exotic fishes in India.

2. Indian system :- The Indian carps are cultured together and are also cultured with Chinese carps. These carps are rohu - *Labeo rohita*, catla - *Catla catla* and mrigal - *Crirrhina mrigala*.
3. European system :- The main species cultured is the common carp - *Cyprinus carpio*.

Other Chinese carps used for composite fish culture are : big-head carp - *Aristichthys nobilis*, mud carp - *Cirrhinus molitorella* and black carp - *Mylopharyngodon piceus*.

The predatory catfish and murrels can also be incorporated in the composite fish culture system. However, catfish and murrels should be stocked only after the carp species have grown to a considerable size. The trash fish and the young of common carp if any, in the culture pond would serve as a good source of food for catfish and murrels.

The fringe-lipped carp and the milk fish are commonly cultured in the composite fish culture in brackish water culture system. The air-breathing fishes like murrels, catfishes and koi are also cultured together in the freshwater culture system.

In India and China, polyculture is more popular unlike in the European countries, where monoculture is still common and prevalent. Due to the fact that seed production of common carp is easier than that of the other cultivable carps, perhaps, it has been the dominant cultivated species throughout the world.

Indian major carps are more riverine in nature and these do not ordinarily breed in confined waters. Hence, their young ones are still collected during the monsoon season from the flooded rivers. Species-wise segregation of natural collection is most difficult, their mixture along with undesirable species are stocked in the ponds. This practice eventually gave rise to the system of polyculture, the scientific basis of which has been realized recently.

During the late fifties exotic carps species, common carp, silver carp and grass carp were introduced in India. These have been successfully cultured together and are now cultured along with Indian major carps. The grass carp in a culture system is essential as it helps in the biological control of aquatic weeds. Grass carp feed voraciously on aquatic vegetation. Composite fish culture is the most significant development of the country in freshwater aquaculture, during which period, the evolution of multispecies fish culture technology in stocking ponds took place.

At each trophical level in the food chain, considerable amount of the original energy is lost from the system. Hence, efficient fish culture aims at making the chain as short as possible. Thus, herbivorous fishes are preferred along with zooplankton feeding fish. It is always better to exclude carnivorous fishes from the system.

Usually a mixture of plankton and macrophyte feeders are stocked in fish culture systems. They utilize the nutrients, which are already found in the ponds or applied from outside. If the proper balance is not maintained they do not grow at the same pace and one group dominates over the other, often utilizing most of the nutrients and leaving litter for the other. To maintain a balance, stocking is done with a mixture of fishes of different feeding habits. Ungrazed phytoplankton are fed upon by the zooplankton, and to utilize them the fish which feed on these zooplankton are included in the combination. The best combination in India in a polyculture system is rohu, catla, mrigal, common carp, silver carp and grass carp. Their feeding habits are entirely different, they never compete with each other and are not predatory fishes. Rohu is a column feeder and utilizes the plankton of that area only. Catla is a surface feeder and feeds on only Zooplankton. Mrigal is bottom feeder and fee on the plankton which is available at the bottom, mostly benthos. Common carp is also bottom feeder, but eats the detritus only. Silver carp is a surface feeder, but feeds only on phytoplankton. Grass carp feed only on aquatic vegetation. That means they utilize most of the food organisms present in the pond. The combination of the phytoplankton-feeding silver carp, the zooplankton-feeding big head and the weed-eating grass carp is most common in China and South-East Asia.

8.1.5. Stocking densities and stocking ratio

Generally fish production increases with the increase in the number of fish stocked per unit area to a maximum and then starts decreasing. There is always an optimum stocking rate in a particular situation, which gives the highest production and largest fish. Under crowded condition at a higher stocking density fish may compete severely for food and thus suffer stress due to aggressive interaction. Fishes under stress eat less and grow slowly. By increasing the stocking density beyond the optimum rate the total demand for oxygen increases with obvious dangers, but no increase of the total yield of the fish is obtained. Stocking density and stocking ratio of fishes should be on the basis of the quantity of water and the amount of oxygen production. The above six varieties of Indian and Chinese major carps should be stocked at a rate of 5000 fingerlings of 75-100 mm size/ha. The percentage of stocking of the above fishes can be as follows:

Catla and silver carp	-	30 - 35 %
Rohu	-	15 - 20 %
Mrigal and common carp	-	45 %
Grass carp	-	5 - 10 %

In the 5 - species combination excluding grass carp, the optimal stocking ratios are catla 6(30%) : rohu 3(15%) : mrigal 5(25%) : common carp 4(20%) : silver carp 2(10%).

In a 4 - species combination excluding silver carp and grass carp, the optimal stocking ratios are - catla 6(30%) : rohu 3 (15%) : mrigal 6(30%) : common carp 5(25%).

In a 3 - species combination excluding exotic carps, the optimal ratios are - catla 4 (40%) : rohu 3 (30%) : mrigal 3 (30%).

An 8 - species combination is also possible for composite fish culture, where milk fish and fringe-lipped carps are included in the culture system along with Indian and Chinese major carps. But the growth of the additions is not satisfactory. The milk fish is a brackish water fish. Usually the stocking ratio is catla 2 : rohu 2 : mrigal 4 : common carp 3 : silver carp 5 : grass carp 2 : fringe-lipped carp 1 : milk fish 1.

8.1.6 Management techniques

Pre-stocking management and post-stocking management methods are already discussed in the stocking pond management chapter, 5.

8.1.1.6 Feeding:

With the increase in the carrying capacity of the pond either by aeration of water, fish growth can be augmented further with the addition of supplementary feed. For getting very high production, fishes are fed with protein - rich feed. Usually the conversion coefficient is 1 : 2 i.e. 2Kg of feed is given for every 1Kg of fish yield. With supplementary feeds such as rice bran and oilcake, the fishes grow 10 times more. Detailed information is given in the chapter on supplementary feeding.

The Grass carp are normally fed tender aquatic weeds, like *Najas*, *Hydrilla*, *Ceratophyllum* and *Chara*, forage grasses or chopped green cattle foders like Napier grass, Barseem, maize leaves, etc and kitchen vegetable refuse. The cattle fodder is grown on the terraced embankment of the pond and fed to the grass carp. They are fed twice at the rate of 100 Kg/ha in the first month and the quantum is increased by 100Kg/ month at fortnightly or monthly intervals, till the end of harvesting. The food of grass carp is normally placed on a floating frame made of bamboo poles.

8.1.6.2 Harvesting and yield:

Harvesting of fish is generally advocated after one year of rearing. Shorter rearing periods may also be resorted to depending on the pond conditions and size preference in the local markets. An individual fish grows to the size of 0.8-1Kg in 12 months. Grass carp have a faster growth rate and attains a size of 3Kg weight in and year. It contributes to about 30% of the total fish production of a pond. Recent results in Pune, indicated a new record in fish production through composite fish culture. The production obtained was 10, 194 Kg/ha/yr in a 0.31 ha pond with 8000 fingerlings per hectare. An average production of 5000Kg/ha/yr can easily be obtained from the culture system. This clearly indicates the potentiality of fish production through composite fish culture.

Trial netting is done once a month to check the growth of the fish. It also helps in timely detection of parasitic infection if any. Netting also helps in raking the pond bottom which results in the release of obnoxious gases from the pond bottom as well as release of nutrients from the bottom soil.

In an experiment on polyculture of brackish water fishes like *Chanos chanos, Mugil cephalus, Etroplus suratensis* and *Liza parsia* a production of 2189Kg/ha/yr was obtained. The combination of *Chanos* and *Mugil* showed the highest production. *Chanos* showed the best growth followed by *Mugil.*

8.1.7 Hazards in composite fish culture

Composite fish farming runs the risk of encountering several incidental hazards, which may cause heavy losses unless they are anticipated and remedial measures taken in time in order to overcome them. Most of the problems emanate because of poor management. Hazards may be either biological or problems of management or harvesting

8.1.7.1 Biological problems:

Biological hazards arise from the existence of weeds, predatory fishes, insects and snakes in the culture ponds. These problems can be controlled if sufficient measures are taken before stocking fishes in between successive cultures.

Aquatic weeds, if any found in the pond, can be very effectively controlled by the introduction of weed eating fishes like grass carp and *Puntius* species. The common predatory fishes *Mystus, Ompok, Wallago, Notopterus, Oreochromis, Gobius*, etc. and weedy fishes, *Salmostoma, Esomus, Barbus, Ambasis, Rasbora, Amblypharyngodon*, etc., are found in the ponds and compete with fingerlings of carps. These should be eradicated during the preparation of the pond. Aquatic insects such as beetles, *Cybister*, *Stemolopus; bugs, Belostoma, Anisops* and dragon fly nymphs, etc. should be eradicated.

Others like snakes also cause considerable damage to the fish crops by feeding on fingerlings. Molluscs in large numbers always affect the fish adversely. They can be controlled by stocking the fish, *Pangasius pangasius* in the pond. They feed on molluscs and reduce their infestation.

Due to the early maturity and natural breeding of the common carp, the rate of these fishes is increased and the stocking density of the culture pond is greatly altered unless some precautionary measures are taken. Hence, common carp may be harvested before they are fully ripe. Otherwise aquatic weeds can be kept in the corners of the pond to lay eggs which are adhesive in nature. The weeds with attached eggs can be removed and the eggs, if so desired, can be incubated separately to obtain hatchlings. By this, the farmers will avoid the breeding of common carp in the pond with less cost and at the same time raise the spwan for sale. Common carp, because of its burrowing nature, can spoil the dyke by making holes in it. Crabs also damage the dyke. Tilapia is a continous breeder, hence it must be avoided in the ponds.

Algal blooms with *Microcystis, Euglena,* etc. which are found generally in summer months cause serious problems of dissolved oxygen. During day time oxygen is supersaturated and in the night oxygen is depleted. The chemical method is good for eradication of blooms. Pumping of freshwater into the pond at the time of emergency is a safe method. A part of the pond is covered with shady plants like *Eichornia* and *Pistia* so as to cut off light. But if they spread in the pond again eradication is a big problem.

The most serious and common hazard is the depletion of oxygen level in the water. The distressed fishes swim at the surface with their snouts protruding above to gulp the air. The growth rate of the fish is seriously affected and often mass mortality occurs. When the fishes come to surface to engulf air, the farmer must aerate the water by pumping freshwater into the pond to save his fish crop. To increase the oxygen content of water, he should beat the water with bamboo poles. Addition of KMnO4 (1ppm) increases the dissolved oxygen content of water and also acts as a disinfectant. Quick-lime or slake-lime at a rate of 200 Kg/ha should also be added to counteract the adverse effect of putrication of organic matter. Repeated drag net facilitates the release of obnoxious gases. Cut banana stem has also beneficial effects on the fish in the above circumstances.

In composite fish culture, excessive growth of plant material is cut down by silver carp and grass carp which subsist on phytoplakton and aquatic weeds respectively. Presence of mrigal and common carp also considerably reduces the adverse effects created by the depletion of oxygen due to the decomposing organic matter since they feed on it. Many ponds in the village are completely shaded by large trees and bamboos, and these interfere seriously with the photosynthetic process in the ponds by cutting down the sunlight. The situation becomes much more serious during windy days and especially during spring when the falling leaves start putrefying in the water. It is always desirable to avoid trees and bamboos as much as possible onthe margin of the pond. Banana plants can be planted on the dyke, except on the eastern side so that the sunlight is not cut off by these in the morning. Banana plantation should not be allowed to become bushy. The dwarf variety is most suitable for this purpose. Fish diseases is another problem in the culture pond, fish diseases are discussed in detail in chapter-VI,G.

8.1.7.2 Management problems:

It is always necessary to keep at least 1m of water in the pond. Serious drought severely affects the level of the water in the rain-fed ponds. Alternative sources of water supply like tube-wells could be of some help in fighting against drought. Heavy rain and flood cause serious damage to the ponds by breaking the dykes or over flooding them. In both the cases the fish escape from the pond. Temporary measures such as protection of the dykes or screening of the ponds may be resorted to. Sometimes, it is better to harvest the fish even before such a situation is encountered. Poaching is another problem in fish culture. Besides employing watchmen, bushy plant materials can be introduced into the ponds to prevent easy netting. Trained watch-dogs may prove more effective and economical in controlling poaching.

8.1.7.3 Harvesting Problems:

It is essential to harvest the fish stock before the rate of growth of the fish for the invested inputs such as feed and fertilizers start declining. The nutritive value of water for feeding the fish cannot be increased after a certain stage. Differential growth complicates the harvesting program, and , it is suggested that, if the harvesting times are very much difficult to synchronize in a community of fish even after careful manipulation of stocking ratio and density, partial harvesting may be resorted to.

The sale prices of fish of less than a Kg is somewhat less as compared to those fish which weigh over a Kg or so. This also influences the harvesting programming, and, to get more profit it is essential to consider this aspect also before harvesting.

Interrelationship of the species cultured is also required to be seriously considered. Bottom feeders subsist partly on faecal matter of grass carp and an unplanned removal of grass carp would, in turn, affect the growth of the bottom feeder, whereas if only bottom feeders are totally harvested the excessive faecal matter of grass carp may pollute the water.

The hazards involved in composite fish culture are manageable and could be effectively averted with by proper precaution and vigil.

8.1.8 Economics

Economics of production of fish in composite fish culture varies from place to place depending on land price, soil condition, cost of labor, cost of farm construction material and transportation. It may not be possible to generalize the nature of fish production and its cost functions. Over all it is highly profitable.

8.2 Integrated fish farming

The land-holding of rural people are small and fragmented, and the modern large scale production technologies with high input requirements offer no tangible solution to their problems of low income and low productivity. These small and marginal farmers have livestock in the form of cattle, pigs, a small flock of ducks or chicks, agricultural land and surplus family labour. With these problems and resources, efforts are made to develop low cost farming systems based on the principles of productivity utilization of farm wastes, available resources and man power. The research efforts have resulted in the development of integrated farming systems, involving fish culture, livestock raising and agriculture. The package of practices for integrated farming have been developed and verified extensively for economic viability and feasibility at the farmer’s level.

Fishes can be reared in paddy, wheat and coconut fields. Fruiting, flowering plants and vegetable plants are cultivated on the dykes. Azolla - fish culture is also becoming popular.

8.2.1 Paddy - cum - fish culture

Paddy - cum - fish culture is a promising venture and if best management inputs are given it can bring fancy returns to the growers. The system works well in paddy fields fed copiously by rivers or lakes. India has a traditional system of paddy - cum - fish culture largely practiced in the coastal states of Kerala and West Bengal. However, paddy - cum - fish culture in freshwater paddy fields has not been popular although considerable potentiality exist in India. In India, though six million hectares are under rice cultivation only 0.03 percent of this is now used for rice - fish culture. The reason for this is largely attributed to the change in the cultivation practice of paddy from traditional methods to the more advanced methods involving high yielding varieties and progressive use of pesticides. Multiple cropping further improved the returns from such agricultural land, thus shifting the emphasis from such integrated farming.

This integrated culture needs abundant water and low lying areas are most suitable. Many million hectares of water spread are most convenient for integrated culture. In this system two crops of paddy and one crop of fish can be cultured in an year.

Water-logged paddy fields are the ideal natural habitat of various types of fish. Fish in the paddy fields result in an increased yield of grain varying from 5 - 15 percent. Fish consume large quantities of weed, worms, insects, larvae and algae, which are either directly or indirectly injurious to paddy. Fish also assist in making fertilising material more readily available to paddy.

Advantages of paddy - cum -fish culture

Paddy - cum - Fish culture has several advantages such as

1. Economical utilization of land
2. Little extra labour is required
3. Saving on labour cost towards weeding and supplemental feeding
4. Enhanced rice yield by 5 -15 %, which is due to the indirect organic fertilization through the fish excreta

5. Production of fish from paddy field
6. Additional income and diversified harvest such as fish and rice from water and onion, bean and sweet potato through cultivation on bunds
7. Fish control of unwanted filamentous algae which may otherwise compete for the nutrients
8. Tilapia and common carp control the unwanted aquatic weeds which may otherwise reduce rice yield up to 50 %
9. Insect pests of rice like stem borers are controlled by fish feeding on them mainly by murrels and catfishes
10. Fish feed on the aquatic intermediate host such as malaria causing mosquito larvae, thereby controlling water-bom diseases of human beings
11. Rice fields may also serve as fish nursaries to grow fry into fingerlings. The fingerlings, if and when produced in large quantities, may either be sold or stocked in production ponds for obtaining better fish yield under composite fish culture.

Considering these advantages, it is imperative to expand fish culture in the rice fields of our country.

8.2.1.1 Site selection:

About 80 cm rainfall is optimum for this integrated system. Fields having an almost uniform contour and high water retention capacity are preferred. Groundwater table and drainage system are important factors to be taken into consideration for selection of site.

8.2.1.2 Types of paddy fields for integrated system:

Preparation of the paddy plot can vary according to the land contours and topography.

1. Perimeter type: The paddy growing area may be placed at the middle with moderate elevation and ground sloping on all sides into perimeter trenches to facilitate easy drainage.

