Course Manual

# Model Training Course
on
# Freshwater Fish Culture

17 - 24 February, 2014

## College of Fishery Science

Udgir Dist. Latur - 413517

(Maharashtra Animal & Fishery Sciences University, Nagpur)

# CREDITS

| | | |
|---|---|---|
| **Course Director** | : | **Shri. B. R. Kharatmol**<br>Associate Dean,<br>College of Fishery Science,<br>Udgir, Dist. latur |
| **Course Co-Directors** | : | **Shri. V. B. Sutar**<br>Assistant Professor,<br>Dept. of Fisheries Hydrography<br>College of Fishery Science,<br>Udgir, Dist. Latur<br><br>**Dr. A.S. Kulkarni**<br>Assistant Professor,<br>Dept. of Fisheries Resources, Economics,<br>Statistics and Extension Education.<br>College of Fishery Science,<br>Udgir, Dist. Latur |
| **Course - coordinator** | : | **Shri. A.T. Markad**<br>Assistant Professor,<br>Dept. of Fisheries Engineering<br>College of Fishery Science,<br>Udgir, Dist. Latur |
| **Course Associates** | : | **Shri. A. T. Tandale**<br>**Shri. S. N. Kunjir**<br>**Shri. M. M. Girkar**<br>**Shri. U.A. Suryawanshi** |
| **Edited By** | : | **Shri. V. B. Sutar**<br>**Dr. A.S. Kulkarni**<br>**Shri. A.T. Markad**<br>**Shri. S.R. Yadav**<br>**Shri. S.N. Kunjir** |
| **Date of Publication** | : | **February 17, 2014** |

# PREFACE

Aquaculture is being recognized world over as a profitable business venture allied to agriculture. In the country, plenty of freshwater, brackishwater, marine water, cold water resource are available. Which shows tremendous scope for aquaculture currently India ranks second in global Inland fish production. Culture & breeding of Indian major carps & exotic carps being practiced with varying degree of success.

Carp culture technology is popular in all the states of India and contributed in the improvement of livelihood of rural people. Thereby, India is known as "Carp Culture Country". Though carp culture technology is established, but production of fingerlings of required size is an area of concern. Other areas such as feed standardization, health management, advance harvesting methods etc. needs attention. In the recent period, technologies have come up in the area of fresh water fish culture and has to be transferred to the doorsteps of the farmers. State fisheries department, Fisheries Institutes and NGO's can play major role in transfer of technology.

In view of these, Model Training Course on 'Freshwater Fish Aquaculture' is being organized at College of Fishery Science, Udgir. I hope this course would fulfill purpose.

**B. R. Kharatmol**
Course Director &
Associate Dean,
College of Fishery Science, Udgir.

## ***ACKNOWLEDGEMENTS***

It is our privilege to have been associated in Coordination committee for organising Model Training Course on "Freshwater Fish Culture" funded by Directorate of Extension, Ministry of Agriculture, New Delhi, during 17-24, February, 2014. The course is based on recent technologies developed in the area of fresh water fish culture and which will help to transfer these technologies to the farmers and entrepreneurs.

We have great pleasure in expressing our deep sense of gratitude to Hon.ble Vice-chancellor, Prof. A. K. Misra, Maharashtra Animal & Fishery Sciences University, Nagpur, Dr. N. N. Zade, Director of Extension & Training and Dr. D. R. Kalorey, Dean, Faculty of Fisheries, MAFSU, Nagpur for providing precious guidance and encouraged us in organising Model Training Course at this institute.

We are very grateful to Shri. B.R.Kharatmol, Associate Dean, College Of Fishery Science, Udgir who entrusted us the present assignment of organising this training course and providing all sorts of guidance and necessary help.

Our Sincere thanks to The Commissioner Of Fisheries, State Fisheries Department, Govt. Of Maharashtra, for kind cooperation and support in organising this training course.

**Course- Coordinator** **Course Co-Director** **Course Co-Director**

# CONTENT

# Present Status & Prospects of Freshwater Aquaculture Development in Maharashtra

B.R. Kharatmol
Associate Professor, Fishery Biology &
I/C. Associate Dean, College of Fishery Science, Udgir,

## Introduction

The population profile of India rapidly increasing, in another two decades or so and the country is hurtling to become the highest populated in the world. The greatest challenge faced by our planners and agricultural scientists is to ensure the food security for increasing population. Fortunately, one silver lining in this context is that our country is bestowed with diverse inland water resources such as rivers, floodplain wetlands, man-made reservoirs, tanks and ponds, lagoons, canals, upland lakes, estuaries, backwaters, brackish-water impoundments and mangroves. Harnessing them in a properly conceived and diligent way with prescience can substantially foster sustained fish production. This, in turn, will help in narrowing the gap in animal protein component in the food basket of the common man. Fish is a source of chief protein, vitamins, iron, phosphorus and especially omega 3 fatty acids. The rural poor, about 260 million, have a different tale and suffer from malnutrition of all kinds, the children from blindness owing deficiency of vitamins A in their diet. Unlike agriculture and animal husbandry practices, fisheries do not consume water and make significant demands into the already scarce water resources. On the other hand, it can help to improve the quality of our open waters.

## Fish production projections

Reliable estimates of fish production and projections to the year 2020 suggest that freshwater aquaculture is the only panacea for meeting the demand for fish in the country. Fish production from Marine capture fisheries is likely to remain stagnant at its current level of production of about 4.10 million mt. It is the Freshwater aquaculture that has to be tapped to satisfy the demand for fish. Present capture fish production is 4.02 million mt and aquaculture fish production 4.27 million mt. which contributing total fish production of the country 8.29 million mt.(2010-11)

## Where do we stand at present?

Although aquaculture is a global industry, Asia still accounts for nearly 90% of the aquaculture production. On the global front, with the production of about 4.27 million tones, India stands a very distant second (almost by default) to the top producer — China. China alone produces almost three fold more fish from aquaculture than the combined volume of the eleven next largest producers including India, Norway and Chile.