2. Central pond type: Paddy growing area is on the fringe with slopes towards the middle (Fig. 8.1)

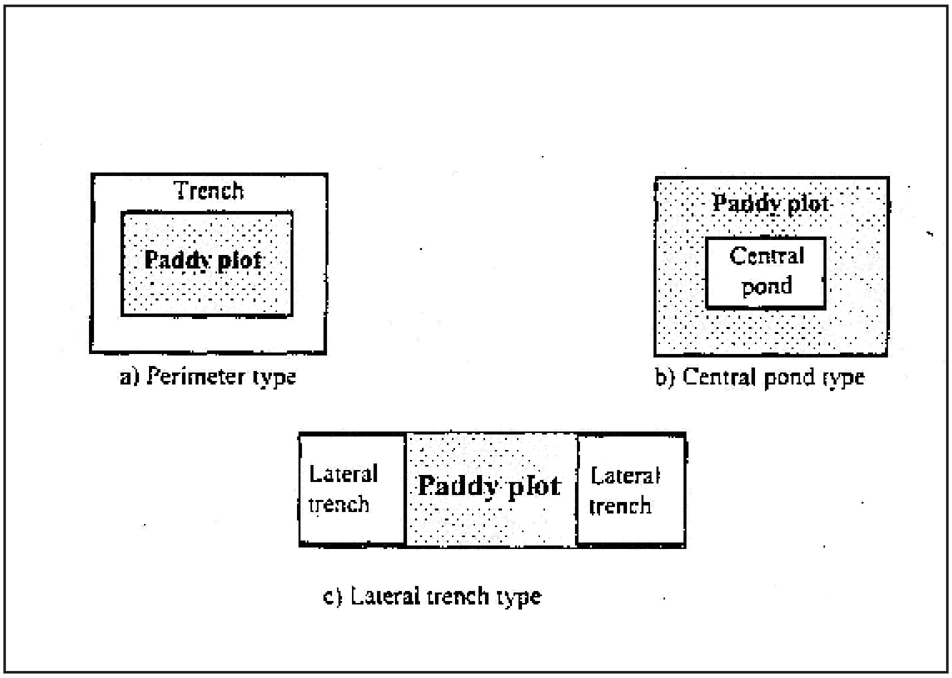


Fig. 8.1 Fish cum-paddy indegrated field

3. Lateral trench type: Trenches are prepared on one or both lateral sides of the moderately sloping paddy filed.

Suppose the area of the integrated system is 100 m X 100 m- i.e.,1 ha. The area to be utilized for paddy should be 82 m X 82 m -i.e., 0.67 ha. The area to be utilized for fish culture should be 6m X 352 m -i.e., 0.21 ha (4 sides). The embankment area should measure 3m X 388 m - 0.12 ha. and the area for fruit plants should be 1m X 388 m - i.e., 0.04 ha. This is an ideal ratio for preparation of an integrated system.

8.2.1.3 Paddy cultivation

1. Rice varieties used for integrated system: The most promising deep water varieties chosen for different states are PLA-2 (Andhra Pradesh) , IB-1, IB-2 , AR-1, 353-146 (Assam) , BR-14, Jisurya

(Punjab), AR 61-25B, PTB-16 (Kerala) , TNR-1, TNR (Tamil nadu), Jalamagan (Uttar Pradesh), Jaladhi-1, Jaladhi-2 (West Bengal) and Thoddabi (Manipur). Manoharsali rice variety seeds are used in rice fields where the fishes are reared.

The paddy plot should be made ready by April - May. Having prepared the plot, deep water variety of paddy is selected for direct sowing in low lying areas after the first shower of monsoon rain.

2. Fertilization schedule: The paddy plots are enriched with farm yard manure or compost at 30 t / ha on a basal dose. The nutrient uptake of deep water paddy being very high, the rate of inorganic fertilizer recommended are nitrogen and potassium at 60 kg/ha. Nitrogen and posphorus are to be applied in three phases viz., at planting, tilling and flowering initiation.

3. Pesticide use: Paddy - cum - fish culture is not developed much due to the use of pesticides in rice fields for the eradication of different pest and these are toxic to fish. To overcome the pesticide problem, the integrated pest control system may be introduced and pesticides less toxic to fish may be used in low doses, if absolutely necessary. Pesticides like carbomates and selective organophosptes only should be used. Furadon when used 7 days prior to fish stocking proved to be safe.

During the Kharif crop period, pesticides should be avoided. Harvesting of Kharif crop takes place in November - December. The yield in this crop is 800 - 1200 kg/ha.

During the Rabi crop, the pesticides can be used according to the necessity. Before adding pesticides to paddy, the dyke of the trench should be increased so that the pesticide may not enter into the trenches. The yield in this rice crop is 4000 - 5000 kg/ha.

8.2.1.4 Culturable species of fish in rice fields: The fish species which could be cultured in rice fields must be capable of tolerating shallow water (>15 cm depth), high temperature (up to 350 C), low dissolved oxygen and high turbidity. Species such as *Labeo rohita, Catla catla,* *Oreochromis mossambicus, Anabas testudineus, Clarias batrachus, Clarias macrocephalus, Channa striatus, Channa punctatus, Channa marulius, Heteropneustes fossilis, Chanos chanos, Lates calcarifer and Mugil sp* have been widely cultured in rice fields. The minor carps such as Labeo bata, Labeo calbasu, Puntius japanicus, P.sarana, etc. can also be cultured in paddy fields. Culture of freshwater prawn Macrobrachium rosenbergii could be undertaken in the rice fields. The selection of species depends mainly on the depth and duration of water in the paddy field and also the nature of paddy varieties used.

8.2.1.5 Major systems of paddy - cum - fish culture:

Two major systems of paddy-cum-fish culture may be undertaken in the freshwater areas:

1. Paddy-cum-carp culture
2. Paddy-cum-air breathing fish culture

1. Paddy-cum-carp culture: Major or minor carps are cultured in paddy fields. In the month of July when rain water starts accumulating in the paddy plot and the depth of water in the water way becomes sufficient, the fishes are stocked at the rate of 4000 - 6000 / ha . Species ratio may be 25% surface feeders, preferably catla, 30% column feeding, rohu and 45% bottom feeders mrigal or common carp.

2. Paddy-cum-air breathing fish culture: Air breathing cat fish like singhi and magur are cultured in paddy fields in most rice grown areas. The water logged condition in paddy fields is very conducive for these fast growing air breathing cat fish. Equal number of magur and singhi fingerlings are to be stocked at one fish/m2. *Channa* species are also good for this integrated system.

8.2.1.7 Fish culture in rice fields:

Fish culture in rice fields may be attempted in two ways, viz. simultaneous culture and rotation culture.

Simultaneous culture: Rice and fish are cultivated together in rice plots, and this is known as simultaneous culture. Rice fields of 0.1ha area may be economical. Normally four rice plots of 250 m2 (25 X 10 m) each may be formed in such an area. In each plot, a ditch of 0.75 m width and 0.5 m depth is dug. The dykes enclosing rice plots may be 0.3 m high and 0.3 m wide and strengthened by embedding straw. The ditches serve not only as a refuse when the fish are not foraging among rice plants, but also serve as capture channels in which the fish collect when water level goes down. The water depth of the rice plot may vary from 5 - 25 cm depending on the type of rice and size and species of fish to be cultured.

Five days after transplantation of rice, fish fry are stocked at the rate of 5000/ha or fingerlings at the rate of 2000/ha. The stocking density can be doubled if supplemental feed is given daily. The simultaneous culture has many advantages, which are mentioned under the heading advantages of paddy-cum-fish culture. The simultaneous fish - rice culture may have few limitations, like

1. use of agrochemicals is often not feasible
2. maintaining high water level may not be always possible, considering the size and growth of fish.
3. fish like grass carp may feed on rice seedling, and
4. fish like common carp and tilapia may uproot the rice seedlings. However, these constraints may be overcome through judicious management.

2. Rotational culture of rice and fish:

In this system fish and rice are cultivated alternately. The rice field is converted into a temporary fish pond after the harvest. This practice is favoured over the simultaneous culture practice as it permits the use of insecticides and herbicides for rice production. A greater water depth up to 60 cm can be maintained throughout the fish culture period.

One or two weeks after rice harvest, the field is prepared for fish culture. The stocking densities of fry or fingerlings for this practice could be 20,000/ha and 6,000/ha respectively. Fish yield could exceed the income from rice in the rotational culture.

8.2.1.7 Fish culture:

The weeds are removed manually in trenches or paddy fields. Predatory and weed fishes have to be removed either by netting or by dewatering. Mohua oil cake may be applied at 250 ppm to eradicate the predatory and weed fishes.

After clearing the weeds and predators the fertilizers are to be applied. Cow dung at the rate of 5000 kg/ha, ammonium sulphate at 70 kg/ha and single superphosphate at 50 kg/ha are applied in equal instalments during the rearing period.

Stocking density is different in simultaneous and rotational culture practices, and are also mentioned under the respective headings above. The fishes are provided with supplementary food consisting of rice bran and groundnut oil cake in the ratio 1:1 at 5% body weight of fishes in paddy-cum-carp culture. In paddy-cum-air breathing culture, a mixture of fish meal and rice bran in the ratio 1:2 is provided at the rate of 5% body weight of fishes.

After harvesting paddy when plots get dried up gradually, the fishes take shelter in the water way. Partial harvesting by drag netting starts soon after the Kharif season and fishes that attain maximum size are taken out at fortnightly intervals. At the end of preparation when the water in the waterway is used up for irrigation of the Rabi paddy, the remaining fishes are hand picked. The fish yield varies from 700 - 1000 kg/ha in this integrated system. Survival rate of fish is less than 60 %. Survival rate is maximum in renovated paddy plots when compared to fish culture in ordinary paddy plots.

The dykes constructed for this system may be used for growing vegetables and other fruit bearing plants like papaya and banana to generate high returns from this system. The fish can also be cultured along with wheat. This practice is found in Madhya Pradesh.. Like paddy fields, the same fish can also be cultured in wheat fields. The management practices are similar to fish - cum - paddy culture. Fish can also be cultured along with coconut plants.

8.2.2 Fish cum horticulture

Considerable area of an aquaculture farm is available in the form of dykes some of which is used for normal farm activities, the rest remaining fallow round-the -year infested with deep-rooted terrestrial weeds. The menacing growth of these weeds causes inconvenience in routine farm activities besides necessitating recurring expenditure on weed control. This adversely affects the economy of aqua-farming which could be considerably improved through judicious use of dykes for production of vegetables and fish feed. An integrated horti-agri-aquaculture farming approach leads to better management of resources with higher returns.

Several varieties of winter vegetables (cabbage, cauliflower, tomato, brinjal, coriander, turnip, radish, beans, spinach, fenugreek, bottle gourd, potato and onion) and summer vegetables (amaranth, water-bind weed, papaya, okra, bitter gourd, sponge gourd, sweet gourd, ridge gourd, chilly, ginger and turmeric) can be cultivated depending upon the size, shape and condition of the dykes.

8.2.2.1 Suitable farming practices on pond dykes:

Intensive vegetable cultivation may be carried out on broad dykes (4m and above) on which frequent ploughing and irrigation can be done without damaging the dykes. Ideal dyke management involves utilisation of the middle portion of the dyke covering about two-thirds of the total area for intensive vegetable cultivation and the rest one-third area along the length of the periphery through papaya cultivation keeping sufficient space on either side for netting operations. Intensive cultivation of water-bind weed, Indian spinach, radish, amaranth, okra, sweet gourd, cauliflower, cabbage, spinach, potato, coriander and papaya on pond dyke adopting the practice of multiple cropping with single or mixed crops round the year can yield 65 to 75 that year.

Semi-intensive farming can be done on pond dykes (2 to 4 m wide) where frequent ploughing, regular irrigation and deweeding are not possible. Crops of longer duration like beans, ridge gourd, okra, papaya, tomato, brinjal, mustard and chilli are found suitable for such dykes.

Extensive cultivation may be practised on pond dykes (up to 2 m wide) where ploughing and irrigation by mechanical means are not at all possible. Such dykes can be used for cultivation of sponge gourd, sweet gourd, bottle gourd, citrus and papaya after initial cleaning, deweeding and digging small pits along the length of the dykes. Extensive cultivation of ginger and turmeric is suitable for shaded dykes.

8.2.2.2 Carp production using leafy vegetables and vegetables wastes:

A huge quantity of cabbage, cauliflower, turnip and radish leaves are thrown away during harvest. These can be profitably utilised as supplementary feed for grass carp. During winter, grass carp can be fed with turnip, cabbage and cauliflower leaves, while in summer, amaranth and water-bind weed through fortnightly clipping may be fed as supplementary feed for rearing of grass carp. Monoculture of grass carp, at stocking density of 1000 fish/ha, fed on vegetable leaves alone, fetches an average production of about 2 t/ha/yr. while mixed culture of grass carp along with rohu, catla and mrigal (50:15:20:15) at a density 5000 fish/ha yields an average production of 3 t/ha/yr.

Integrated farming of dairy, piggery and poultry has been traditionally practiced in many parts of the world with a varying degree of success. In India, this system of freshwater fish culture has assumed significance presently in view of its potential role in recycling of organic wastes and integrated rural development. Besides the cattle farm wastes, which have been used traditionally as manure for fish pond, considerable quantities of wastes from poultry, duckery, piggery and sheep farming are available. The later are much richer in nutrients than cattle wastes, and hence smaller quantities would go a long way to increase fish production.

8.2.3. Azolla - aquaculture

The significance of biological nitrogen fixation in aquatic ecosystems has brought out the utility of biofertilization through application of heterocystous blue-green algae and related members. This assumes great importance in view of the increasing costs of chemical fertilisers and associated energy inputs that are becoming scarce as also long-term environmental management. *Azolla,* a free-floating aquatic fem fixing atmospheric nitrogen through the cyanobacterium, *Anabaena azolla,* present in its dorsal leaves, is one of the potential nitrogenous biofertilizers. Its high nitrogen-fixing capacity, rapid multiplication as also decomposition rates resulting in quick nutrient release have made it an ideal nutrient input in fanning systems.

Arolla is a hetrosporous fern belonging to the family azollaceae with seven living and twenty extinct species. Based on the morphology of reproductive organs, the living species are grouped into two subgenera. viz., *Euazolla (Azolla caroliniana, A.filiculoides, A. microphylla, A.mexicana. A., rubra*) and *Rhizosperma (A.pinnata, A.niloiica*). Proliferation of *Azolla*Ms basically through vegetative propagation but sexual reproduction occurs during temporary adverse environmental conditions with the production of both microsporocarp and megasporocarp.

8.2.3.1 Potentials of Azolla

Though *Azolla* is capable of absorbing nitrogen from its environment, *Anabaena* meets the entire nitrogen requirements of *Azolla-Anabaena* association. The mean daily nitrogen fixing rates of a developed *Azolla* mat are in the range of 1.02 - 2.6 kg/ ha and a comparison with the process of industrial production of nitrogenous fertilisers would indicate the efficacy of biological nitrogen fixation. While the latter carried out by the enzyme nitrogenase, operates with maximum efficacy at 30°C and 0.1 atm. The fertiliser industry requires reaction of nitrogen and hydrogen to form ammonia at temperature and pressure as high as 300°C and 200 - 1000 atm respectively.

The normal doubling time *of Azolla* plants is three days and one kilogram of phosphorus applied result in 4 - 5 kilograms of nitrogen through *Azolla,* i.e., about 1.5 - 2.0 t of fresh biomass. It may be mentioned that *Azolla* can survive in a wide pH range of 3.5 to 10.0 with an optimum of 4.5 - 7.0 and withstand salinities of up to 10 ppt. With a dry weight range of 4.8 - 7.1 % among different species, the nitrogen and carbon contents are in the ranges of 1.96 - 5.30 % and 41.5 -45.3 % respectively. The percentage ranges of other constituents on dry weight basis are crude protein 13.0 -30.0, crude fat 4.4 - 6.3, cellulose 5.6 -15.2, hemicellulose 9.8 -17.9, lignin 9.3 - 34.8 and ash 9.7 - 23. 8. The ranges of elemental composition are phosphorus 0.10 - 1.59 %, potassium 0.31 - 5.97%, calcium 0.45 - 1.70 %, magnesium 0.22 - 0.66 % and sulphur 0.22 - 0.73%. Added to these are its high rates of decomposition with mean daily loss rates of 1.36 - 4.57% of the initial weight and nitrogen release rate of 1.25% which make *Azolla* a potential biofertilizer in aquaculture systems.

8.2.3.2. Cultivation of Azolla

While *Azolla* is grown either as a green manure before rice transplantation or as a dual crop in agriculture. It is necessary to cultivate *Azolla.* separately for aquaculture and resort to periodic application in fish ponds. A system suitable for such cultivation, comprises a network of earthen raceways (10.0 X 1.5 X 0.3 m) with facilities for water supply and drainage. The operation in each raceway consists of application *of Azolla* inoculum (6 kg), phosphatic fertiliser (50 g single superphosphate) and pesticide (carbofuron dip for inoculum at 1 - 2 ppm), maintenance of water depth of 5 - 10 cm and harvesting 18 - 24 kg in a week’s time. The maintenance includes periodic removal of superficial earth layers with organic accumulation, dyke maintenance, application of bleaching powder for crab menace and algal blooms, etc. A unit of 0.1 ha area that can hold about 50 raceways is suitable for a family to be taken up as cottage industry in rural areas. *Azolla* can be cultured in puddles, drainage and shallow water stretches, at the outlets of ponds and tanks and hence prime agricultural land need not be used. It is advisable to set up central *Azolla* culture units to serve for the community in the villages.

8.2.3.2. Applications in fish farming

Azolla is useful in aquaculture practices primarily as a nitrogenous biofertilizer. Its high decomposition rates also make it a suitable substrate for enriching the detritus food chain or for microbial processing such as composting prior to application in ponds.

Further, *Azolla* can serve as an ingredient of supplementary feeds and as forage for grass carp too. Studies made on *Azolla* biofertilization have shown that the nutrient requirements of composite carp culture could be met through *application Azolla* alone at the rate of 40 t/ha/yr providing over 100 kg of nitrogen, 25 kg of phosphorus and 90 kg of potassium in addition to about 1500 kg of organic matter. This amounts to total substitution of chemical fertilisers along with environmental upkeep through organic manuring.

Azolla is a new aquaculture input with high potentials in both fertilisation and tropic enrichment. Studies are also being made with regard to reduction of land requirement and production costs through in situ cultivation in shallow zones or floating platforms in fish ponds, use of organic inputs like biogas slurry, etc. The costs may be reduced further if the *Azolla* culture system is managed by the farmer or by his household members. The technology would pave the way for economic, eco-friendly and environment conserving fertilisation in aquaculture.

8.2.4 Integrated fish-cum-poultry farming

Much attention is being given for the development of poultry farming in India and with improved scientific management practices, poultry has now become a popular rural enterprise in different states of the country. Apart from eggs and chicken, poultry also yields manure, which has high fertilizer value. The production of poultry dropping in India is estimated to be about 1,300 thousand tons, which is about 390 metric tones of protein. Utilization of this huge resource as manure in aquaculture will definitely afford better conversion than agriculture.

8.2.4.1.Pond management:

It includes clearance of aquatic weeds, unwanted fishes and insects, which is discussed in detail in the stocking pond management chapter 5.

a. Stocking:

The application of poultry manuring in the pond provides a nutrient base for dense bloom of phytoplankton, particularly nanoplankton which helps in intense zooplankton development. The zooplankton have an additional food source in the form of bacteria which thrive on the organic fraction of the added poultry dung. Thus, indicates the need for stocking phytoplanktophagous and zooplanktophagous fishes in the pond. In addition to phytoplankton and zooplankton, there is a high production of detritus at the pond bottom, which provides the substrate for colonization of micro-organisms and other benthic fauna especially the chironomid larvae. A stocking emphasis, therefore, must be placed on bottom feeders. Another addition will be macro-vegetation feeder grass carp, which, in the absence of macrophytes, can be fed on green cattle fodder grown on the pond embankments. The semi digested excreta of this fish forms the food of bottom feeders.

For exploitation of the above food resources, polyculture of three Indian major carps and three exotic carps is taken up in fish cum poultry ponds. The pond is stocked after the pond water gets properly detoxified. The stocking rates vary from 8000 - 8500 fingerlings/ha and a species ratio of 40 % surface feeders, 20 % of column feeders, 30 % bottom feeders and 10-20 % weedy feeders are preferred for high fish yields. Mixed culture of only Indian major carps can be taken up with a species ratio of 40 % surface, 30 % column and 30 % bottom feeders.

In the northern and north - western states of India, the ponds should be stocked in the month of March and harvested in the month of October - November, due to severe winter, which affect the growth of fishes. In the south, coastal and north - eastern states of India, where the winter season is mild, the ponds should be stocked in June - September months and harvested after rearing the fish for 12 months.

b. Use of poultry litter as manure: The fully built up deep litter removed from the poultry farm is added to fish pond as manure. Two methods are adopted in recycling the poultry manure for fish farming.

1. The poultry droppings from the poultry farms is collected, stored it in suitable places and is applied in the ponds at regular instalments. This is applied to the pond at the rate of 50 Kg/ha/day every morning after sunrise. The application of litter is deffered on the days when algal bloom appear in the pond. This method of manurial application is controlled.

2. Constructing the poultry housing structure partially covering the fish tank and directly recycling the dropping for fish culture. Direct recycling and excess manure however, cause decomposition and depletion of oxygen leading to fish mortality.

It has been estimated that one ton of deep litter fertilizer is produced by 30-40 birds in a year. As such 500 birds with 450 kg as total live weight may produce wet manure of about 25 Kg/day, which is adequate for a hectare of water area under polyculture. The fully built up deep litter contain 3% nitrogen, 2% phosphate and 2% potash. The built up deep litter is also available in large poultry farms. The farmers who do not have the facilities for keeping poultry birds can purchase poultry litter and apply it in their farms.

Aquatic weeds are provided for the grass carp. Periodical netting is done to check the growth of fish. If the algal blooms are found, those should be controlled in the ponds. Fish health should be checked and treat the diseased fishes.

8.2.4.2 Poultry husbandry practices:

The egg and chicken production in poultry raising depends upon multifarious factors such as breed, variety and strain of birds, good housing arrangement, blanched feeding, proper health care and other management measures which go a long way in achieving the optimum egg and flesh production.

a. Housing of birds:

In integrated fish-cum-poultry farming the birds are kept under intensive system. The birds are confined to the house entirely. The intensive system is further of two types - cage and deep litter system. The deep litter system is preferred over the cage system due to higher manurial values of the built up deep litter.

In deep litter system 250 birds are kept and the floor is covered with litter. Dry organic material like chopped straw, dry leaves, hay, groundnut shells, broken maize stalk, saw dust , etc. is used to cover the floor upto a depth of about 6 inches. The birds are then kept over this litter and a space of about 0.3 - 0.4 square meter per bird is provided. The litter is regularly stirred for aeration and lime used to keep it dry and hygienic. In about 2 months time it become deep litter, and in about 10 months time it becomes fully built up litter. This can be used as fertilizer in the fish pond.

The fowls which are proven for their ability to produce more and large eggs as in the case of layers, or rapid body weight gains is in the case of broilers are selected along with fish.

The poultry birds under deep litter system should be fed regularly with balanced feed according to their age. Grower mash is provided to the birds during the age of 9-20 weeks at a rate of 50-70 gm/bird/day, whereas layer mash is provided to the birds above 20 weeks at a rate of 80-120 gm/bird/day. The feed is provided to the birds in feed hoppers to avoid wastage and keeping the house in proper hygienic conditions.

b. Egg laying:

Each pen of laying birds is provided with nest boxes for laying eggs. Empty kerosene tins make excellent nest boxes. One nest should be provided for 5-6 birds. Egg production commences at the age of 22 weeks and then gradually decline. The birds are usually kept as layers upto the age of 18 months. Each bird lays about 200 eggs/yr.

c. Harvesting:

Some fish attain marketable size within a few months. Keeping in view the size of the fish, prevailing rate and demand of the fish in the local markets, partial harvesting of table size fish is done. After harvesting partially, the pond should be restocked with the same species and the same number of fingerlings depending upon the availability of the fish seed. Final harvesting is done after 12 months of rearing. Fish yield ranging from 3500-4000 Kg/ha/yr and 2000-2600 Kg/ha/yr are generally obtained with 6 species and 3 species stocking respectively.

Eggs are collected daily in the morning and evening. Every bird lays about 200 eggs/year. The birds are sold after 18 months of rearing as the egg laying capacity of these birds decreases after that period. Pigs can be used along with fish and poultry in integrated culture in a two-tier system. Chick droppings form direct food source for the pigs, which finally fertilise the fish pond. Depending on the size of the fish ponds and their manure requirements, such a system can either be built on the bund dividing two fish ponds or on the dry-side of the bund. The upper panel is occupied by chicks and the lower by pigs.

8.2.5 Integrated fish-cum-duck farming

Integrated fish-cum-duck farming is the most common practice in China and is now developing in India, especially in West Bengal, Assam, Tamilnadu, Andhra Pradesh, Kerala, Bihar, etc. As ducks use both land and water as a habitat, their integration with the fish is to utilise the mutual benefits of a biological relationship. It is not only useful for fattening the ducks but also beneficial to fish farming by providing more organic manures to fish. It is apparent that fish cum duck integration could result in a good economic efficiency of fish farms.

The ducks feed on organisms from the pond such as larvae of aquatic insects, tadpoles, molluscs, aquatic weeds, etc., which do not form the food of the stocked fish. The duck droppings act as an excellent pond fertilizer and the dabbling of ducks at the pond bottom in search of food, releases nutrients from the soil which enhances the pond productivity and consequently increases fish production. The ducks get clean and healthy environments to live in and quality natural food from the pond for their growth. German farmer Probst (1934) for the first time, conducted experiments on integrated fish-cum-duck farming.

8.2.5.1. Benefits of fish-cum-duck farming

1. Water surface of ponds can be put into full utilization by duck raising.
2. Fish ponds provide an excellent environment to ducks which prevent them from infection of parasites.
3. Ducks feed on preda’tors and help the fingerlings to grow.
4. Duck raising in fish ponds reduces the demand for protein to 2 - 3 % in duck feeds.
5. Duck droppings go directly into water providing essential nutrients to increase the biomass of natural food organisms.
6. The daily waste of duck feed (about 20 - 30 gm/duck) serves as fish feed in ponds or as manure, resulting in higher fish yield.
7. Manuring is conducted by ducks and homogeneously distributed without any heaping of duck droppings.
8. By virtue of the digging action of ducks in search of benthos, the nutritional elements of soil get diffused in water and promote plankton production.
9. Ducks serve as bioaerators as they swim, play and chase in the pond. This disturbance to the surface of the pond facilitates aeration.
10. The feed efficiency and body weight of ducks increase and the spilt feeds could be utilised by fish.
11. Survival of ducks raised in fish ponds increases by 3.5 % due to the clean environment of fish ponds.
12. Duck droppings and the left over feed of each duck can increase the output offish to 37.5 Kg/ha.
13. Ducks keep aquatic plants in check.
14. No additional land is required for duckery activities.
15. It results in high production of fish, duck eggs and duck meat in unit time and water area.
16. It ensures high profit through less investment.

8.2.5.2 Pond managment:

This is similar to fish-cum-poultry farming. The stocking density can be reduced to 6000 fingerlings/ha. Fingerlings of over 10 cm size are stocked, as the ducks are likely to prey upon the small ones.

Use of duck dropping as manure:

The ducks are given a free range over the pond surface from 9 to 5 PM, when they distribute their droppings in the whole pond, automatically manuring the pond. The droppings voided at night are collected from the duck house and applied to the pond every morning. Each duck voids between 125 - 150 gm of dropping per day. The stocking density of 200 - 300 ducks/ha gives 10,000 - 15,000 kg of droppings and are recycled in one hectare ponds every year. The droppings contain 81 % moisture, 0.91 % nitrogen and 0.38 % phosphate on dry matter basis.

8.2.5.3 Duck husbandary practices:

The following three types of farming practice are adopted.

1. Raising large group of ducks in open water

This is the grazing type of duck raising. The average number of a group of ducks in the grazing method is about 1000 ducks. The ducks are allowed to graze in large bodies of water like lakes and reservoirs during the day time, but are kept in pens at night. This method is advantageous in large water bodies for promoting fish production.

2. Raising ducks in centralised enclosures near the fish pond

A centralised duck shed is constructed in the vicinity of fish ponds with a cemented area of dry and wet runs out side. The average stocking density of duck is about 4 - 6 ducks/sq.m. area. The dry and wet runs are cleaned once a day. After cleaning the duck shed, the waste water is allowed to enter in to the pond.

3. Raising ducks in fish pond

This is the common method of practice. The embankments of the ponds are partly fenced with net to form a wet run. The fenced net is installed 40 - 50 cm above and below the water surface, so as to enable the fish to enter into the wet run while ducks cannot escape under the net.

4. Selection of ducks and stocking

The kind of duck to be raised must be chosen with care since all the domesticated races are not productive. The important breeds of Indian ducks are Sylhet Mete and Nageswari. The improved breed, Indian runner, being hardy has been found to be most suitable for this purpose, although they are not as good layers as exotic Khaki Campbell. The number of ducks required for proper manuring of one hectare fish pond is also a matter of consideration. It has been found that 200 - 300 ducks are sufficient to produce manure adequate enough to fertilize a hectare of water area under fish culture. 2 - 4 months old ducklings are kept on the pond after providing them necessary prophylactic medicines as a safeguard against epidemics.

5. Feeding

Ducks in the open water are able to find natural food from the pond but that is not sufficient for their proper growth. A mixture of any standard balanced poultry feed and rice bran in the ratio of 1:2 by weight can be fed to the ducks as supplementary feed at the rate of 100 gm/ bird/day.

The feed is given twice in a day, first in the morning and second in the evening. The feed is given either on the pond embankment or in the duck house and the spilled feed is then drained into the pond. Water must be provided in the containers deep enough for the ducks to submerge their bills, along with feed. The ducks are not able to eat without water. Ducks are quite susceptible to afflatoxin contamination, therefore, mouldy feeds kept for a long time should be avoided. The ground nut oil cake and maize are more susceptible to *Aspergilus flavus* which causes aflotoxin contamination and may be eliminated from the feed.

6. Egg laying

The ducks start laying the eggs after attaining the age of 24 weeks and continue to lay eggs for two years. The ducks lay eggs only at night. It is always better to keep some straw or hay in the corners of the duckhouse for egg laying. The eggs are collected every morning after the ducks are let out of the duck house.

7. Health care

Ducks are subjected to relatively few diseases when compared to poultry. The local variety of ducks are more resistant to diseases than other varieties. Proper sanitation and health care are as important for ducks as for poultry. The transmissible diseases of ducks are duck virus, hepatitis, duck cholera, keel disease, etc. Ducks should be vaccinated for diseases like duck plague. Sick birds can be isolated by listening to the sounds of the birds and by observing any reduction in the daily feed consumption, watery discharges from the eyes and nostrils, sneezing and coughing. The sick birds should be immediately isolated, not allowed to go to the pond and treated with medicines.

8. Harvesting

Keeping in view the demand of the fish in the local market, partial harvesting of the table size fish is done. After harvesting partially, the pond should be restocked with the same species and the same number of fingerlings. Final harvesting is done after 12 months of rearing. Fish yield ranging from 3500 - 4000 Kg/ha/yr and 2000 - 3000 Kg/ha/yr are generally obtained with 6 - species and 3 - species stocking respectively.

The eggs are collected every morning. After two years, ducks can be sold out for flesh in the market. About 18,000 - 18,500 eggs and 500 - 600 Kg duck meat are obtained.

8.2.6. Integrated fish-cum-pig farming

The raising of pigs with fish by constructing pig - sties on the pond embankment or near the pond so that the pig wastes are directly drained into the pond or lifted from the pig house and applied to the pond. The pig dung acts as an excellent pond fertilizer, which raises the biological production of the pond, and this, in turn, increases the fish yield. The fish also feed directly on the pig excreta which consists of 70 % digestible feed for the fish. No supplementary fish feed or pond fertilization is required in this integrated system. The expenditure on fish culture is drastically reduced as the pig excreta acts as a substitute for fish feed and pond fertilization which accounts for 60 % of the input cost in the fish culture. This system has a special significance as it can improve the socio-economic status of rural poor, especially the tribal community who traditionally rear pigs.

8.2.6.1. ***Benefits of fish-cum-pig farming***

1. The fish utilize the food spilled by pigs and their excreta which is very rich in nutrients.
2. The pig dung acts, as a substitute for pond fertilizer and supplementary fish feed, hence, the cost of fish production is greatly reduced.
3. No additional land is required for piggery operations.
4. Cattle foder required for pigs and grass are grown on the pond embankments.
5. Pond provides water for washing the pig - sties and pigs.
6. It results in high production of animal protein per unit area.
7. It ensures high profit through less investment.
8. The pond muck which gets accumulated at the pond bottom due to constant application of pig dung, can be used as fertilizer for growing vegetables and other crops and cattle foder.

8.2.6.2 Pond management practices:

Pond management is very important to get good production of fish. The management techniques like selection of pond, clearance of aquatic weeds and unwanted fish, liming stocking and health care are similar to fish-cum- poultry system.

Use of pig waste as manure:

Pig - sty washings including pig dung, urine and spilled feed are channeled into the pond. Pig dung is applied to the pond every morning. Each pig voids between 500-600 Kg dung/year, which is equivalent to 250-300 Kg/pig/6 months. The excreta voided by 30 - 40 pigs is adequate to fertilize one hectare pond. When the first lot of pigs is disposed off after 6 months, the quantity of excreta going to the pond decreases. This does not affect the fish growth as the organic load in the pond is sufficient to tide over for next 2 months when new piglets grow to give more excreta. If the pig dung is not sufficient, pig dung, can be collected from other sources and applied to the pond.

Pig dung consists 69 - 71 % moisture, 1.3 - 2 % nitrogen and 0.36 - 0.39 phosphate. The quality and quantity of excreta depends upon the feed provided and the age of the pigs. The application of pig dung is deferred on the days when algal blooms appear.