It is time to examine our role in the context of changing global scenario especially with regard to intellectual property rights, the need for regulation in implementation of aquaculture practices, code of practices for responsible aquaculture; and increasing pressures on aquaculture resources — land and water towards achieving nutritional security of the country.

## Indian Freshwater Aquaculture

*Present Aquaculture Practices*

Carp culture in ponds and tanks — the mainstay of Indian freshwater aquaculture - during the last five decades has grown in terms of area coverage and diversification of culture species and systems. Demonstration of a host of culture technologies depending on the availability and provision of varied types and levels of input in different regions has made carp farming practice more acceptable and remunerative. Species diversification with high valued commodity like catfishes and freshwater prawns has also made the farming practice more lucrative. Though localized, the non-conventional culture systems like sewage-fed fish culture, integrated farming systems, cage and pen culture, etc. have shown their potential as eco-friendly and alternative farming options in several regions across the country.

The freshwater aquaculture systems in the country has been primarily confined to three Indian major carps, viz., *catla, rohu and mrigal*, with the exotic silver carp, grass carp and common carp forming the second important group. Although introduction of these exotic carps into the carp polyculture system during early sixties added new dimension due to their high growth rates and compatibility with our major carps, the low consumer preference has been the major bottleneck for their large-scale adoption. Although the standard recommended practice in the country involves polyculture of three Indian major carps or combination of three Indian major carps and three exotic carps, adoption has, with several modifications, largely dependent on prevailing market demand and resource availability in different regions. Though scientific farming on a national basis at farmers' level has shown production of 3-5 tons/ha/year, production levels of 8-10 tons/ha has been a common occurrence in commercial farms of Krishna-Godavari deltaic areas of Andhra Pradesh.

Among the catfishes, magur (*Clarias batrachus*) has been the single species that has received certain level of attention both from the researchers and farmers due to its high consumer preference, high market value and most importantly its suitability for farming in shallow and derelict water bodies with adverse ecological conditions. Recent years, however, has witnessed increasing interest for farming of *Pangasius spp*., especially in Koleru Lake region of Andhra Pradesh due to its higher growth potential and ready market.

Freshwater prawn culture is probably the only accepted diversified farming practice being taken up in commercial scale in the country, which is largely driven by higher market value of the produce in the international market. The giant freshwater prawn, *Macro brachium rosenbergii* has been the principal species, adopted both under monoculture and mixed farming of freshwater prawn with carps. Andhra Pradesh has been the lead producer with contribution of 86.6% of the total freshwater prawn production of about 43,000 tons in the country at present.

In spite of possessing a rich diversity of ornamental fishes in the country the domestic production and trade of ornamental fishes largely confined to breeding of live-bearers like guppies, mollies, platys and swordtails, and a few egg-layers like goldfish, angel fish and gouramis. The areas adjacent to the metropolitan cities like Kolkata, Chennai and Mumbai have been the major breeding centers for these fishes due to ready urban market and availability of international airport for both import and export business. Recent years, however, have witnessed establishment of several breeding units in states like Kerala, Andhra Pradesh, Orissa and Bihar.

**Status of Maharashtra**

Inland fisheries play a major role in the economy of the state and provide a good source of protein rich nutritious food to the people. It also provides employment to thousands of people and also earns sizeable foreign exchange to the country. The state is endowed with rich marine and inland fishery resources. Of late, marine fish production is drastically fluctuating and showing downward trend. On the other hand, freshwater aquaculture is showing upward trend in the state. Maharashtra with vast freshwater water resources in the form of ponds, tanks, reservoirs, rivers and brackish water has excellent potential for fisheries development in general and aquaculture in particular. Though the progress achieved in the field of aquaculture is satisfactory, it is still suffering from problems like inadequate supply of quality seed of desirable fish species and quality feeds, poor management practices coupled with pollution and health hazards, etc. It is time to critically examine some of the constraints and discuss and formulate future strategies to meet the future challenges.

**Inland aquatic resources**

Maharashtra, the third largest State of the Indian Union, both in population and geographical area, is surrounded by the Arabian sea in the West, Andhra Pradesh in the southwest, Karnataka in the south, Gujrat in the northwest and Madhya Pradesh in the north. State has over 3.0 lakhs ha of water spread area comprising reservoirs 1,83,000 ha (61%) major irrigation tanks 1387 number. Besides this, the state has 3200 kms of rivers stretch and 14,455 ha of brackish water area is suitable for aquaculture. The water bodies below 10 ha in size have been considered as of aquaculture systems and have not been included under man-made lakes. The small reservoirs (<1000 ha) occupy 119515 ha (44%), out of the total 273750ha. Among the remaining 152205ha, the large reservoirs (>5000 ha), the other falling under the medium (1000 to 5000 ha) category Srivastava et.al.(1985). They can be utilized for inland fish production. But majority of the tanks are heavily accumulated with silt, encroached by public and infested with aquatic: weeds. As a result, most of the tanks are not utilized for fish production in the state. Removal of silt and weeds from the tanks and restoration of tanks from encroachment will help fisheries development in the state. The available information on inland water resources is based on surveys conducted long back. However, advanced tools viz., Geographical Information System (GIS), Remote Sensing (RS) and Satellite Imaging and Mapping would help in enumerating inland water resources with much ease. It will also assist in knowing details of ponds and other water bodies on aspects of their size, shape, weed infestation, water quality, fish population a: abundance, derelict and waterlogged areas, etc. Further, the information will also guide the planners and policy makers to develop suitable programmes for expansion aquaculture activities.

**Aquaculture species and practices**

More than 100 different varieties of fish species available in the state are suitable for commercial aquaculture. However, more than 7o% of inland fish production in the state is contributed by Indian major carps (*catla, rohu and mrigal*) and exotic carps (silver carp, grass carp and common carp). But there are several species of medium and minor carps (*Labeo fimbriatus, L. gonius, L. bata, Cirrhinus reba, C. cirrhosa, Puntius puichellus, P.sarana, P. kolus*, etc) and air-breathing fishes *Clarius batracus, Heteorpneustes fossilis, Channa spp, Wallago attu, Mystus spp*, etc., indigenous to the state and have high consumer demand in different parts of the state. Presently, the state is mainly dependant on Indian major carps for enhancing aquaculture production. The carp seeds regularly stocked in most of the inland waters without considering the negative impact of these fishes on many endemic and native fish species inhabiting these water bodies. Though the fact is realized, still no headway is made for diversifying aquaculture activities from the existing carp farming. It is time that the scientists of the state must focus their research efforts to develop farming technologies for commercial farming of indigenous fishes.