8.2.6.3 Pig husbandry practices:

The factors like breed, strain, and management influence the growth of pigs.

a. Construction of pig house: Pig houses with adequate accommodation and all the requirements are essential for the rearing of pigs. The pigs are raised under two systems the open air and indoor systems. A combination of the two is followed in fish cum pig farming system. A single row of pig pens facing the pond is constructed on the pond embankment. An enclosed run is attached to the pen towards the pond so that the pigs get enough air, sunlight, exercise and dunging space. The feeding and drinking troughs are also built in the run to keep the pens dry and clean. The gates are provided to the open run only. The floor of the run is cemented and connected via the drainage canal to the pond. A shutter is provided in the drainage canal to stop the flow of wastes to the pond. The drainage canal is provided with a diversion channel to a pit, where, the wastes are stored when the pond is filled with algal bloom. The stored wastes are applied according to necessity.

The height of the pig house should not exceed 1.5 m. The floor of the house must be cemented. The pig house can be constructed with locally available materials. It is advisable to provide 1 - 1.5 square meter space for each pig.

b. Selection of pigs: Four types of pigs are available in our country - wild pigs, domesticated pigs or indigenous pigs, exotic pigs and upgraded stock of exotic pigs. The Indian varieties are small sized with a slow growth rate and produce small litters. Its meat is of inferior quality. Two exotic upgraded stock of pigs such as large - White Yorkshire, Middle - White Yorkshire, Berkshire, Hampshire and Hand Race are most suitable for raising with fish culture. These are well known for their quick growth and prolific breeding. They attain slaughter maturity size of 60 - 70 Kg within six months. They give 6 - 12 piglets in every litter. The age at first maturity ranges from 6 - 8 months. Thus, two crops of exotic and upgraded pigs of six months each, are raised along with one crop of fish which are cultured for one year. 30 - 40 pigs are raised per hectare of water area. About two months old weaned piglets are brought to the pig-sties and fattened for 6 months, when they attain slaughter maturity, are harvested.

c. Feeding: The dietry requirements are similar to the ruminants. The pigs are not allowed to go out of the pig house where they are fed on balanced pig mash of 1.4 Kg/pig/day. Grasses and green cattle fodder are also provided as food to pigs. To minimize food spoilage and to facilitate proper feeding without scrambling and fighting, it is better to provide feeding troughs. Similar separate troughs are also provided for drinking water. The composition of pig mash is a mixture of 30 Kg rice bran, 15 Kg polished rice, 27 Kg wheat bran, 10 Kg broken rice, 10 Kg groundnut cake, 4 Kg fish meal, 3 Kg mineral mixture and 1 Kg common salt. To reduce quantity of ration and also to reduce the cost, spoiled vegetables, especially the rotten potatoes can be mixed with pig mash and fed to pigs after boiling.

d. Health care: The pigs are hardy animals. They may suffer from diseases like swine fever, swine plague, swine pox and also infected with round worms, tapeworms, liver flukes, etc. Pig - sties should be washed daily and all the excreta drained and offal into the pond. The pigs are also washed. Disinfectants must be used every week while washing the pig - sites. Piglets and pigs should be vaccinated.

e. Harvesting: Fish attain marketable size within a few months due to the availability of natural food in this integrated pond. According to the demand of fish in the local market, partial harvesting is done. After the partial harvest, same number of fingerlings are introduced into the pond as the fish harvested. Final harvesting is done after 12 months of rearing. Fish yield ranging from 6000 - 7000 Kg/ha/yr is obtained. The pigs are sold out after rearing for six months when they attain slaughter maturity and get 4200 - 4500 Kg pig meat.

8.2.7 Integrated fish-cum-cattle farming

Fish farming by using cattle manure has long been practiced in our country. This promotes the fish-cum-cattle integration and is a common model of integration. Cattle farming can save more fertilizers, cut down fish feeds and increase the income from milk. The fish farmer not only earns money but also can supply both fish, milk and beef to the market.

8.2.7.1 Pond management practices:

These practices are similar to poultry or pig or duck integration with fish. Cow dung is used as manure for fish rearing. About 5,000 - 10,000 Kg/ha can be applied in fish pond in instalments. After cleaning cow sheds, the waste water with cow dung, urine and unused feed, can be drained to the pond. The cow dung promotes the growth of plankton, which is used as food for fish.

7.2 *Cattle husbandry practices:*

The cow sheds can be constructed on the embankments of the fish farm or near the fish farm. The locally available material can be used to construct the cow shed. The floor should be cemented. The outlet of the shed is connected to the pond so that the wastes can be drained into the pond.

Cultivable varieties of cows are black and white (milk), Shorthorn (beef), Simmental (milk and beef), Hereford (beef), Charolai (beef), Jersey (milk and beef) and Qincuan draft (beef).

8.2.8. Integrated fish - cum - prawn culture

Through a lot of work has been done on composite fish culture incorporating Indian major carps and exotic carps having different feeding habits, and a considerable production achieved, no large scale polyculture of prawns and fish has been attempted. The culture of the surface and column feeding carps and bottom feeding prawns could be taken up as a polyculture practice in Indian waters to gain maximum yield. In this polyculture system, the culture of carps and freshwater prawns is more common than that of brackish water prawns with other fish.

8.2.8.1 Pond preperation:

The ideal size of the production ponds for polyculture is 0.2 ha. The pond size can go up to 0.1 - 1 ha area and would be conducive for netting, harvesting and other management practices. The optimal depth required is 0.7 - 1.0m, and it can even go upto 1.5 m. This depth is suitable for netting operations. The slope of the wet side bunds may be 1.3 and of the dry side bunds 1.2. Prawns use their appendages to crawl on wet lands during the night, specially during rain. Therefore, bunds may be kept 1 - 1.5 m wide and 0.5 m. height over the water level to prevent their movement from one pond to another. Drainable ponds may be more convenient and relatively inexpensive for complete harvesting and good management. Draining out water is desirable for water exchange so as to maintain favourable water quality during the culture period, for exposing bottom of ponds to sun and air, and for removal of silt and organic matter for improving the bottom soil. Such ponds having complete water flow or water circulation would enhance the production.

Application of lime and fertilizers:

Depending on the nature of the pond bottom, lime should be administered. Quick lime may be applied at the rate of 1000 Kg/ha. The water usable for the production ponds should have a pH of 7 - 8.5. If the pH of the water goes above 8.5, the same may be stagnated in the ponds for about 2 - 4 weeks prior to stocking with seed. Monthly or installment application of lime is essential to maintain pH, dissolved oxygen, hardness as well as calcium content in the water. If the pH is lower than 6.5, then the growth rate may suffer and moulting of prawns is delayed which may cause disease susceptibility and mortality of the prawns. Prawns utilise calcium from the water for their exoskeleton formation and therefore the calcium level in the water is likely to drop.

As prawns feed mainly on detritus, production ponds intended for monoculture of prawns need not be fertilized. However, for growing prawns and carps together, the ponds need to be fertilized just as in composite fish culture ponds. The ponds are first fertilized with organic manure like cowdung at the rate of 10 - 20 t/ha. It is better if a part of this manure is dissolved and added in the pond water 15 days before the release of fish and prawn seeds. The rest is added monthly in equal instalments. The other chemical fertilizers to be added are ammonium sulphate, urea, superphosphate and muriate of potash at the rate of 450, 200, 250 and 40 Kg/ha respectively and are added in equal instalments. Mahua oil cake can also be used as biocide as well as fertilizer at the rate of 200 - 250 ppm.

8.2.8.2 Stocking:

After three weeks of application of lime and fertilizers, quality seed is stocked during the morning hours. It is always better to acclimatise the seed to the pond conditions by keeping them for about 10 - 15 minutes in the pond before release. Sometimes heavy mortality occur due to wide variation in water pH between the pond and seed container. Therefore, it is always desirable to keep the transport seed for a few hours or even for a day in pond water for acclimatisation. To ensure good survival four week old juvenile prawns and carp fingerlings could be stocked. Soon after release into the pond, prawn seed disperses in different directions and either take shelter at the pond bottom or close to the submerged vegetation.

The stocking density of prawns in polyculture may be reduced to 50% of monoculture, i.e. 15,000 - 25,000 juveniles / ha for good growth and production. The size range of 30 - 50 mm is ideal for stocking. The freshly metamorphosed post - larvae are stocked in nursery tanks for a short duration (30 - 45 days) to raise the juveniles of size 30 - 50 mm. This helps to ensure good survival in culture pond and it is possible to have two crops a year with judicious stocking. Stock manipulation through selective harvesting of marketable prawns and restocking of juveniles is also recommended.

Prawns are omnivorous and are bottom feeders. Therefore, while selecting fish it is better if the bottom feeding common carp, mrigal, kalbasu, tilapia, etc. are avoided as they compete both for space and feed at the bottom. Compatible fish like catla, rohu, silver carp, grass carp, etc. are recommended for stocking with prawn juveniles. Carps being nonpredatory, competition for space or food does not occur to any noticeable extent. The juveniles or adult prawns do not prey upon or injure the fish. Directly or indirectly, the faecal matter of the fish may serve as a source of food for the prawns. Generally 3000 - 7000 fish seed per hectare is the appropriate stocking density under intensive fish farming. But stocking of carps fingerlings 1500 - 3000/ha is the ideal density for culture with prawn. Juveniles of 30 - 50 mm size are desirable for stocking to get better growth and survival in the pond. Catla, rohu, silver carp and grass carp may be stocked in the ratio of 2 : 1 : 2 : 1.

8.2.8.3 Food and feeding:

Natural feed like plankton are available through biological process. Pond fertilization, liming and even supplementary feeding help to maintain natural productivity in culture pond. It is very essential to provide supplementary feed to enhance growth and production under culture operations. Feed of cheap and abundantly available local variety like crushed and broken rice and rice products, groundnut and coconut oil cake, poultry feed, corn, peanut cake, soybean cake, small shrimps (*Acetes*), foot of apple snail (*Pila*), bivalve meat and prawn waste from freezing plant, trash fish or any fish or any non - oily inexpensive fish, squid meat, butcher waste, etc., in nutritionally balanced form is provided as supplementary feed. The feed may be given once or twice in a day at the rate of 5 - 10 % body weight. Feeds containing about 40 % protein have been found to give better growth. For carps particularly during the periods of absence of live food (plankton) in pond, food balls of ground nut oil cake and brawn rice mixed in the ratio of 1 : 1 may be given.

8.2.8.4 Production and harvesting:

As these prawns attain marketable size in about five months, two crops of prawns could be produced in a year. Mixed culture of *M.malcolmsonii* with Indian major carps and minor carps indicated higher growth production rate and survival (Rajyalakshmi et al, 1979, Venkateswaram et al, 1979). Maximum production of 327 Kg of prawns and 2,084 Kg of fish was achieved at 30,000 / ha mixed stocking rate. Under a system of stocking twice and repeated harvesting Ramaraju etal (1979) and Rajyalakshmi et al (1983) reported a production of 900 Kg/ha/year of the same species. About 1000 Kg/ha/year of prawns and 3000 Kg/ha/year of fish can be obtained from the polyculture system. *M. rosenbergii* could be cultured along with milk fish and mullets in brackish water ponds with a 12 - 25 % salinity. An individual growth of 100 gr/ 5 months has been reported with a stocking density of 29,000 - 1,66,600 /ha.

In prawn culture, either in monoculture or polyculture, early harvest is better for good returns. Unlike fishes, prawns take feed and moult very frequently during the process of growth. If the harvesting time is prolonged, chances of cannibalism is more and this ultimately affects the survival rate. Two principal methods are generally followed to harvest the prawn. Intermittent harvest is carried out to remove the larger prawns. The other method is complete harvesting at the end of culture. Generally the fishes are harvested only after 12 months. By adopting the above stated techniques it is possible to obtain prawn production of over one ton/ha/yr with average survival of 50 % in either one or two crops and over 3 tons/ha/yr fish with survival of 50 - 80 %. Farming for this should be done with proper management and measures.

8.2.9 Integrated fish farming web:

Various types of combinations of aquaculture, agriculture, animal husbandry and horticulture can constitute the integrated fish farming web. Integrated fish cultures attuned economically and socially for rural development treats the water and land economically and socially for rural development. It treats the water and land ecosystem as a whole with the good of producing valuable protein from wastes, changing ecological damage into benefits and sustaining local circulation of resources. This strategy of ecological aquaculture can not only increase fish production and further improve ecological efficiency but also improves social and ecological upliftment. It is not only useful in the development of fish culture but will also improve the quality of the environment. The control water of quality by means of fertilization takes priority in fish culture management. The fish pond is a living habitat for fish, a culture base for living food organisms and a place of oxygenation of decomposed organic compounds. These properties determine the characteristics of the input and output of matter and energy in integrated fish culture.

Summary

In olden days, the average yield of fish from ponds was as low as 500 kg/ha/yr. This quantity is considered as very poor. In composite fish culture more than 10,000/kg/ha/yr fish yield can be obtained in different agro-climatic regions of our country.

Monoculture is the culture of a single species of fish in a pond.

Composite fish culture is undoubtedly more superior over monoculture. In composite fish culture, the above problems will not be found. Six varieties of fishes utilize food of all niches of the pond, get good amount of food, grow well without any competition and the yield is also very high.

Fishes can be reared in paddy, wheat and coconut fields. Fruiting, flowering plants and vegetable plants are cultivated on the dykes. Azolla - fish culture is also becoming popular.

Questions

1. Discribe the composite fish culture

2. What is integrated fish farmi ng? Discuss fish cum poultry farming.

3. Discribe the fish culture in paddy fileds.

4. Explain integrated fish cum ping farming.

5. Discribe the polyculture.

9. TYPES OF CULTURES

9.1 Air - Breathing fish culture

Murrels and cat fish are known for their esteem and good market demand owing to their low fat content and few intramuscular spines. The air breathing fishes are hardy and capable of breathing atmospheric air with their accessory respiratory organs. Due to the presence of these accessory respiratory organs these fishes can survive for few hours out side the water. These accessory respiratory organs are respiratory trees in *Clarias*, labyrinthine organ in *Channa*, air bladder in *Heteropneustes*, branchial chamber in the above fishes, etc. and are capable to engult air. These can be cultured in areas of low dissolved oxygen such as shallow foul waters, derelict ponds and swamps. Due to their ability to live out of water, their culture involves low risk and simple management.

In India, Andhra pradesh, Assam, Uttar pradesh, Madhya Pradesh, Tamilnadu, Karnataka, Maharastra, Bihar and Meghalaya support the most significant natural fishery of air breathing fishes. These fishes are carnivorous in nature and they adopt excellently to supplementary feeding. As there is not much wastage of energy through respiration by the growing air breathers of shallow waters, good yields could be expected.

The culturable species of air breathing fishes are Fig. 9.1

Channa straitus	-	Big or striped murrel or snake head fish
Channa punctatus	-	Spotted murrel
Channa marulius	-	Giant murrel
Clarias batrachus	-	Magur
Heteropneustes fossilis	-	Singhi
Anabas testudineus	-	Koi or climbing perch.

Out of these *Channa striatus* has highest demand in the markets and is also commands a higher price. Next best are *Clarias* and *Heteropneustes*. The culture of the above species are profitable.

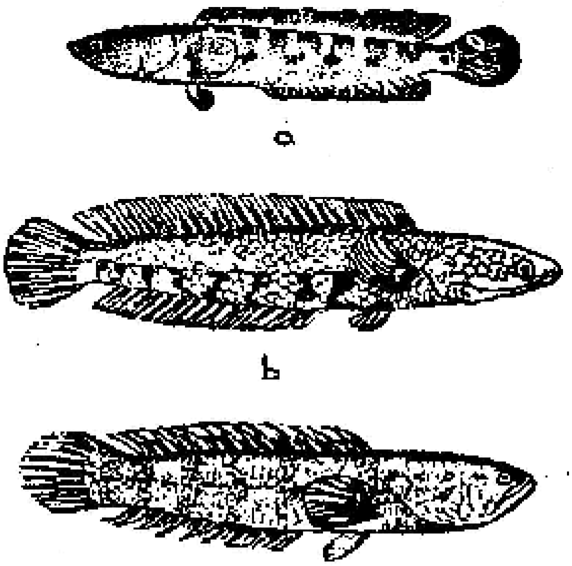


Fig. 9.1a Murrels

a) Channa marulius b) Channa straitus c) Channa punctatus

9.1.1 Culturable areas

The culture of air breathing fishes needs shallow waters with a depth of 50 - 75 cm. Ponds for air-breathing fish culture need not be fertilized by chemicals. Air breathing fishes may also be cultured in cages in running water systems like streams, canals and unmanageable waters like reservoirs. The air breathing fish culture is equally adaptable in waters unsuitable for conventional culturable species of carps as well as in carp culture ponds. Shallow ponds are useful for fishes, in which the fish has to spend less energy in travelling to surface for intake of atmospheric oxygen.

9.1.2 Seed collection

The seed of murrel, magur and singhi are collected from the natural resources, inspite of success achieved in induced breeding. Even today, seed collected from nature continues to be the most dependable source of material for stocking. Murrels attain maturity in two years are known to breed throughout the year. The fry of 2-4 cm can be collected all round the year and from rainfed ditches and shallow water bodies with abundant weeds. However peak spawning is known to occur just before the monsoons.

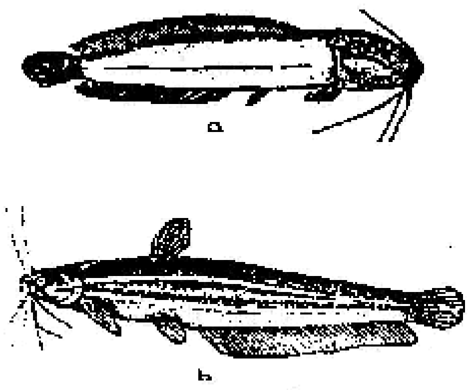


Fig. 9.1b Air-breathing cat fishes

a) Clarias batrachus b) Heteropneustes fossilis

The young ones emerging from the eggs move in shoals and their collection in large numbers is always easy. The fingerlings may not tend to move in shoals. Fry of giant murrel can be identified by their dark grey body and a lateral orange yellow band from eye to the caudal fin. Fry of stripped murrel have bright red body with reddish golden band and a dark black band from eye to the caudal fin. The spotted murrel fry can be recognised by their dark brown body with a golden yellow lateral band and a mid dorsal yellow line on the back.

In murrel culture, it is better to stock fingerlings rather than the fry. Cannibalism is found in murrel fry. The survival rate of fry which produced by induced breeding will be poor and to maintain the spawn and grow them to the fry stage is difficult. The spawn do not eat anything for two days after their emergence from eggs. Hence, the fry should be trained to accept supplementary food in separate ponds. The supplementary feed consists of boiled eggs, silkworm pupae, minced trash fish and worms along with yeast and vitamin B. It is given for about 15 days at the rate of 20 % of their total body weight. The fry reach the fingerling stage of 4-6 cm length within a month.

The cat fishes breed twice in a year with the peak breeding season during rainy season. Magur fingerlings can be identified with their longer dorsal fin and slate colour. Singhi fingerlings are having a short dorsal fin and pink colour. Koi fingerlings can be identified by the dark spot on the caudal peduncle and greenish hue on the dorsal surface of the body. The magurs make a hole of 25 cm depth in the bund below the water surface. The fertilised eggs adhere to grass and are guarded by the males. 2,000 - 15,000 fry can be collected from each hole with the help of small fine meshed hand nets and reared in nurseries until they reach fingerling stage with about 5 cm in length.

Magur can be cultured in ponds for the production of fry. 1 X 1 m compartments of wire screen are made on the margins of the bund. At the centre of each compartment, a hole of 30 cm diameter is dug and is provided with few aquatic plants. After releasing both the sexes, about 5,000 fry can be collected from each compartment within 10 days. The males and females can also be reared in small earthern ponds. They can be stocked 20,000 / pond and fed either with filtered zooplankton or chopped fish meal and ground nut oil cake. The fry can be reared for 15 days in nurseries.

The peak season for the collection of seed of singhi is pre-winter period when paddy is harvested and the low lying fields get exposed.

9.1.3 Seed transport

The fry or fingerlings of air breathing fishes can be transported without oxygen packing. Polythene drums or iron drums are used for transport of fry or fingerlings. The carrier must have enough of space for their habitual surfacing to breath atmospheric air. The carrier should have a small amount of aquatic weeds like *Vallisneria*, *Hydrilla*, *Myriophyllum* and *Ceratophyllum*. The weeds may help to avoid jumping of the fish during transportation. If the distance is more, it is better to transport them in oxygen packed polythene containers.

9.1.4 Pond management

Nurseries are about 10 - 15 m2, having a water column of 50 cm. These are stocked with 0.2 - 1.5 million fry / ha. Prior to stocking, manuring is done with raw cattle dung at the rate of 500 Kg/ha alone. The soap - oil emulsion to eradicate insects is applied to the nursery water. Fry and fingerlings of magur and singhi collected from natural resources require nursery management, but murrels have to be trained in nursery ponds before stocking. After nursery management the fingerlings are to be transfered in stocking ponds.

9.1.4.1 Stocking

Uniform sized fingerlings are chosen for stocking. The fingerlings are disinfected with 2 % KMNO4 solution for 5 minutes or dipped in 200 ppm formalin solution for 50 seconds before stocking. Wounded fingerlings are treated with 0.3 % acriflavine for 5 minutes.

These fishes may escape through climbing or burrowing. Hence, the pond bunds should be firm with heavy log or wood, or fenced with bamboo cane or wire screens to a height of about 50 cm.

More fingerlings can be stocked in their culture system. 40,000-60,000 fingerlings/ha of cat fishes can be stocked in monoculture systems. In polyculture systems 20,000 - 30,000 fingerlings/ha of cat fishes may be stocked. In monoculture systems, 15,000 fingerlings/ha of giant murrels, 20,000/ha in case of striped murrel and 20,000 - 30,000 / ha in case of spotted murrelare stocked. In polyculture systems, striped and spotted murrel may be stocked at a rate of 20,000 fingerlings / ha in the ratio of 1:1.

Polyculture of murrels - carps and catfishes - carps is also possible with proper care and management. The seed of air breathing fish should be stocked only when the carps have grown to a minimum of 300 gr, so that air breathing fishes may not prey on the carps. With this, not only an additional income can be obtained through the yield of air breathing fish, but also the growth of carps can be enhanced. The later is possible, as the trash fishes which may compete with carps for food and space, are eradicated by the growing air breathers.

9.1.4.2 Feeding

To maintain an abundant food supply for growing air breathers, the stocking pond must be rich in animal food source like frog tadpoles and trash fish. If this food source is not sufficient tilapia may also be grown in murrel and cat fish ponds. Dried marine trash fish also used in fish culture and is more economical. Feeding can be given to catfishes with fish offal or slaughter house waste or dried silkworm pupae mixed with rice bran and oil cake in the ratio of 1 : 1 : 1 : 1. A mixture of oil cake, rice bran and bio-gas slurry in the ratio of 1 : 1 : 1 has provided successful low cost feed for singhi. Rice bran and poultry feed in 3 : 1 and biogass slurry and rice bran in 1 : 2 also be given at the rate of 5 - 8 % of body weight.

During the eight months semi-intensive culture in stagnant ponds, the air - breathing catfish stock may be fed at the following rate daily during dark hours of the day to obtain better feed utilisation (Table 9.1).

Table 9.1: The feed and its ratio in different months in cat fish culture.

Period	weight of feed Kg/day (stocking density 50,000 / ha)	feed ratio trash fish : rice bran
1-2 month	12	1 : 2
3-4 month	24	3 : 1
5-6 month	35	1.5 : 3
7-8 month	48	1 : 3

The feed may either be broadcast in the pond in small amounts from the bund or may be served in feed baskets lowered near the bank in addition to broadcasting of feed to ensure availability of feed to all the fishes in the pond. Light traps can be installed in murrel ponds, by which the insects may be attracted by light and utilised by murrels as a protein-rich food.

Trained murrel fingerlings will also accept cheaply dried marine trash fish soaked in water, which may be provided as per the following feeding schedule (Table9.2). Slaughter house waste and silkworm pupae as a of source animal protein can also be used.

Table9.2 : The feed for murrels in different months.

Period	Feed Kg/day
1-2 months	3.75
3-6 months	11.25
5-6 months	17.50
7-8 months	25.00

9.1.4.3 Growth and production

Murrels and cat fishes attain marketable size in a period of months respectively. If the management practices are proper, giant and striped murrels can attain a growth of 1 - 2 Kg/yr. and 0.75 Kg/yr. respectively, whereas spotted murrels grow to 160 gr. in 8 months. Cat fishes are known to grow slowly when compare to murrels. Magur and singhi grow to 0.2 Kg and 0.1 Kg respectively. The conversion rate with recommended feed is approximately 2 : 1.

Murrels with forage fish as supplementary food yield about 4 tonnes/ha/yr. Magur with dried trash fish and rice bran supplementary feed, give the production of 10 tonnes/ha/yr. Singhi give an yield of 4.4 /tonnes/ha/yr. Polyculture of murrel and koi, fed with rice bran, mustared oil cake and trash fish, give a production of 11.8 tonnes/ha/yr, while magsur and singhi fed with rice bran and trash fish give an yield of 5 tonnes/ha/yr. Mixed culture of 3 species of murrels produce 4 tonnes/ ha/yr when fed with soaked and dried marine trash fish and fresh silkworms pupae as food . In the intensive culture magur can give 7 tonnes/ha/5 months.

9.1.5 Culture with carps

With a stocking density of 5000/ha of Indian and Chinese carps and 1000 magur fingerlings produce 2518 Kg/ha/yr of carps and 3711 Kg/ha/yr of magur. This indicates that the polyculture is more profitable, and it is useful to include magur in the carp culture system. With a stocking density of 20,000/ha of magur along with left over carps (after partial harvesting of carps) production of 3.96 tonnes/ha/yr is obtained with 50 : 30 : 17 : 3 ratio of rice bran, fish meal, groundnut oil cake and minerals as supplementary feed. The magur is found suitable for composite fish culture of carps in place of common carp. Magur, koi and singhi are also suitable to culture along with a highly priced carp makhana, *Euryale ferox*.

9.1.6 Harvesting

Summer season is ideal for harvesting air - breathing fishes from ponds. The pond is drained and the fishes are harvested with the help of scoop nets or hand nets. Due to their high demand and market price, the culture of these air - breathers provide profitable income to fish farmers with simple management techniques.

9.1.7 Cage culture

The air - breathers can be cultured in cages also. The cages are prepared with mats made up of split bamboo in running waters. The optimal cage area measures 2m X 1m X 1m in size. The top of the cage is half covered with mat and the uncovered part is covered with a net to facilitate feeding and to prevent escape of fishes. Synthetic fibre mesh is also used to prepare cages.

Magur are stocked at a rate of 200/cage, fed with 10% of body weight on dried trash fish, oil cake and rice bran and produce 10 - 12 Kg/cu.m./yr. Singhi produces 12-20 Kg/cu.m./yr with a stocking density of 100 - 150/cage and 10 % of body weight feed of silkworm pupae, rice bran and mustard oil cake. Koi produce 4.2 Kg/cu.m./yr with a stocking rate of 50 - 100 /cage with the same food as singhi. Spotted murrel produce 4 Kg/cu.m./yr with trash fish and rice bran. Hence, the air breathing fish culture is highly proftable, as well as a rich source of animal protein. This fish is considered as a delecacy, and commands a very high price and continuous demand in the markets.

9.2. TROUT CULTURE

Trout is either grown as a food fish or sport fish, are released into natural waters for sport fishermen. Trout is popular because it is an attractive, active fighting fish and provides very high quality meat. Trouts have been released and cultured in water all over the world. Trouts have been grown on a commercial scale in USA since a very long time. Its culture in Europe dates back 400 years. It is a cold-water fish. It mainly inhabits rivers, streams, brooks, lakes and ponds. In India it is found in Kashmir, Himachal Pradesh, Uttar Pradesh, Nilgiris, Kodai hills and Munnar high range.

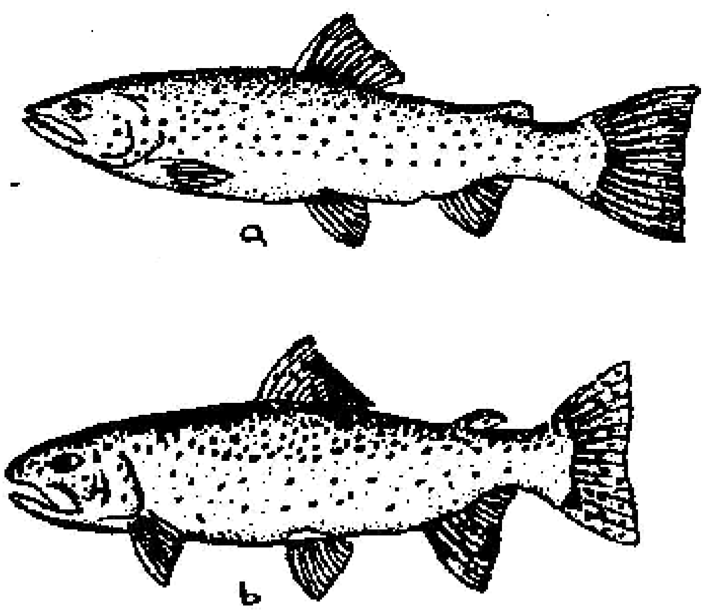


Fig. 9.2 Trouts
a) Salmo trutta b) Salmo gairdineri

Many species of trout are grown, but the three most common of them are the rainbow trout, *Slamo gairdneri* or *Oncorynchus mykiss*, the Eurorean brown trout, *S.trutta* (Fig. 9.2)and the brook trout, *Salvelinus fontinalis*. Trouts have a streamlined body, narrow gill openings and reduced gills. Trouts are adapted to highly oxygenated waters and freezing point temperatures. Trouts have great power of locomotion with clinging and burrowing habits. Mouth is modified with rasping lips for food collection from pebbles, rocks, etc..

9.2.1. Spawning

The spawning season of *S.gairdneri* is from September to February, *S.trutta* is from October to December and *S.fontinalis* is from October to January. Trouts prefer gravelly substratum to safeguard their eggs and the eggs stick to gravel and debris. Trout build nests and spawn in streambeds. Culturists allow artificial fertilisation, because streambed fertilisation results less hatching rate than artificial fertilisation. Manipulation of the photoperiod and water temperature can be used to induce gonadial maturation, so that young fishes are generated throughout the year. Trouts are caught at or near maturity as they are swimming upstream and raised to maturity ro ponds. The brood fish are placed in small ponds with flowing water and are often covered with netting to prevent them from jumping. The milt of a single male can be used to fertilise two females, so that more females are stocked with few males.

Trouts exhibit sexual dimorphism. Males become more brightly coloured and the lower jaw develop a hooked beak during the breeding season. Females develop extended bellies and the genital papilla becomes larger and reddish. When they are fully matured, milt or eggs comes out with little pressure on the abdominal vent. When the trout is ripe, the female fish are stripped and eggs collected in a black coloured enamel or plastic container to which the milt of the male is added and mixed thoroughly with a quill feather for fertilisation. Water is added after mixing and the water causes the eggs to swell. Water should not be added before the mixing, since motility of the sperm is greatly reduced in the presence of water. To ensure a better survival rate, the eggs may be collected in a small quantity of saline solution (10 lit. fresh water +

90 gr. common salt + 2 gr. potassium chloride + 3 gr. calcium chloride). The fertilised eggs develop a green tinge and are known as ‘green’, which are then transferred to hatcheries. Before transferring remove the foreign particles and dead eggs.

9.2.2. Transportation of trout eggs

The fertilised and hardened eggs (hardened for 24 hours) of trout are transported in cardboard cartons of 20 X 30 X 20 cm size. The inner side of the card board box is lined with styrofoam lining. Two moist sponges or cotton pads are arranged, one at lower side and other at upper side. Porous polyethylene bags containing about 4,000 eggs are placed in between the moist sponges and cotton pads. A polyethylene bag with IKg broken ice is kept for maintaining low temperature, above the upper pad. These cardboard cartons are transported to various places.

9.2.3. Hatchery techniques

The trout eggs are incubated by keeping them in concrete troughs with flat and horizontally arranged trays, incubators or jar. Hatcheries should be provided with circulating filtered and silt - free freshwater. In olden days baskets were used for incubation. Vertical flow incubators are the most common. It has many stainless steel, of fiberglass, aluminium, or wood, or PVC, or plastic trays, arranged one above the other. The bottom of the trays are provided with perforated zinc sheets, glass grills or mesh cloth for ensuring the passage of water through the different trays. The size may vary from 180 X 30 X 10 cm to 500 X 100 X 50 cm. Each tray has an upper egg basket and a lower perforated compartment on which basket rests. The eggs are placed in the basket for incubation. The water is introduced to the tray in such a way that it flows up through the basket containing the eggs, then down to the tray below and up through that basket and so on through the incubator. This upward flow of water through the eggs allows increased aeration and facilitates removal of metabolites.

Hatching jars are also used for the incubation of trout eggs. It consists a galvanised screen of 0.5 mm mesh with gravel bed at the bottom, just above the inlet. This gravel bed is useful as filter to remove the unwanted particles. The eggs are placed above the filter for hatching. Water passed through the inlet, upwells through the filter and eggs and drains through the outlet. After hatching, the hatchlings are maintained for some time in the jars.

The eggs are highly sensitive during the hatching period. Newly fertilised eggs can be killed if directly exposed to sunlight. During incubation, water must be moving and have a high oxygen content. Incubation normally takes place in water with 8° -12°c temperature. The fry can be held in the trays until they become active and are able to begin to feed. They can be released for stocking in natural waters.

9.2.4. Culture of trouts

The fry are reared in small rearing troughs before they have completely absorbed their yolk sac, and introduce to live on artificial feeds. Then they are transferred to nursery ponds for rearing to advanced fry stage. The nursery ponds may be concrete or stone-walled with 2.5 X 1 X 0.75 m to 9 X 1 X 0.75 m size. The water flow may be maintained 100 lit/min. inside the nursery pond.