**Fish seed production**

Fish seed is the backbone for inland aquaculture development in the state. The state is facing severe shortage of fingerlings of right size and species during the right season in spite of having several fish seed farms both in governmental and private sector and is not able to meet the existing demand. The annual requirement of fish seed in the state is more than 50 corer fingerlings. However, at present the state's production is around 15 corer fingerlings. Therefore, the dependence on other states for fish seed is increasing year by year. The government should immediately prepare strategies and action plans to reduce this gap. The sick and non-functional fish seed farms should be rejuvenated and targets given to produce quality seeds. The buy back arrangements of fish seed from private producers must be streamlined and encouraged. There should be a system to forecast the fish seed requirement on annual basis and aqua culturists should be informed from time to time on availability of seeds. There is urgent need to diversify aquaculture practices as balancing act to make it long standing. Further, immediate action should be initiated to expand the number of species to be cultivated. Private farmers should be encouraged to take up seed production of catfishes, murrels, other medium carps and freshwater prawns based on technologies available with research organizations.

**Riverine fisheries and its potential**

River system forms the base of inland fisheries. The total length of rivers and associated irrigation canal systems runs to more than 3200 km in Maharashtra. But, at present there is no organized fishing in riverine sector and fishing is seasonal. Hence, reliable estimate of fish catch and composition is not available for any river. The rivers in the state do not provide lucrative commercial fisheries in their upper and middle reaches. However, creation of reservoirs brought out radical changes in the fish and fisheries of river system. The stocking of Indian major carps and common carp in the impoundments of rivers system has given positive impact on the fisheries. Good fishing areas in the river are upstream of reservoirs.

**Reservoir fisheries and its potential**

There are 95 number of reservoirs in Maharashtra with a combined water spread area of 3.00 lakh ha offer excellent scope for fisheries development. At present, the reservoir fisheries management in the state consists mainly on stocking, which is often erratic and largely depends on the availability of fish seed rather than the suitability of the species to the ecosystem and issue of licenses by the Department of Fisheries for exploitation of stock. There is no agency to monitor catch composition and effort. The infra-structural facilities for stocking and exploitation of reservoirs are meager. Hence, the resource remains underutilized. However, during the last 2-3 years the reservoir stocking is gaining importance due to the interventions of National Fisheries Development Board, Hyderabad who finance stocking of reservoirs with advance fingerlings and also insist on monitoring. With estimated yield of 75 kg/ha from large and 200 kg/ha from small and medium reservoirs, they have the potential to produce around 25,000 tons fish per year.

**Fish health**

Use of conventional chemicals for health management in fishes should be re-examined if the epidemic fish diseases have to be prevented and controlled. Health safeguards like health hazards and critical control point in farming system should be incorporated. In places of heavy concentration of aquaculture farms, the Department should have mobile health clinics that can be of greater help in diagnosing and suggesting treatments to prevent and control the spread of fish/prawn diseases.

**Aquaculture extension**

Transfer of economically viable, environmentally sound and sustainable aquaculture technologies is one of the most challenging jobs. Compared to extension activities that are in practice in agriculture and allied sector, the extension linkages in fisheries is very poor in the entire country in general. There is total lack of focused extension system, programmes and directions and authorities in the state. Transfer of fish production technologies by the Department of Fisheries for adoption is not significant. The extension services in majority of instances have restricted to the supply of fish seeds and other requisites (nets, crafts, etc.), implementation of government schemes, providing subsidies, auctioning / leasing of water bodies, etc. Although regular training programmes are held, but they are not with fervor required. There is no follow up after the training. Proper assessment of feed back from the end users on the acceptance, adoption and success/failure of technologies that are transferred is totally lacking.

**Financing Aquaculture**

Though aquaculture has been proved to be a profitable avocation, the financing has not been properly channeled. The funding agencies and banks are not fully convinced about the potentials of aquaculture. There is need to develop suitable proven technologies and make them available to the fish farmers and banking sector to extend funding support to various aquaculture activities. Recently NABARD has modified its policy of direct funding and has come forward to lend the finances through primary societies at village level. Reformation of various credit schemes to meet the financial requirements of aqua culturists in the state is highly essential.

Besides development of various eco-friendly aquaculture technologies, in order to attain a special unenviable status in the field of food security, it becomes a prerequisite to create primarily the awareness among all those involved in aquaculture with a clear conception of future aims to make integrated and sustainable development of aquaculture a reality in the ensuing days.

Fish for all and fish for ever!!!

# Biology of Fresh Water Cultivable Fishes

U.A.Suryawanshi
Assistant Professor, Dept. of Fisheries Biology
College of Fishery Science, Udgir, Dist. Latur.

**What is Biology?**
**Biology** is a natural science concerned with the study of life and living organisms, including their structure, function, growth, origin, evolution, distribution, and taxonomy.

**Biology of Indian major carps ( IMC)**

**Biology of Gibelion catla ( Formarly *Catla catla*) Prelude**
*Gibeleo catla* is the fastest growing Indian major carp, commercially important for its domesticated nature, fair growth, herbivorous feeding habit and good market price, due to high consumers preference for its delicacy in taste. It is the most preferred species for the fresh water aquaculture in India.

**Identifying-Characters.**
- A true bony fish with body moderately laterally compressed, broad, deep, thick, with rounded abdomen.
- Lateral line at the caudal peduncle passes medially, dorsal profile much more humped than the ventral.
- Head broad, large, with superior, upturned mouth, lower jaw being terminal, gape prominent, lips thick, folded outwardly, barbells absent.
- Paired and unpaired fins with serially arranged soft, articulated branched and un-branched fin rays, single large broad dorsal fin originating before the pelvic.
- Scales are large, thick cycloid all over the body.
- The body is greyish in dorsal side, whitish on the ventral side.

**Distribution**
- *Gibelio catla* is very widely distributed in the Indian subcontinent, in the Indian river system, namely the Ganga, Bramhaputra, Mahanadi, Godavari, Krishna, Cauvery, Narmada, And Tapti.
- In Bangaladesh in the river Padma and its tributaries, in Pakistan in the river Indus and its tributaries and in the river of Myanmar like the river Iravati.
- Originally, the *catla* is a riverine fish but it has established well in the natural lakes and reservoirs.
- Jhingran (1968) described the distribution of *Catla,* which starts from the river Ganga network in the north to the Krishna river down south of India, Pakistan, Banggladesh, Burma and Nepal ( De witt, 1960).

**Habitat**
- The favourite habitat of *Catla* is broad, deep pools of river, where they largely remain localised during winter and summer month ascending the river during local breeding migration during monsoon. *Catla* is also able to thrive in slightly brackish water with low salinity ( Raj-1939).

- Feeding habits According to Mukherjee-1945 and Mitra-1953 *Catla* is surface feeder, but Chako and Kurian-1948 described it to be a surface and mid water feeder.
- Natrajan and Jhingran-1963 observed that while *Catla* is primarily a surface feeder, it is prone to explore all the layers and section of the water. According to them, through dominant occurrence of zooplankton in the gut primarily indicates a surface feeding propensity of the fish, the occurrence of detritus mingled with sand, mud and sorted vegetation indicates a bottom browsing habit as well.

- **Reproduction**
- *Catla* is heterosexual i.e sexes are separate, sexual dimorphism is absent except in breeding season, when the pectoral fins of males are rough and larger than the female where the pectorals are smooth.
- Female shows bulging abdomen and a swollen reddish vent. Perhaps the rough surface of pectoral fins could be of help in gripping the female during sex-play

- **Maturity**
- *Catla* attains maturity in the $2^{nd}$ years of life. Alikuni-1957 mentioned that in ponds *Catla* became matured when it is 22 months old. 48.7 cms long.

- **Fertilization**
- Fertilization is external, the fertilised egg are swept away by current and depending upon the location of the spawning ground, either drifted to the edge of the bundh or get washed down in the river, in the bundh a large nos. of egg were accumulated.

- **Fecundity**
- Khan-1929 found 4,27,500 eggs in a *Catla* weighing 5.1 kgs. The no of eggs per kg body weight was estimated by him was 77,832 nos. Natrajan and Jhingran found the fecundity of *Catla* to vary from 2,30,831 to 4,20,250 depending upon the length and growth of fish.

**Spawning**

- The spawning season of *Catla* coincides with the south west monsoon in Northern India and Bangladesh, where it lasts from May to August and in North indo Pakistan from June to September. In South Indian rivers the spawning season appears to be variable.

**Eggs Structure and Size**

- Eggs are mostly spherical and rarely oval in shape, they are transparent, light red in color, non floating and non-adhesive.
- The yolk sphere contains no oil globule but a larger perivitalline space.
- The diameter of the fully ripened ovarian egg has been recorded as 2.22 mm and the fertilized eggs after being laid in water, are reported to swell to 5.3 to 6.5 mm ( Mukherjee-1945).
- The embryo becomes prominent 10 hrs. after fertilization and measure 2.1 to 2.5 mm in length.

**Biology of Rohu**

**Identifying-Characters**

- A true bony fish with body moderately elongated and laterally compressed, bilaterally symmetrical, with rounded abdomen.
- Lateral line at the caudal peduncle passes medially, ventral is comparatively profile more arched than the dorsal.
- Head relatively smaller, with inferior mouth, upper jaw prominent, lips thick and fringed with 2 pairs of small barbells .
- Paired and unpaired fins with serially arranged soft, articulated branched and un-branched fin rays, single dorsal fin originating anterior to pelvic, which is abdominal.
- Regular medium sized cycloid scales all over the body.
- The body is faintly bluish with red tinge.

**Distribution**

- Rohu is widely distributed from West pakistan through upper India to south west Tamilnadu.
- It is also transplanted in most tanks of India and Shrilanka. However, according to FAO besides the above mentioned countries the distribution of Rohu has also extended to the Philippines, USSR, Japan, Sri Lanka, Laos, Pakistan, Malaysia, Thailand, Vietnam, Madagascar Mauritius etc.

**Habitat**

- An habitat of fresh water rivers, the fish can live in slightly brackish water, available in confined waters, where its cultivation is possible.

**Growth**

- It attains maximum growth up to 3 feet ( 94 cms) which is attained in 3 years. In 1$^{st}$ year attains a length of 35 to 45cms. and weight in average 676 gms.

**Maturation**

- Rohu attains maturity towards the end of 2 $^{nd}$ year ( Alikuni-1957). At Cuttack it has also been observed that a certain percentage of induced bred stock attains maturity even in 1$^{st}$ year, but rarely Rohu matures in 1$^{st}$ year.

**Fecundity**

- Ripe female 4.54 kgs contain 19.05 lacks of egg or 420 eggs per gm body weight or 4.20 lakhs per kg body weight. Absolute fecundity of specimens from 51 cms to 75.2 cms and weight 1.5 to 7.5 kgs ranges from 2.256 lakhs to 27.94 lakhs, weight of the overy 200-2000 gms.

**Breeding**

- Breeding habit of Rohu is similar to Catla, spawning season June to September, does not breed in confined water, can breed in bundhs or through the induced breeding. The Rohu and the Mrigal are very easy to breed as they very quickly respond to induced breeding. The eggs are reddish, diameter 1.5 mm, when swollen 3 to 4 mm diameter before being laid to water, on adhesive, transparent, dimersal.

**Food and Feeding Habits**

- The fish feed on decaying vegetative matters, microscopic plants, sand and mud. The juveniles generally feed on water fleas. The fish is a column and bottom feeder, which is characterized by the sub-terminal ventral mouth.