The advanced fry are reared to adults in rearing pond and raceways. Rearing pond is a natural body of water, and a raceway is merely a running water fish pond. The size of raceways should range from 20 -100 m2 with a depth of 1.5 m. A series of raceways are constructed either side of the stream or river. Each raceway gets water from stream and water goes out of the raceway through the outlet which is found on the opposite side. Zinc plate screens are used at inlets and outlets. The water flow is maintained 50 lit/sec, into the ponds from river. Circular and oval ponds are used in USA. The stocking rate may be limited to produce 5-10 Kg/m2. High production of 200 Kg/mis also possible in raceways, if management is good.

Cage culture of trout is also common. In an experiment, fingerlings were stocked at 1.4 Kg/m2 in cagesand fed 3 % of their body weight daily. These trouts grew to 27-88 gr. in two months. The feed given to trouts includes cattle spleen, heart and lung and marine or freshwater trash fish. Many commercial trout feeds are available in the market. Trout are fed 3 - 4 times daily. There are number of ways of giving feed to trouts. The feed is either sprayged on the surface of the water, or the feed can be kept in a bag or in a container in the corner of the pond. It is used for the demand feeders, in which whenever a trout bumps into the trigger the feed is released into water, or automatic feeders can also be used. Jars and drums are also used for rearing trout fry.

9.3 Sewage - Fed Fish Culture

Sewage is a cloudy, dirty and odorous fluid from our toilets and kitchens of our houses. It has minerals and organic nutrients in a dissolved state or dispersed in a solid condition. Disposal of sewage has become a global problem because of urbanization. It is an effect of demophora, i.e. an unabated growth of human population. In recent years, sewage has become a major pollutant of inland waters, especially rivers. It is a source of many epidemics. It is responsible for a serious threat to soil and water ecosystems. The approach towards waste water disposal should be utilization of this residue with the concept of their reuse or recycle through an ecologically balanced system involving mainly aquaculture. The utility of sewage effluent to enhance fertility of freshwater ponds has long been known in many countries of the world.

The amount of sewage produced is India in 3.6 mm3/d (million cubic meters per day) or 800 mg/d (million gallons per day). About 30% (1.9 mm3/d) is produced at urban centers. Only 1.3 mm3/d (20.4% of India’s one-day total) is treated at these centers. Nearly 80% of the country’s one day total still remains to be treated and utilized. The amount of manure obtained from one-day production of sewage in India is about 0.126 m.tonnes. This is equal to 46 m.tonnes/year. The manure from one-day sewage is enough to cultivate 0.1 m.hectare of annual crop of fish. Sewage is also useful to cultivate fishes. In India only 130 plus sewage-fed fish farms are found covering an area of 12,000 hectares. The Vidyadhari sewage-fed fisheries near Calcutta is an example, where fishermen have taken full advantage of the sewage disposal systems of Calcutta. Here the fish yield is about 1,258 Kg/ha. The high manurial capacity is combined with the potentiality to serve as an additional source of water for fish culture and enhance the fish production.

9.3.1 Composition of sewage

The composition of sewage varies from place to place and according to season. Water is a major component of sewage (99%) and the solid suspension in sewage amounts to 1% only. On an average the sewage of Indian towns contains 52 ppm nitrogen, 16 ppm phosphorus, 45 ppm potassium and 350 ppm biodegradable organic matter. The organic carbon component is 25-40 ppm, the ratio of carbon and nitrogen being 1:3. Salts of several heavy metals such as Zn, Ni, Cr, Pb, etc. are also found above the permissible levels in sewage. The organic refuses in the sewage have proteins, carbohydrates and fats in varied proportions depending on the nutritional status and food habits of the population. Among carbohydrates, readily degradable starch, sugar and cellulose are detected.

Table 9.3 Ecological parameters of sewage water and freshwater ponds

Parameter	Sewage water pond	Freshwater pond
pH	6.9 - 7.3	>7.0
Dissolved oxygen (ppm)	0-2	5.0 - 9.0
CO2 (ppm)	20 - 35	10 -15
H2 (ppm)	<2.0	Nil
Specific Conductivity (Mohs)	35 - 400	20 - 50
BOD (ppm)	100 - 300	1 - 15
Free NH3 (ppm)	traces - 20	Nil
Albumenoid NH3 (ppm)	Nil - 16	Nil
Nitrites (ppm)	0.06 - 1	Traces
Nitrates (ppm)	0.01 - 30	Traces
Phosphates (ppm)	7 - 20	Traces

Some ecological features of different waters are mentioned in Table 9.3. Sewage water has high BOD (Biological Oxygen Demand) and Oxygen Consumption (OC) values. Dissolved oxygen becomes depleted in sewage water due to high oxygen demand and low photosynthetic rate. Photosynthesis is low because of poor illumination as the suspended solids in sewage water obstruct sunlight. On an average, strong, medium and weak sewage consist of 1200 ppm, 720 ppm and 350 ppm of total solids respectively, out of which 850 ppm, 500 ppm and 250 ppm occurs in a dissolved state and 350 ppm, 220 ppm and 100 ppm is found in suspended form. Dissolved salts being very high in sewage water, manifest high specific conductivity. Production of acids in high amounts render the water acidic, making the medium unfit for supporting life (Fig. 9.3). Acidity of water below pH4 is known to kill the flora and fauna.

Sewage enriches water with organic matter that begins to decompose aerobically thereby depleting dissolved oxygen and leading to anoxic condition. Anoxia causes non-mortality of animals, adding organic matter further to the already rich organic content. In the absence of dissolved oxygen the organic matter undergoes anaerobic decomposition as a result of which obnoxious gasses like H2S, CH3 and CO are produced. These gasses besides being toxic, react with water to form acids.

Immediate effect of sewage on the biota is eutrophication. Sewage water stimulates rapid growth of phytoplankton leading to an algal bloom followed by rapid increase in zooplankton. For utilizing sewage in aquaculture, the properties such as the concentration of dissolved and suspended solids, organic carbon, nitrogen and BOD are essential.

9.3.2 Microbiological charactaristics

Harmless and even useful non-pathogenic bacteria are present in much greater numbers in domestic sewage as compared to pathogenic bacteria comprising mostly the intestinal microorganisms found in the community producing the waste. Usual load of coliform bacteria in raw sewage ranges between 108 and 109 MPN/100ml.

9.3.3 Site selection and construction of sewage-fed fish farm

Fish farm in the vicinity of an urbanized area has the scope to receive domestic sewage for the recycling of nutrients. Any area adjacent to a municipal sewage treatment plant is ideal for the location of a sewage-fed fish farm. The fish farm site should be at a lower level than the treatment plant so that the sewage can easily enter into the pond through a pipeline by gravity. The fish farm should have facilities of draining out water from the ponds.

The plan of the fish farm depends upon the source of the sewage, system of culture and topography of the land. Nearly 75% of the total area is converted into ponds leaving the rest for dykes and other purposes. Rectangular fish ponds of 0.3 to 1 ha are constructed with a slope of 1:3 for the embankment and maximum depth of 1.5m. Each pond should have proper drainage facilities.

The effluent is collected in a sump at the farm, from where the effluent is taken into the ponds through the distributing system. Additional arrangement is made to connect the pipelines with freshwater supply for emergency dilution.

9.3.4 Sewage treatment

Sewage treatment is necessary to kill the harmful microbes, prevent anoxia, raise the pH to an alkaline level, increase photosynthesis, reduce organic content, etc. The treatment has to be inexpensive and one which induces in sewage water the conditions prevailing in a natural freshwater pond. Sewage is treated in following three ways - mechanical treatment, chemical treatment and biological treatment.

9.3.4.1 Mechanical treatment:

Solids and organic matter are removed to a large extent by mechanical treatment, which involves flowing, dilution and sedimentation. Usually screening and straining of sewage it is done to remove the waste solids. The liquid and semisolid wastes are then

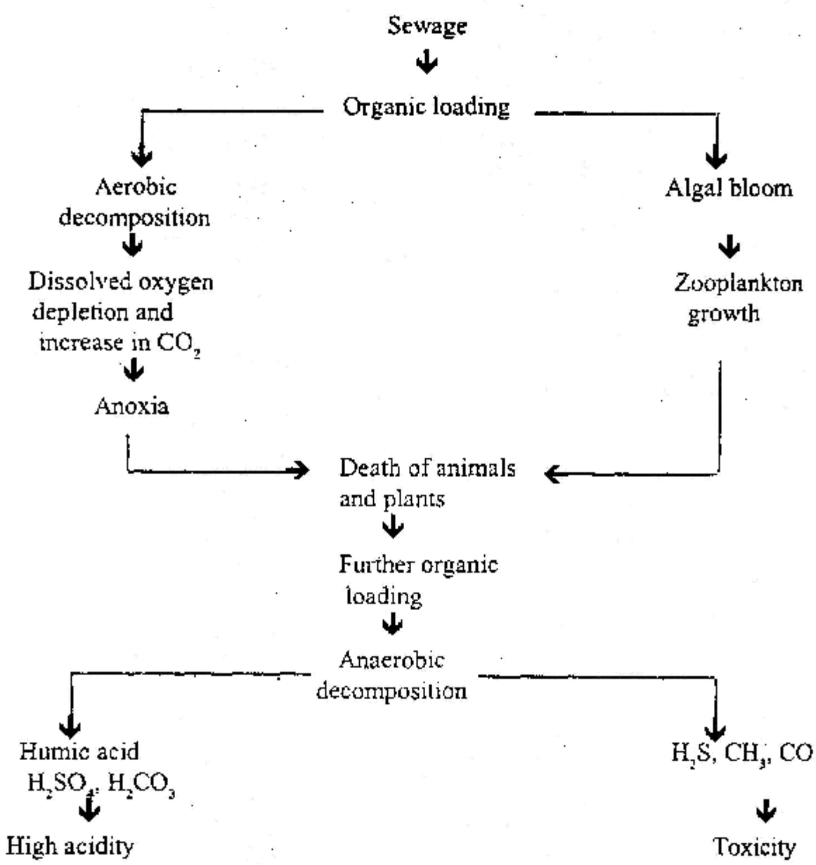


Fig. 9.3 Toxicity in sewage water ecosystem

subjected to treatment for the removal of colloidal and semisolid suspension by dilution, H2S, CO2, CO, NH3, CH3 concentrations are brought below the normal levels. Thus, through primary treatment the supernatent effluent is separated from the sludge.

9.3.4.2 Chemical treatment:

In chemical treatment, several dissolved substances, harmful germs and aggressive odours are eliminated. Inexpensive precipitants,

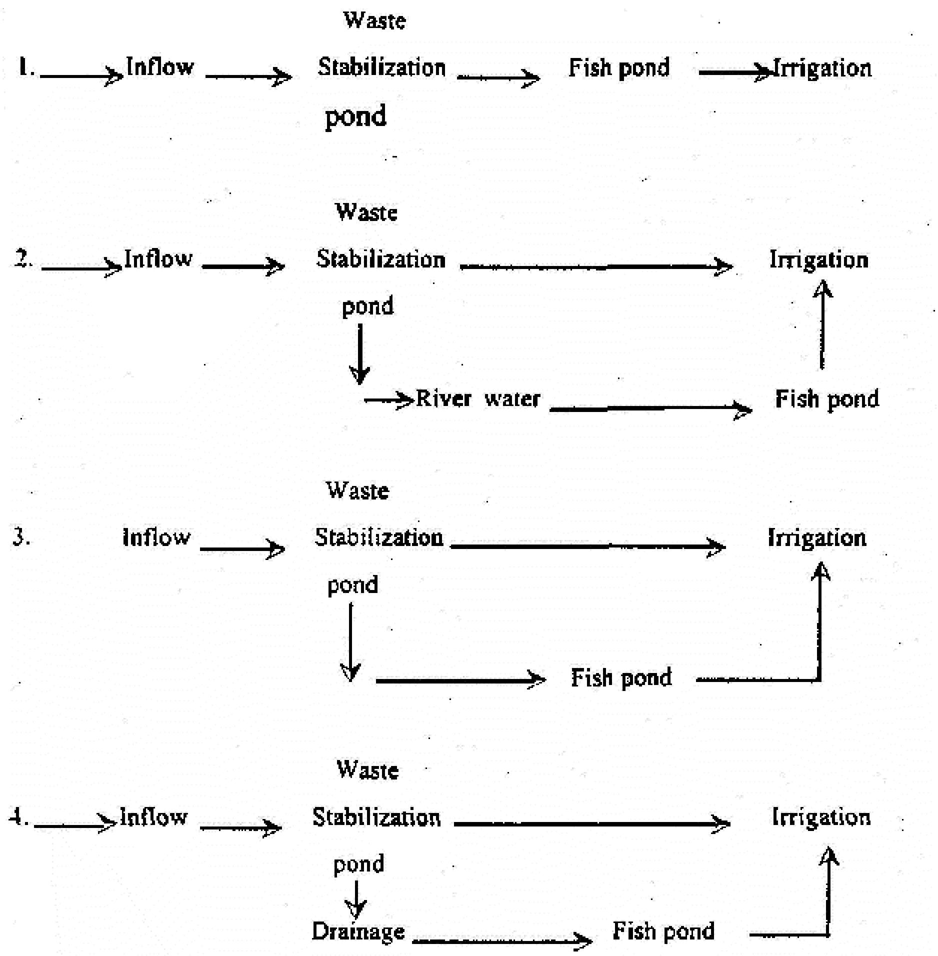


Fig. 9.4 Design for sewage-fed fisheries and irrigation at Vidyadhari-Kulti sewage complex Calcutta

coagulants, chelating substances, disinfectants, deodorising agents, etc. are used in this treatment. The sewage water is also treated with chlorine, bleaching powder and copper sulphate. It is also known as secondary treatment.

9.3.4.3 Biological treatment:

In biological treatment of sewage care is taken to promote bacterial growth. Bacterial action promotes oxidation of organic matter. The end products nitrogen oxides, bring about rapid growth of algae, particularly the blue green Microcystis. This arrests anoxia of water by raising the dissolved oxygen, lowering the CO2 content and by increasing the pH from acidic to alkaline levels. The algal bloom reduces the concentration of dissolved salts in the sewage water.

9.3.5 Pond Management

9.3.5.1 Fertilization

Fertilization of sewage-fed pond is done in two phases, pre-stocking and post-stocking fertilization. In dewatered and sun dried ponds, primary treated sewage effluent is taken up to a depth of 60 - 90 cm during premonsoon months (April - May). The effluent is then diluted with rain water or freshwater till the pond BOD reduces to 50 ppm. Periodic fertilization with sewage effluent is carried out after two months of stocking to maintain nutrient status and productivity of the pond at a desired level. The quantity of sewage effluent to be allowed into a pond solely depends on its quality determined on the basis of BOD values.

9.3.5.2 Liming

Application of lime in sewage-fed ponds is most essential. It is a useful promotor of fertility in ponds and act as a disinfectant against harmful microorganisms. Prestocking liming is recommended at a rate of 200 - 400 Kg/ha as initial dosage. Subsequent liming of 150 - 200 Kg/ha on standing crop is necessary throughout the year during sewage intake and during winter months, when parasitic infection is more.

9.3.5.3 Stocking

The cultivable species of freshwater fish such as Indian major carps and exotic carps can be grown in sewage-fed waters. Considering the high carrying capacity and high productivity of sewage-fed ponds with respect to plankton and benthic fish food concentration, fish are usually stocked at a reasonably higher density. The stocking rate recommended 10,000 - 15,000 /ha of carp fingerlings of about 10 gr. each and it is preferred to stock more of omnivorous scavengers and bottom feeders to maintain fish pond hygiene for higher yield. The ratio of carps for better output is rohu 2.5 : catla 1: mrigal 2.5 : common carp 2 : silver carp 2. Omnivores and bottom feeders directly consume the organic detritus of sewage-fed ponds, and thereby directly helping in keeping the pond aerobic. The stocking rate of fish is kept on a higher side considering the profuse growth of algae which will otherwise grow, decay, putrify and finally deplete the oxygen concentration of fish pond.

9.3.5.4 Ecological considerations and algal control

Maintenance of aerobic conditions of the sewage-fed pond is highly essential and as such early morning dissolved oxygen level should not deplete below 2 ppm for carps. The BOD should be below 30 ppm for better survival of fishes. CO2 concentration should not be allowed to increase beyond 20 ppm to keep the toxicity level within tolerance limit for fish and to control algal blooms. Liming helps in regulating CO2. Heavy metal pollution, if any, can be controlled by introducing water hyacinth at the pond margins and barricading them with bamboo poles to prevent spreading of the weed throughout the water surface of the pond.

Algal control is a must to maintain proper dissolved oxygen. It should be more than 2ppm and optimal 5 - 6 ppm in a sewage-fed pond. The presence of silver carp regulate the algae in the culture system. When biological control of algal bloom is not possible, application of simazin at rate of 0.5 - 1 ppm is recommended.