**Biology of Mrigal**

**Identifying character of Mrigal**

- A true bony fish with body elongated and laterally compressed, bilaterally symmetrical with rounded abdomen.
- Lateral line at the caudal peduncle passes medially, dorsal profile is more arched than the ventral.
- Head smaller in comparison to body, with acute snout and terminal mouth, lips thin and unfringed with a pair of small barbells .
- Paired and unpaired fins with serially arranged soft, articulated branched and un-branched rays, single dorsal fin nearly as high as body depth originating anterior to the pelvic.
- Regular medium sized cycloid scales all aver the body.
- The body is dark greyish along the back pelvic, anal and caudal tinged red with golden yellow eyes.

**Distribution**

- Mrigala is distributed in almost all rivers of north India.
- Day reported that this fish is not found in south Indian river like Godavari. But Alikuni has mentioned that is also found in the river Godavari.
- Chako 1951 reported that Mrigal constitutes 20 % of the total fishery of Godavari and Krishna River.
- It is also distributed in Pakistan, Bangladesh and Myanmar. According to FAO besides the above mentioned countries the distribution of Mrigal has also extended to the Philippines, USSR, Japan, Sri Lanka, Laos, Pakistan, Malaysia, Thailand, Vietnam, Madagascar ,Mauritius etc.

**Habitat**

- A fresh water river fish, which can be cultured in confinements and can tolerate salinity to certain extent.

**Growth**

- When stocked in nursery @ 10-12.5 lakhs per hectare it attains 180 mm in 3½ month ( Basu-1946). In one year its normal growth was recorded as 37.5 to 45 cm length and 590 gms weight ( Chako and Ganpati-1950). In ponds it grows in 1 $^{st}$ year 650 to 1800 gms. In 2$^{nd}$ year 2600 gms. and in 3 $^{rd}$ year 4000 gms( Hora & Pillay)

**Maturation**

- It attains maturity in the 2 $^{nd}$ year of life, it is found matured during May and June and spawn in June and July. The maturity rate is very fast between April to June

**Fecundity**

Ripe female of 1.47 Kgs weight contain 2.16 lakhs of egg i.e 147 eggs per gm body weight.

**Breeding**

Its breeding habit is similar to the Catla and Rohu. Eggs are 1.5 mm in diameter in the ovary and when swollen 3.4 mm in diameters, dimersal, non-adhesive, transparent, hatching period varies between 16 to 18 hrs.

**Food and Feeding habit**

It is a bottom feeder and there is no selectivity so far as food type is concerned.

**Biology of silver carp**

- **Identifying character**
- A true bony fish with body deep elongated, much laterally compressed, bilaterally symmetrical, with keeled abdomen.
- Lateral line at the caudal peduncle passes medially, ventral profile more arched than the dorsal.
- Head moderate in size, with blunt rounded snout, oblique upturned mouth, with slightly longer lower lip, eyes more towards the dorsal profile than the ventral, thin lips without barbells.
- Paired and unpaired fins with serially arranged soft, articulated branched and un-branched rays, single small, rayed dorsal originating posterior to the ventral but mid-way between snout and caudal base, ventral abdominal anterior to dorsal, caudal homocercal and deeply forked.
- Small, shining cycloid scales, arranged regulalarly all over the body.
- The body coloration is silvery shinning.

**Food and Feeding Habits**

The fish is a surface feeder, mainly subsisting upon phytoplankton's such as flagellates. Dianophyceae and diatomaceae and on zooplankton such as protozoan and rotifers, supplemented with detritus and macro- vegetations.

**Reproduction**

According to Alikuni-1965, the male fish matures in 9 month and female in 1 year. The breeding behavior is similar to that of IMC. Matured inter ovarian ova measures approximately on an average 1.2 mm.

A water hardened egg is round in shape, 4-4.7 mm in diameter and ash gray in color. In India, it takes some 20 hrs for incubation of the egg at 28-33 $0^{c}$.

**Age and growth**

Generally the silver carp has great potentiality of growth and the rate of growth is governed by the amount of food given, stocking density and water temperature.

**Biology of Grass carp**

**Identifying characters**

- A true bony fish with body elongated, moderately deep and laterally compressed, bilaterally symmetrical with rounded abdomen.

- Lateral line at the caudal peduncle passes medially, dorsal and ventral profile more or less equally arched.
- Head moderate in size, with obtuse snout and sub terminal mouth with thick lip, upper lip slightly longer than the lower without barbells. Eyes located more towards the snout than the operculum; inter orbital space more, pre orbital length less than the post orbital length.
- Paired and unpaired fins with serially arranged soft, articulated branched and un-branched rays, single small, rayed dorsal originating from middle of the body, ventral abdominal originating opposite to dorsal, caudal homocercal and forked.
- Cycloid scales, present all over the body.
- The body is dark greenish grey dorsally becoming lighter ventrally.

**Distribution**

In India the 1 st consignment of grass carp was brought Hongkong, during 1959 to the pond culture division of CIFRI, Cuttack. Since then through induced breeding of the fish, it has been distributed to most of the Indian water. Through originally it is a fresh water carp, it can tolerate slight salinity (Singh-1967). At present it has not been stocked in the Indian rivers and reservoirs but only cultured in the ponds.

**Reproduction**

- In India the males kept in the pond generally matures in the 2 nd year and the females in the 3 rd year ( Alikuni and Sukumaran-1962).
  Alikuni-1963 reported 3.88 to 6.18 lakhs of egg in 73-74 cms long fish with 82 ova per gram weight of the fish. The mature inter-ovarian ova range 1.19 to 1.37 mm in diameter. The ovarian eggs are yellow or deep golden- brown in color. Fully swollen water hardened eggs are pelagic and measures 3.8 to 5.5 mm in diameter.

**Food and Feeding Habit**

The fish is voraciously herbivorous, which subsists on the marginal weed in the pond. The fries below 20 mm length use rotifers, crustaceans and algae, above 20 mm. The fish above 30 mm completely switch over to vegetation of the water media. The pharyngeal teeth are specially adopted for chewing the various types of grasses.

**Age and Growth**

The fish has got tremendous growth potentiality. Nicholosky-1961 reported the growth as 12.1, 25.6, 34.2, 41.4, 47.1, 52.5 and 80.6 cms in 1st to 7th years of life respectively. According to Alikuni-1964, in India the fish attains a length of 61.7 cms and weight of 1.8 kgs in 1 st year.

**Biology of common carp**

- ***Cyprinus carpio* have 3 different variety**
- **The scale carp:** *Cyprinus carpio var. communis*- The cycloid scale are uniformly arranged all over the body.
- **The mirror carp:** *Cyprinus carpio var. specularis- The cycloid scale with* irregular arrangement all over the body, bigger in size and shape, with shinning appearance.
- **The Leather carp:** *Cyprinus carpio var.nudus*- The fish is particularly scale less or with very few minute cycloid scale arranged in 3 different rows.

**Introduction of common carp in India**

Two different strains of common carp are introduced in to India namely the **Prussian strain and the Bangkok strain**

**The Prussian strain**

The Prussian strain when brought to plain i.e to the chetput fish farm, madras city at 33 $0^c$ the fish was found to refuse breeding in warm water of plain, but the growth rate was very satisfactory.

**The Bankok strain**

In July 1957 a consignment of fish fry of size ½ to ¾ was brought to CIFRI, substation, Cuttack from Bankok, It was brought that the fish can be bred in warm waters of the plain.

As per record, this fish is a native of Central Asia and Russia. According to Okade the native place of this fish is central Asia and it has been transplanted in to China, Japan, Greece, Italy, Rome but at present this fish enjoying the whole world.

**Scale carp-( *Cyprinus carpio var. communis)***

- **Identifying character of Scale carp**
- A true bony fish with body deep moderately elongated and laterally compressed, bilaterally symmetrical with rounded abdomen.
- Lateral line at the caudal peduncle passes medially, dorsal profile is more arched than the ventral.
- Head moderate in size, with obtuse snout, lips thick with tubular protruding mouth. 2 Pairs of stout, well developed barbells, longer maxillary barbells reaches up to the eyes.
- Paired and unpaired fins with serially arranged soft, articulated branched and un-branched rays, single rayed dorsal originating more towards the anterior than to the posterior proximity, dorsal large extending up to the anal unbranched rays of dorsal and anal osseous.
- Regular moderate sized cycloid scales all over the body.
- The coloration is faintly yellowish with golden tinge.

**Identifying character of Mirror carp**

- A true bony fish with body deep moderately elongated and laterally compressed, bilaterally symmetrical with rounded abdomen.
- Lateral line at the caudal peduncle passes medially, dorsal profile is more arched than the caudal peduncle passes medially; dorsal profile more arched than the ventral.
- Head moderate in size, with obtuse snout, lips thick with tubular protruding mouth,
- 2 Pairs of stout, well developed barbells, longer maxillary barbells reaches up to the eyes.
- Paired and unpaired fins with serially arranged soft, articulated branched and un-branched rays, single rayed dorsal originating more towards the anterior than to the posterior proximity, dorsal large extending up to the anal unbranched rays of dorsal and anal osseous.
- Cycloid scales, irregular in shape and size, arranged haphazardly over the body.

- The coloration is silvery shinning, mirror like becoming blackish dorsally

**Biology of *Channa Marulies ( Giant snake head)***

**Identifying Character**

- Body elongated fairly cylindrical compressed posterior.
- Head snake like, depressed and its upper profile is compressed.
- Mouth large terminal, teeth villiform arranged in several rows in jaws and vomer usually absent in palatines.
- Scale cycloid, thick medium sized extend on summit of head.
- Pre dorsal scale 15 to 16 in numbers. Single dorsal fin very long extending from nape to near caudal base.
- Pectoral fin above half of the head length
- Body colour grayish green on the back lighter on both sides and whitish on the abdomen

**Geographical distribution**

The giant murrel is widely distributed in India, Pakistan, Bangladesh, Srilanka, Burma, China and Thailand. In India it inhabits fresh water of almost all the state like West Bengal, UP, M.P., Bihar, Punjab, Haryana, Orissa, Assam; Gujrat, A.P., Tamilnadu and Karnataka.

The species is widely distributed in Cauvey and Tungabhadra river system and swamp, derelict water bodies from peninsular India

**Habitat**

In general *C. Marulius* is fresh water riverine fish, but frequently available in lakes, reservoir, swamp and large water bodies. The species is also found in jheels, beels, tanks and ponds in large marshy water.

**General Biology**

The accessory respiratory organ in pharyngeal region of *C. Marulius* are well developed which serve as air sac to breath by atmospheric oxygen.

**Food and feeding habits**

In giant murrels selective feeding is seen in different size group. Alikunhi (1953) reported naupli of copepods, colonical rotifers and other plankton from the gut of fifth day of larvae. While Arumugum(1966) reported that fry of murrels are predominantly insectivorous

**Sexuality**

*C.Marulius* is heterosexual. Externally sex can be distinguished only during the breeding season when the slit like vent appears pale in male and rounded reddish in the female. In addition the abdomen of the female will be slightly bulging compared to that of male.

**Maturity**

Giant murrel attains maturity in two years (Devraj1973; Parameswaran)

**Fecundity**

Devraj( 1975) studied the fecundity by 13 specimen of giant murrel which was found ranged from 2214 number of eggs in a fish 500 mm length to 18475 number in another 820 mm length. Fecundity differs in different agro climatic region as well as habitat.

**Spawning**

The spawning season of *C.marulius* in different region appears to be influenced by the pattern of rainfall ( South west and North east mansoon and local rain). The breeding commences a month or two monsoon season with the peak coinciding with the peak rainfall.

**Egg**

The salient characters of the developing egg of *C. marulius* are free floating spherical and non adhesive and have oil globule. Fully ripe ovarian eggs which are brownish golden yellow in colour measures 1.58 to 1.980 mm. The fertilized egg slightly swell up after being laid.