9.3.5.5 Control of aquatic insect

Aquatic insects are found in sewage-fed ponds, especially more during winter months. The insects of the pond mainly comprises hemiptera, coleoptera, odonata, zygoptera and trichoptera. Dipteran insects dominate, especially the larval stages of Chironomids associated with annelid worms of tubificidae.

Other insect larvae of the sewage-fed ecosystem belong to tubanidae, anthomyiodae, tetanocoridae, etc. The predacious hemiptera, coleoptera and a few odonata, zygoptera are needed to be controlled. An emulsion of soap and vegetable oil at a rate of 4 Kg/ha and in the ratio of 1:3 is applied to control these insects.

9.3.5.6 Harvesting and yield

After 5 - 6 months culture, when the biomass grows to an optimal level, the stocking density is thinned out through periodical and partial harvesting. The water depth of the pond is reduced by dewatering for final harvest when the fishes are removed by repeated drag netting.

In a mixed culture of five carp species in sewage-fed ponds, the yield rate varies from 5.4 - 8.6 t/ha/yr with an average production of 7 tonnes/ha/yr. The fishes are around 500 gr. to 1000 gr. during culture operations.

The recurring expenditure on sewage-fed fish culture is meagre compared to that of fresh-water fish culture. This culture is lucrative and a fish farmer can obtain an income, on an average of more than Rs. 40,000 /ha/yr. If murrels are cultured in oxidation ponds and the excess sewage is utilised for the cultivation of crops, the revenue could be further augmented.

Full utilization of sewage has manifold benefits. Outbreak of epidemics can be prevented. Biogas from sewage can be used as fuel to ease the pressure on LPG, electricity and fuel wood. Slurry from biogas plants can be used as a manure. Water reclaimed from sewage can be recycled for irrigation and pisciculture. Besides, scientific handling of sewage generates employment opportunities to educate youths. More than all these water bodies, rivers, particularly can be saved from sewage pollution by proper management.

9.4 Utilisation of Biogas Slurry for fish culture

In our country, especially in rural areas, mere has been a tremendous growth of biogas plants as a source of non-conventional energy. Biogas is also called as gober gas. The biogas plant is a device for conversion of fermentable organic matter, especially cattle dung into combustible gas and fully matured organic manure or slurry by anaerobic fermentation. The nutrients of the generated slurry can be harvested for production of feed and food and replace conventional inorganic fertilizers. Due to lack of knowledge and communication to farmers, most of the generated slurry is not used properly. The biogas plant can also digest night soil, poultry and piggery droppings, weeds and other fermentable materials along with cattle dung. Biogas slurry consists of 1.52 mg/lit nitrogen, 0.82 mg/lit of phosphorus and 0.83 mg/lit of potash. Biogas slurry is rich in humus and contains nutrients mostly in the available form. The oxygen demand for its decomposition is much less than for raw cattle dung or any other organic manure. Due to the high nutrients value of biogas slurry, it can be used as a fertilizer in fish culture ponds. Slurry application improves the soil structure. It enhances zooplankton production in water.

Gober gas plant is a composite unit of a digester and gas holder. Gas holder floats on the top of digestor, wherein gas is collected. In the plant, the whole system is based on continuous operation. The organic manure to be fermented is fed in semi-fluid form at the one end and the fermented spent slurry is extracted at the other end periodically with disturbing the whole system. Slurry is odourless, free from flies and other sources of infection.

In a preliminary experiment, the slurry from plant is drained into a fish pond of 0.15 ha area, which is stocked withrohu, catla, mrigal, common carp, silver carp and grass carp at a density of 7,500 fishes/ha, resulted in production of 5080 kg/ha/11 months (762 kg/ha/0.15 ha/ 11 months). This experiment indicates that the high production potentiality of the pond using only biogas slurry as fertilizer. In Madurai Kamaraj University, the experiments conducted with *Oreochromis mossambica* by using only biogas slurry as fertilizer and found the enhanced production. They indicated that males grow larger than females. They got the production of 2.4 tonnes/ha/125 days with a stocking density of 30,000 juveniles/ha and initial size of O.Sgm. They also got 4.4 tonnes/ha/125 days with a stocking density of 60,000 juveniles/ha and initial size of 0.5 gm.

In a polyculture experiment with Indian major carps at ratio of 4 rohu: 3 catla : 3 mrigal at a density of 5000/ha by using only biogas slurry (0.15% concentration every three days) as feed and fertilizer resulted 5500 kg/ha/yr. The fishes grow well with only slurry, without any supplementary food and other fertilizers, this reduces the cost of feed and fertilizer. But there is little chance of microbial attack, it can be controlled with good management. In an experiment at ANGRAU with biogas slurry in different dosages - 5000, 10,000 and 15,000 kg/ha/yr applied in different fish ponds 1/3 of the slum' was applied initially and the remaining slurry was applied in equal fortnightly instalments. Catla, rohu, mrigal, common carp, silver carp and grass carp were stocked at a ratio of 2:2:1:1:2:2 at the rate of 5000 kg/ha. The production was obtained was 1956. 2096, and 2052 kg/ha/yr in 5000, 10,000 and 15,000 kg/ha/yr biogas slurry treated ponds without any supplementary feed, or organic and inorganic fertilizers. The fish production obtained was 5470, 7230 and 6050 kg/ha/yr in the above three slurry treated ponds with supplementary feed, but without organic and inorganic fertilizers. Supplementary feed was given in the form of rice bran and groundnut oil cake in the ratio of 2:1 at the rate of 5% body weight of fishes.

The experiments indicate that high production offish in biogas slurry treated ponds and at the same time the expenditure is lesser than normal culture systems because organic and inorganic fertilizers and supplementary feeds are not used. By using the waste of biogas plant in the form of slurry, profitable fish production can be obtained. Fish produced through recycling of organic manure is more healthy and has less fat accumulation. The recycling system, however, requires effective management. One of the problems is the difficulty in balancing the expertise needed in fish animal husbandry. Over concentration on one system may be detrimental to the other. The monitoring of dissolved oxygen level in pond water is absolutely essential when the integrated systems are adopted. Excessive manuring causes water pollution. It rapidly decreases oxygen level in the water, produces toxic gases like ammonia often leading to fish kills. Application of manure should be regulated according to the dissolved oxygen level which is very essential for the rapid growth of fishes. No serious health hazards due to slurry was noticed, though animal excreta is a potential source of infection. Moreover, fermentation of the manure in a biogas plant kills and destroys the eggs of parasites.

9.5 Cage and Pen Culture

9.5.4 Cage culture

Fish culture in ponds is the primary method of freshwater and brackish water fish culture. However, there are other methods of fish culture used in places where pond culture is not possible. Other methods of fish culture are those carried out in dams and reservoirs, cages, pens and rice fields. Due to exponential growth in population and the great pressure on land for habitation and agriculture, the large water resources such as tanks, lakes, reservoirs and canals, which have been not exploited so far can be used for augmenting fish production. Due to the large water bodies, the management has complex problems. The best thing seems to be captive, regulated culture of suitable fishes in impoundments installed in them.

A practical approach to increase the aquaculture production could be takeup as fish husbandry in cages, pens and other enclosures in large water bodies like tanks, swamps, lakes, reservoirs and canals along with open ranching, without prejudice to their other use. By virtue of the short gestation period, these unconventional systems yield quick results with minimum conflict of interaction on land demand with agriculture and other animal husbandry practices. Enclosure aquaculture can play a significant complementary role in augmenting yields from our capture fishery resources, especially those having large predatory fish population.

Cages and pens could be utilized as nurseries for raising fish seed and for the grow-out of table fish. They dispense with the need for land based nursery forms cutting down on the cost of seed production. Investment on long distance transport of fingerlings for stocking reservoirs and handling mortality can be avoided by insitu rearing of fry in cages and pen installed in them. One of the impoundment cultures is in cages. Many countries are practicing cage culture of fishes and prawns successfully. Cage culture has also been started in India only recently.

*9.5.*1.1 Advantages of cage culture

The advantages of cage culture are

1. Large water bodies could be utilized better for fish culture.
2. The flowing water could be better utilized for fish culture.
3. Cage culture reduces demands on prime agricultural land for fish farm construction.
4. Free exchange of water.is possible in cages.
5. High density stocking and intensive feeding of the stock can be achieved, which gives high yield per unit area.
   Decomposition and degradation of concentrated waste products do not arise in cage culture.
   Oxygen depletion can not be found in cages. Monitoring growth of the stock, diseases is easy.
9. Considerable reduction or extreme compactness in the production area is thus achieved in cages.
10. Several units of cages could be installed in a water body for gainful employment and income.
11. Harvesting is simple and easy.
12. Considerable indirect employment will be generated.
13. With ca’ge culture, the animal protein production can be increased.
14. The left over feed, faecal matter and metabolites enrich the water body in which cages are installed.

*9.5.1.*2. Location of cages

The ideal location for cages is weed-free shallow waters. Flowing water is best for cage culture. The site should have adequate circulation of water. The wind and wave action should be moderate. The water should be free from pollution and weeds. The area should be easily accessible. Cage culture can also be practiced in areas like swamps where there is water not being used for any other purpose. Seed should be available in the vicinity. A ready market for fish should be available near the site. Flowing waters with a slow current of 1 - 9 m/minute'lare considered ideal for cages. The cages should be a little away from the shores to prevent the poaching and crab menace.

9.5.1.3 Types of cages

Cages can be circular, cubic and basket like and the shape has little effect on yield rate. Cages may be floating at the surface, just submerged or made to sit on the bottom. Floating cages may be the most appropriate for Indian conditions and the experiments conducted in our country for seed rearing, grow out, nutrition and biomonitoring have been in such enclosures. The size of the cage depends on the type of culture operation and the support facilities available. Large cages are difficult to handle. Although the cost of small cages is higher, handling is easy with low risk of losses. The nursery cages are generally of the floating type, while the ground cages may be floating or immersed depending on the species cultured.

*9.5.1.*4. Construction of cages

The type of material used for cages (Fig 9.4) will depend on the type of culture whether they are used for fry or table fish rearing. Bamboo interspred with wooden planks for cages is commonly used in Indonesia, Vietnam, Thailand and Kampuchia. Thick polythene fibers are used for cages in Japan. Metallic grills are used in—LISA. Aluminum frame and nylon webbing is used for fabrication of cages in USSR and West Germany. In our country, fairly fine mesh nylon netting are used. The cage material are used mainly depending on their cost and availability.

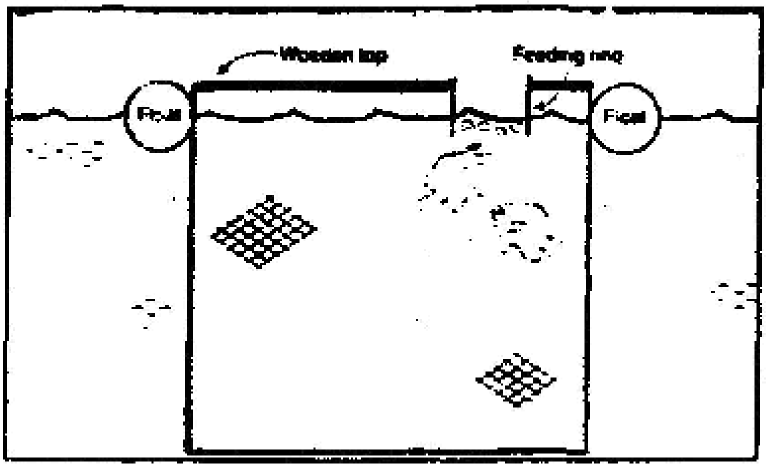


Fig. 9.5 Cage for fish culture

Small cages with mats of locally available plant materials such as palm leaves. *Cyperus* stem, *Phragmites* stem and split bamboo are used in India. These cages are of 1 - 2 m2 area. Split bamboos are joined with the help of coir rope or nylon twine. The cages are installed in the water body with bamboo supports at the four comers and the bottom. Materials other than bamboo mats are decayed by the third month and collapsed within a year. Split bamboo cages remain for over a year. Circular cages with thick bamboo stipes tied with nylon twine the durability of over 3 years.

Cages made up of monofilament woven material of 1 - 3 mm mesh size and 0.3 - 1 mm thickness are light and easy to handle, but remain for 6 to 12 months. The exposed part become brittle and gives way. Knotless nylon webbing of 3 - 6 mm mesh size and knotted nylon webbing of 7 -15 mm mesh have been found to be most durable. Cages made of water - proof surface painted light conduit pipe frames with a 10 m2 area are light in weight and have long durability. A battery of cages is enclosed with a bamboo catwalk and the whole structure floated by sealed empty barrels of 200 1. capacity.

The circular cages with conduit pipe structures which can be easily assembled have been designed with nylon webbing in different dimensions. These cages are floated freely on the water surface with the help of 3 - 4 sealed HDPP jerry cans. These arc extremely useful for cage culture. Due to their circular is shape the wave action in minimum. These can be moved from place to place with least water resistance. Due »their circular shape, the rearing space is maximum in side. The aeration and water circulation is better in these cages. Fishes can move in the cages with least obstruction.

Auto-floating, highly durable HDPP pipe frame nylon net cages with 36 m2 area are also used. These are light in weight and not need floats to float on the water surface.

The size of the cages depend on die scale of culture, species cultured, infrastructure, financial and management resources. The size varies from 2- 10m3 in India, 100 - 150m3 in Indonesia, 60- 180m3 in Kampuchia. 40 - 625 m3 in Vietnam and 30 m3 in Holland. Large cages are operated in Germany with 42 m diameter and 16,500 m3 at the water depth of 12 m. These are provided with automatic or water jet pump-feeding, special handling and harvesting accessories.

9.5.1.5. Calturable fishes in cages and their stocking

The fishes used for the cage culture should be adaptable to captive culture, fast gro\vng, hardy and disease resistant. The Indian and Chinese carps, tilapia and magur can also be cultured where trash fish is cheaply and abundantly available. In Thailand and Kampuchia the cat fishes, *Pangasius* species are being cultured in cages successfully. Koi and Singhi are also cultured in India in cages.

In India, the nursery cages are stocked with carp fry at the range of 150-700 fry/in2 in caaes with different materials. In Japan 15.000-62.000 fry/nr2 of grass carp fry are stocked in nursery cages. The common carp stocking density is 150/nr2 in Kampuchia, 133 -417/nv1 in Indonesia and 80 - 360/nr2 in Vietnam. In Thailand *Pangasius sutchi*, *P. larmmdi* and *P. micronemus* fry are stocked at densities of 150-300/nr2 in cages of size 1-10 m2 area with a depth of 1.5m. .

The number of fish that can be stocked in a cage is variable and depends on the canying capacity of the water area, water quality and rate of circulation, the fish species, the quality and quantity of feed supplied. A safe level may be about 3000 to 6000 fish/ ha. In able - fish rearing cages in India, the fingerlings of carps are stocked at density of 30 - 38no /m2 . The tilapia, *Oreochromis mossambicus* can be stocked a rate of 100 - 200 m-2. Murrels can be stocked at density of 40-100m2.

9.5.1.6. Management and yield

The cage culture can be taken up in two phases - nursery phase and table - fish rearing phase. In nursery phase of cage culture, the spawn or fry are reared to fingerling stage in 2-3 months. Different feeds can be used for culture in nursery cages. Groundnut oil cake, rice bran, egg yolk, soyabean cake, soyamilk and soya flour are used as food for fry in nursery cages. The silkworm pupae are also tried as supplementary food.

The initial size of fish to be stocked in the cages will depend primarily on the length of the growing season and the desired size at harvest. The carp fingerlings for stocking in 16-20 mm mesh cages should be over 10 gr. to expect a final size of over 500 gr. within 6 months. It should be ensured that the fingerlings used for stocking are healthy and disease free. All the fish should be actively moving. It is ideal to stock cages in the cool part of the day.

In India, the growing season is almost year round, except for December - January in northern parts, where the temperature is low during these winter months. Very little natural food such as plankton, insects and various other organisms enter the cages and is available to fish. However, supplementary feeding is essential in the cage culture to get high production. The types of feed used will depend on the species cultured and their prevailing market prices. Murrels, for example, require to be fed with fish, shrimps or other animal matter. Most of the fish cultured are omnivorous and they accept both plant and animal byproducts such as oilcakes, brans, fish meal and silk worm pupae.

Cage fish are generally fed at least once daily throughout the growing period to get better growth. The quantity of feed to be given is important, since under-feeding will reduce growth and production, while over-feeding will waste costly feed and can affect the water quality. A method used to estimate the daily feed to be give in cages is based on the total weight of the fish. The feed is usually expressed on percentage of body weight. In carps, the feeding rate is 4 - 5 % of the body weight per day until they attain approximately 100 gr. And thereafter at 2 - 3 %.

In table-fish rearing phase, involving the high-tech system of saturated stocking and feeding on enriched formulated feeds, the production recorded in common carp is 25 - 35 Kg m° month'1 in foreign countries. The channel catfish, *Lactarius punctatus* in USA yielded a production of 20 - 35 Kg/nr3. In Africa, tilapia yielded 17 Kg/nr3and trout produced 15 Kg/nr3. The food quotient in these cultures varied from 1.3 - 2.1. In India, a production of 1.5 - 2.5 Kg nr: month'1 common carp was achieved with mixed feed of silk worm pupae, ground cake and rice bran. Catla yielded *1.4* - 2.7 Kg nr2 month'1 with groundnut cake and rice bran with the food quotient 5.6. Tilapia produced 1 - 1.6 Kg nr2 month'1 with a mixture of rice bran, groundnut cake and commercial cattle feed and food quotient ranged from 1.8- 2.3 . About 1 Kg nr2 month"' of murrel and 0.3 - 1.5 Kg nr2 month'1 of catfishes, singhi and Koi are obtained.