**Biology of some important cat fishes**

**Biology of *Clarias batrachus* (Walking cat fish)**

- **Identifying characters**
- Body elongate, moderately depressed, head ( to end of gill covers) 5.6, depth 6.5 to 7.5 in total length.
- Upper jaw longer. Mouth terminal, width of mouth gape equal to about half of head length.
- Two depression on head, an oblong one more or less behind eyes, another oval towards nape.
- Occipital process rounded behind it, its width at the base being more than twice its length.
- Jaws with villiform teeth in form of bands,; vomerine teeth villiform or globular crescentic band or two pyriform patches.
- Barbels 4 pairs, maxillary pair extending beyond pectoral fin base, nasal pair being equal to mental barbels reach gill opening.
- Dorsal fin origin slightly anterior to tip of pectoral fin, spineless with 62-76 rays.
- Pectoral spine strong, finely serrated on both ends, often roughly externally.
- Anal rays 45-58, caudal free. A labyrinthic air breathing organ arising from 2 nd to 5 th branchial arches well developed.
- Brownish to green blue, black dark with a greenish lusture, flanks and belly pale brown to delicate reddish, often with numerous striking pale to white spot on flanks , vertical fins with reddish margin

**Geographically distribution**

- Occurs in fresh and brackish water of the plains of India, Bangladesh, Pakistan, Burma, Indonecia, Singapore, Borneo, Srilanka, Thailand, Indo- china, The philippines, Hongkong, China.
- This species abundantly in derelict and swampy waters. It possesses accessory respiratory organs, so it can live out of water for some time and move short distances over land

**Food and feeding habit**

- The food and feeding habits of early post larvae 15 mm long are purely planktophage. Copepods formed the main food, followed by cladocerans. Other food items include ostacods, rotifers egg etc.
- In the late post larvae stage 16-30 mm in length ostracods were the main food items, followed by copepodes, insect larvae etc.

- In the juvenile stage ( 31 to 100 mm in size), insects constituted the main diet.
- The food and feeding habits of the adult *Clarias batrachus* have been variously described as a predatory but not slightly marked piscivorous (Alikunhi,1957), a scavenger (Sidthimunka *et al.,*1968) an omnivore (Hora and Pillay,1962) a carnivore ( Lehri,1971), etc.

**Age and growth**

The maximum age of the fish has been observed up to 4 + age groups occurring in the natural environment in the Bihar region of the Indian subcontinent, the maximum size being 35.8 cm ( Thakur, 1981). However, the length of the largest recorded *c. batrachus is about 46 cm.*

**Male and female identification**

The sexes can be identified easily in fully mature fish. The male has a pointed papilla and the female an oval papilla. The female has more distended abdomen.

**Eggs of *C. batrachus***

Eggs are spherical, yellowish brown in color and 1.3 – 1.6 mm in diameter.

***Omak pabda***

**Common name- Pabda**

**Identifying characters**

- Elongated and compressed body with moderate eye, its lower border reaching below level of mouth cleft.
- Mouth oblique and large; jaws with teeth in villiform bands, vomerine teeth in two small oval patches.
- Barbels 4, maxillary barbels reaching as far as middle of pectoral fin, mandibuler barble till posterior border of eye.
- Anal fin long, origin opposite to dorsal fin commencement. Pectoral spine moderately strong, serration on its inner edge in males, often feebly in females. Caudal fin bilobed with pointed lobes.
- The fish attain silvery grey with yellowish tinge, dark on back, fading to dull grey on belly often with two dark lateral bands on the body; a dark oval spot on shoulder on lateral line.

**Geographical distribution**

Inhabits river, tanks and ponds. Occurs in Afganistan, Pakistan: Indus plain and adjoining hilly areas; india ; Northern eastern state; Bangaladesh and Burma

**Biology**

- Esteemed as food fish. Attains a length of 17 cm. caught in fairly large no in West Bengal and north-eastern states of India.
- Adults inhabit clear as well as muddy rivers, streams, ponds and lakes
- Fertilization is external. One clear seasonal peak per year spawning frequency.

**Identifying characters of *Wallago attu***

- Body laterally compressed. Head large 5 to 5.5, Depth 6.5 in total length.

- Snout depressed. Mouth wide. Mouth cleft wide and somewhat ascending. Eyes small with orbital margin lying above the corner of mouth.
- Eye diameter 6.5 to 10 times in the length of head. Lower jaw more prominent. Barbels two pairs, maxillary pair extending to the anterior part of anal fin, mandibular pair equal to snout. Teeth numerous, cardiform, arranged in bands with both jaws. Lateral line well marked.
- Uniform silvery, may be olive with golden gloss above.

**Geographical distribution**

Indus plain and adjoining hilly areas; India; Sri lanka; Nepal; Bangaladesh; Burma; Thailand; vietnam, Kampuchea, The malay Peninsula; Sumatra and Jawa

**Age and Growth**

The absolute growth of females was greater than that of the males up to initial IV years of life, subsequently the growth of the female was lower than that of the males.

**Sexual dimorphism**

Wallago attu , when mature, exhibit sexual dimorphism. Mature males showed roughness on the first ray of pectoral fin at the lower side and possess narrow and rather pointed genital papillae. In case of females, the pectoral fins are smooth and the genital papillae round with thick musculature around the apertures. Breeding operation can be carried out in the eco-hatchery.

**Life history**

The fertilised egg measures 1.8 $\pm$ o mm in diameter. Germinal disc is formed within 25 min after fertilization. Cleavage was complited within 1 h 20 min, morula stage in 2 h and after fertilisation, followed by the gastrulation within 4 h 15 min after fertilisation. The C- shaped stage was achived in 6 h 45 min after fertilization. The embryo starts its twitching movement in 10 h 45 min after fertilization at a water temperature of 29-30 $0^c$ the hatching took place in 16-18 h after fertilization. Just hatched out larvae of W.attu measured 6.28 $\pm$ 0.40 mm and 2.56 $\pm$ 0.35 mg in weight. The yolk was 1.46 $\pm$ 0.05 mm in length and 1.25$\pm$ 0.05 mm width.