9.5.1.7. Cage culture of prawns

The freshwater and marine prawns are also cultured in cages. The cages are stocked with wild or hatchery reared post larvae. Commercial scale rearing of post larvae in floating and fixed nursery cages (3.7 X 2.7 X 1.3 m) has been done with considerable success. They are fabricated from fine mesh (0.5 mm) nylon netting, supported by bamboo poles which are driven into the bottom of the water body. The optimal stocking density reported is 30,000 post larvae/cage (2 .310 m'3). Feed is provided in trays fixed inside the cages. Initially, the post larvae are fed on a paste of finely ground trash fish, later are fed with fresh mussel meat.

9.5.2. Pen culture

Recent results in the use of cages, pens or enclosures and recirculating water systems suggest some ways of compact intensification of production in aquaculture given the accessory inputs. This practice may provide great possibilities in the future in certain selected and suitable areas.

Aquaculture in open waters through the use of pens or enclosures is also a means of minimising the limiting effect of metabolities and pollutants on cultivated stock. Greater production in very limited space has been found possible under those situations. Production figures from these types of aquaculture environments approximates to 4 -10 t/ha/yr in Laguna lake in Philippines.

9.5.2.1. Selection of sites for pen culture

i) Low tidal amplitude
ii) Fish pen - site must be sheltered as much as possible against high winds
iii) Depth not less than 1 meter during lowest water level
iv) The best site is on the leeward side of the prevailing winds with moderate flow of current especially in a place where current in overturning
v) Water with stable PH slight variation is best. Avoid turbid and polluted water.
vi) Muddy clay and clay - loam soils are best types of bottom soil. Too much still and decomposing organic matter must be avoided.

9.5.2.2. Construction of pens

Pens can be constructed with the help of bamboo screens and nets

a. Construction of pens with bamboo screens

Split bamboo should not necessarily be shaped and rounded. They are soaked in water for two weeks and then dried for one week. During the soaking and drying period, bamboo poles are prepared and staked at the chosen site according to thedesired size and shape of the fish pen. After stacking poles, bamboo splits are closely woven extending to a length of more or less five meters and made into a roll. After weaving, these are set by stretching them from one pole to the other interrurned or just set inside or outside close to the poles from bottom to top. They are tied every pole by rubber and one provided with sliced rubber around, liming one on top and one at the bottom. These splitted rubber prevent them from wear due to wave action. Nursery nets which should be 1/16 th to 1/10 th of the area of the fish pen can be set before constructing the fish pen or after it is set.

b Construction of pen with nets

Construction of a fish pen made out of synthetic netting is easier than one made of bamboo screens. Netting materials can be kuralon, nylon, cremona, tamsi. etc. An ordinary fisherman can connect the nets into the fish.pen after taking into account the desired height or depth of the pen site. After the net is constructed , the poles are staked in mud after making a provision for the front rope and tie rope at the interval of 1.0 - 2.0 m per stake and also the provision for float rope. In preparing the poles, all nodes are cleaned except one node with brunch protending one inch which is staked in the mud from 15 - 30 cm or more depending upon the depth of soft mud. With this node the foot rope is tied, and these together with the bottom net are staked in the mud. Boulders can be used as sinkers in the absence of lead sinkers. Bamboo tips of 1-1 *Vi* m are also used to stake the bottom net with a foot rope firm into the mud to avoid escape of the fish stock. Construction of the nursery net may be done before or after the construction of the fish pen. They should have a free board of about 1 meter above the normal water level to prevent entry or exit of fishes by jumping and as a precaution against water level fluctuations.

Metal and metal coated with HDPP screens are often used for pens which is highly durable.

9.5.2.3. Culture

Pen culture is extensively practiced in Japan, Peru and Philippines. Fish formers in Laguna debay and Sansabo Kekes stock milk fish fingerlings in pens and grow them to marketable size (200 g or above). Prawn are also similarly cultured. Very little work has been done on pen culture of fishes in India.

Traditional trapping and extensive culture of tiger prawn, milk fish, pearl spot, mullet, bekti and thread fins are done in some sort of pens and enclosures in canals joining the backwaters in Kerala and in the shallow areas of Chilka lake (Janos) in Orissa. The pens are made by weaving split bamboo or with netting. The enclosing of fishes is done usually after the monsoon season upto late autumn and the culture period lasts for about 6 to 8 months. The size of Janos in the Chilka lake varies from 5 to 500 ha. Since the stocking and harvesting are not done systematically, precise production S3* figures areajatavailable. The yield, however, is estimated to be about 60 Kg/ha/season.Seed rearing experiments were conducted in a split bamboo enclosure of 247.5 m2 reinforced with a nylon netting in Punarswamy Bhavanisagar (Tamilnadu). It was stocked with mrigal (size 7 mm) and *Labeo fimbratus* (size 5 mm) spawn at the rate of 4.6 million/ha and usual farm practices were followed. In 30 days mrigal attained a size of 38 mm and fimbriatus, 28 mm. At the time of conclusion of the study after 3 months, the former had attained a size of 88 mm and the later 75 mm. The overall survival obtained was 27.8 %.

Major carp seed rearing in pens is being done every year from 1982 onwards in the Tungabhadra reservoir in Karnataka. A shallow bay of the reservoir near Hampusagara is cordoned off with bamboo mats reinforced with Casuarina poles and lined with mononlament cloth during the summer months, prior to the reservoir getting filled. The pen is divided into several compartments with bamboo mats, lined with mononlament cloth. When the nursery pen, get water with the filling of reservoir, they are stocked with spawn of carps. The stocking density varies from 5 to 20 million spawn ha. The feed given is a mixture of ground nut cake and rice bran (1 : 1). After 2 to 4 months the fingerlings are enumerated and released in the reservoir. A *survival* varying from 11 to 30 % is obtained from the varies nursery pens.

A pen culture experiment for raising cattle and rohu in Mamkamaun a flood plain lake in Gandak basic yields a computed production of 4/ ha/6 months. The experiment was conducted in a bamboo screen pen (1000m) and the stock was fed with a mixture of nee bran and mustard cake, apart from a feed formulated from the aquatic weeds collected from the lake. Since intrusion of fishes from outside including predators is possible in pens. It is important to stock larger fingerlings (over 50 g size) to ensure better survival. It is be desirable to have scale pen culture. The species mix and stocking rates will mainly depend on the natural food supply, supplemental feeding strategy, water depth and the duration of rearing.

9.5.2.4. Supplementary feeding

The fish pens that are densely stocked with 10-20 fish per square meter, generally need regular feeding at the rate of 4 -10 % of the total body weight of the stock at least once 3 week, or it could be divided into daily feeding. The amount of food to be given depends on the condition of the culture fish which could be checked through sampling at least once a month.

9.5.2.5 Management

Management offish pens is more laborious and demanding than a fish farm, because there are more risks in managing fish pens. Fingerlings are liable to escape once a single bamboo split breaks or a small portion of the net is torn. Every now and then the fish pens have to be checked for any holes or breaks.

The fish pen site has to be laid idle at least one month a year so that excess food and other organic matter are completely decomposed before stocking with new fingerlings. If the site is not sheltered it would be advisable to remove the net or split bamboo screen during the stormy season and repeat during fine weather condition.

Summary

The culturable species of air breathing fishes are Fig. 9.1

Channa straitus	-	Big or striped murrel or snake head fish
Channa punctatus	-	Spotted murrel
Channa marulius	-	Giant murrel
Clarias batrachus	-	Magur
Heteropneustes fossilis	-	Singhi
Anabas testudineus	-	Koi or climbing perch.

Many species of trout are grown, but the three most common of them are the rainbow trout, *Slamo gairdneri* or *Oncorynchus mykiss,* the Eurorean brown trout, *S.trutta* (Fig. 9.2)and the brook trout, *Salvelinus fontinalis.* Trouts have a streamlined body, narrow gill openings and reduced gills. Trouts are adapted to highly oxygenated waters and freezing point temperatures. Trouts have great power of locomotion with clinging and burrowing habits. Mouth is modified with rasping lips for food collection from pebbles, rocks, etc..

Sewage is a cloudy, dirty and odorous fluid from our toilets and kitchens of our houses. It has minerals and organic nutrients in a dissolved state or dispersed in a solid condition. Disposal of sewage has become a global problem because of urbanization. It is an effect of demophora, i.e. an unabated growth of human population. In recent years, sewage has become a major pollutant of inland waters, especially rivers. It is a source of many epidemics. It is responsible for a serious threat to soil and water ecosystems. The approach towards waste water disposal should be utilization of this residue with the concept of their reuse or recycle through an ecologically balanced system involving mainly aquaculture. The utility of sewage effluent to enhance fertility of freshwater ponds has long been known in many countries of the world.

In our country, especially in rural areas, mere has been a tremendous growth of biogas plants as a source of non-conventional energy. Biogas is also called as gober gas. The biogas plant is a device

for conversion of fermentable organic matter, especially cattle dung into combustible gas and fully matured organic manure or slurry by anaerobic fermentation. The nutrients of the generated slurry can be harvested for production of feed and food and replace conventional inorganic fertilizers. Biogas slurry enhances fish production.

Question

1. Discribe airbreathing fish culture.
2. Explaine trout culture.
3. Discuss sewage-fed fish culture.
4. Discribe cage and pen culture.

GLOSSARY

Air-breathing fish: Fish possessing accessory respiratory organ that enables them to take atmospheric oxygen when required.

Aquaculture: The rearing of aquatic organisms under controlled or semi-controlled onditions

Artificial food: A prepared food formulated to provide protein and other nutrients in excess of those obtained from natural food organisms in the environment.

Beel: A Kind of derelict or semi-derelict wetlands usually formed either by tectonic activities or fluvial actions of rivers. This type of shallow, wide and weed infested water body may or may not have connections with a river.

Brackishwater: The intermediate type of aquatic environment where freshwater mingles with marine water.

Breeding ground: Particular area of the body of water where breeding of a fish species takes place. Also termed as spawning ground.

Breeding season: Part of the year when a fish species is sexually active. Also called spawning season.

Breeding stock / breeders: Groups of mature male and female fishes reared for breeding purpose.

Brood fish: Sexually mature fish, ready to spawn.

Cage culture: Culture carried out in chambers generally constructed of wire or netting around rigid frames, floated or suspended in large water bodies such as rivers, lakes, or bays.

Capture fishery: Fishing activities in open water such as river, lake ocean, etc.

Carnivore: An animal that feeds exclusively on the tissues of other animals.

Cast net: Circular net looks like a large umbrella, usually operated by a single person by throwing the net that ultimately covers the fish.

Caudal peduncle: The region between end of the anal fin and origin of the caudal fin.

Closed system: The type of aquaculture system wherein the water is conserved throughout most or all of the growing season. In most instances the water is recirculated through a culture chamber, a primary setting chamber, a biofilter, and a secondary settling chamber on each pass through the system.

Culture chamber: Any vessel utilized to hold and grow aquaculture organisms. Some examples are tanks, cages, silos, ponds, and raceways.

Detritus: Finely divided suspended organic debris from decomposing plants and animals.

Drag net: An elongated net in which fishes are captured by horizontal dragging (pulling) of gear. Also called pull net.

Egg: The female gamete, especially when it is fertilized or released outside the body.

Environment: The total of all internal and external conditions that may affect an organism or community of organisms.

Estuary: A semiclosed coastal water body with free connection with the open sea, in which seawater is diluted to some degree by freshwater.

Euryhaline: Organisms that can adapt to wide variations in salinity.

Eutrophic: Describing water bodies that contain abundant levels of nutrients, resulting in high levels of organic production. Eutrophication is an intermediate stage in lake succession and can be accelerated by activities of humans.

Extensive culture is characterized by large water areas in which low densities of culture animals are maintained, controlled to a limited extent by the culturist.

Extensive culture: Low intensity aquaculture such as is practiced in ponds by subsistence culturists.

Fecundity: The number of mature eggs produced annually by a female animal or per unit body weight of a female.

Feeding Habit: Characteristic behaviour of a fish while taking or searching its food.

Fingerling(A fish larger than a fry but not of marketable size. Though not rigidly defined, fmgerling fishes are generally between 4 and 10 cm long.

Food chain: A sequence of organisms, each of which provides food for the next, from primary producers to ultimate consumers, or top carnivores.

Food conversion efficiency: The reciprocal of food conversion ratio times 100, expressed as a percentage.

Food conversion ratio: In aquaculture, the amount of food fed divided by weight gain. The lower the FCR, the more efficient the animal is at converting feed into new tissue.

Fry: A stage of fish next to spawn stage when yolk sac has already been absorbed and active feeding commenced. It has the external characteristics of the adult but are smaller than fingerlings.

Gear: Tools or appliances such as net, trap, rod and line employed to catch fish.

Herbivore: Any animal that feeds exclusively on plant material.

Inland water Body: A water body which is enclosed partially or completely by the land.

Intensive culture: The rearing of aquaculture organisms in extremely high densities with a great measure of control in the hands of the culturist. Tanks, raceways, silos and cages are examples of culture chambers utilized in conjunction with intensive culture systems.

Lentic: Designates standing water (eg., Lakes or ponds)

Lotic: Describing a flowing water environment (e.g., a stream of river)

Milt: The white milky fluid oozing from the male fish consisting of sperms.

Natural food: The normal food of an organism in a natural condition.

Oligotrophic: Type of water body characterized by low levels of nutrients and low rate of production.

Omnivore: An animal that consumes both plant and animal material in its normal diet.

Open system: An aquaculture system in which water continuously flows through the culture area and is discarded after a single pass.

Open waters:A general term applied to denote running waters or any inland water body having an outlet.

Plankton: Tiny, microscopic aquatic plants or animals which drift at the mercy of water currents.
Sex ratio: The ratio between males and. females of a given population.

Spawning ground: Particular area of the body of water where breeding of a fish species takes place.

Stream: A fast flowing perennial or seasonal water body with gravel bed. Streams are generally not very wide.

Submerged vegetation: Aquatic plants growing under water and may or may not be rooted.

Supplementary food: Artificial food or natural food organisms to besupplemented in addition to the natural food available in the environment.

Survival rate: Number of fish alive after a specific period of time expressed as percentage of the initial number of hatchlings.

Swamp: Highly weed infested marshy area

Trophic Level: The position of an organism occupies in the food web (e.g., herbivore, omnivore, or carnivore). /-

Watershed: Catchment area of a river system.

Wetland: Marshy or swampy area, usually highly productive.

Reference Books

1. Water quality criteria for fresh water fish .alabaster, J.S. and lloyd, R. Butterworth Scientific London.

2. Fisheries and Aquaculture Ravi Shankar Piska Lahari Publications.

3. Hie wealth of India, Raw materials Vol. IV fish and fisheries CSIR, New Delhi.

4. TJie fishes of India Vol. land Vol. II. francis day

5. The fresh water fishes of India, Pakistan, Bangladesh, Burma, and Ceylon - A handbook jayaram, K.C. Z.S.I., Calcutta.

6. Concepts of Aquaculture Ravi Shankar Piska Lahari Publications.

7. Fresh water Aquaculture S.C. Rath Scientific Publications.

8. Text book offish culture, breeding and cultivation offish marcel must Fishing news books.

9. Aquaculture development, progress andprospects Pillay,T.V.R. Fishing news books.

10. Crustacean farming lee, D.O.C. and wickins, J.F. Fishing news books.

11. Aquaculture -principles and practices Pillay,T.V.R. Fishing news books.

12. Aquaculture training manual swift, donald R. Fishing new books.

13. Introduction to aquaculture landau, mathew John Wiley & Sons New York.

14. Fish aquaculture mesks, christoph Pergamon Press.

15. Carp fanning michaels. V.K. Fishing news books.

16. Fish and fisheries of India jhixgran, V.G. Hindusthan Publishing Co.

17. Diseases of pond cultured shrimps with emphasis on prevention strategies. Gilda. Lio.PO. East Asian Fisheries Dev.-Ctntre, Philippines.

18. Pond culture in Taiwan Lin. Kwei. C. College of Fisheries, Institute of Acquaculrure, Philippines.

CONTENTS

FRESH WATER AQUACULTURE
Fisheries, II year
Paper I

Intermediate Vocational Course
State Institute of Vocational Education
and Board of Intermediate Education

Authors

Dr. Ravi Shankar Piska
Associate Professor
Department of Zoology
University College of Sciences
Osmania University
Hyderabad - 500 017.

Dr. S. Jithender Kumar Naik
Associate Professor
Department of Zoology
Women's College, Koti
Osmania University
Hyderabad - 500 001.

Editor

Dr.Ravi Shankar Piska
Associate Professor
Department of Zoology
University College of Sciences
Osmania University
Hyderabad - 500 017.