***Pangasius pangasius***

- **Identifying character**
- Body laterally compressed. Head large 5.5 to 6, Depth 4 to 5 in total length.
- Granulations on dorsal side of head. Occipital process two times longer than broad at the base and reaches the basal bone of dorsal fin.
- Snout fairly prominent. Eyes large, about 3.5 times in length of head, lying in the anterior half of head. Mouth fairly wide, inferior. Mouth gape reaches opposite centre of front edge of eye. Width of gape of mouth equals nearly half head length.
- Barbels 2 pair, maxillary pair extending to pectoral base, mandibular equal to half of head length. Teeth villiform on jaws and palate, vomero-palatine teeth in a crescentic band, composed of four patches variously jointed together. Anal with 31-34 rays. Caudal fin deeply forked.
- Dusky yellowish- green on back, glossed with silvery- purple on flanks, sides of head golden tinge. Fins light reddish-yellow.

- **Geographical distribution**
- Inhabits large rivers and estuaries in Pakistan, India, Bangladesh, Burma, Thailand, Malay Peninsula-yellow.

- **Food and feeding habit**
- *Pangasius Pangasius* is an omnivore, feeding on a variety of food such as insects, mollusc, crustaceans, offal etc. ( David, 1963), however, it has a preference to molluscs, when they are available( Ramkrishnaiah)
- The maximum sizes recorded for male and female were 725 mm and 802 mm, respectively. However, specimen measuring over 900 mm were noted in the river Krishna, down the reservoir. It showed that the specimens attained greater length in favorable condition.

- **Maturity**
- Pangasius collected from Nagarjunasagar reservoir showed the maximum size of mature male and female, being 630 mm and 640 mm. Specimens above 600 mm were found to be mature. The mature ova ranged from 0.74 mm to 1.72 mm in diameter.

**Fecundity**

The fecundity of pangasius ranged from 73000 to 154000 eggs in fishes measuring 640 to 726 mm in length and 1.5 to 2.5 kg in weight

**Breeding season**

According to Pantulu (1962) pangasius breeds during the summer month ( March to June) in the lower zone of estury.

**Spawning**

Pangasius pangasius does not spawn in confined water. Brood fish can be obtained from wild stock or from culture pond. In India P.pangasius were induced bred recently at Central Institute of freshwater aquaculture, Kaushalyaganj ( Bhubaneswar) ( Gupta et al., 1992).

**Sexual dimprphism**

Adult pangasius exhibited sexual dimorphism .male specimen could be identified by presence of a small but blunt genital papilla along with oozing milt with slight pressure on the abdomen from April onwards. The female genital opening was pinkish red in color surrounded with thick muscular rim like structure.

# Biology and Culture of Indian Magur *Clarius batracus*

Dr.S.D Naik
Associate Professor, Dept. of Fisheries Biology
College of Fisheries, Shirgaon, Ratnagiri.

**INTRODUCTION**

Though culture of fishes in ponds is one of the age old professions of the world,it is gaining prominence, because of the realisation that this source can supply rich and proteinaceous food for human consumption. Majority of the species selected from nature for rearing in ponds belong to the family of crops (Cyprinidae). Of late another group of fishes, collectively known as air-breathing fishes or live fishes is attracting the attention of fish culturists in the Far-East. Some of these hardy fishes have well developed accessory respiratory organs for breathing atmospheric air. This added advantage enables them to live *even* in foul waters deficient in dissolved oxygen which is one of the limiting factors for most of the fishes. As such, these fishes are quite suitable to be cultured in derelict and swampy waters, where carps cannot thrive well. The common live fishes are the murrels *(Channa* spp.), the catfishes *(C/arias batracus)* and ( *Heteropneustes fossilis).* the climbing perch *(Anabas tesll/dineus)* and the giant gourami *(OsphrollemllS goramy).* These are widely distributed in many South East Asian countries, including India. Culture of *clarias* spp. is practised on a large scale in countries like Thailand, Philippines, and Indonesia, where *very* high average production is reported from ponds. Such large scale culture of live fish is not done in any part of India. But these fishes are marketed mostly in live condition and in some places they are reported to fetch higher prices than the popular Indian major carps. In view of these favourable factors, the need for culture of air-breathing fishes has long been felt in the country. With this in view, the Indian Council of Agricultural Research initiated in 1971 an all India coordinated research project on the breeding and culture of live fishes. Some useful information is already available on the biology, breeding and culture of these fishes, even though no comprahensive work was attempted on them till recently. However, the work that has been going on in some of the other South-East Asian countries has provided valuable information . It is felt that a review of this available information would greatly help in the promotion of this live fish culture in India.

**BIOLOGY AND BREEDING OF INDIAN MAGUR *(Clarias batrachus)* :**

This is catfish which has several similarities with singhi and is more widely distributed in India, Sri Lanka, Pakistan , Burma, Thailand, Malysia,Vietnam, Indonesia and Philippines. It has also been introduced to United States, where it is commonly known as 'walking catfish '. The accessory respiratory organs present in this fish not only help the fish to breathe in atmospheric air but may also probably be serving a hydrostatic function. Magur matu res when they are one year old. Though it breeds almost throughout the year. It has a short, well defined breeding season restricted to the monsoon. In south India, it was observed that fish collected locally from paddy fields and wells have revealed that magur breeds during the months June-July in this region **.** In addition to natural breeding, this fish has been successfully induced bred both through hypophysation and stripping. Some Experiments conductetd were conducted in the ICAR institutes have resulted in successful breeding of magur by administering homoplastic and heteroplastic pituitary extract injections. In the latter case, for the first time, the pituitary glands from marine catfish *Tachysurus* spp. were used sucessfully. The dosage administered varied from 12 to 30 *mg/kg* weight of fish given in two doses, a provocative dose of 5- 10 *mg/kg* and a final dose of 8- 20 *mg/kg .at* a 5-6 hours interval, as is usually done for major carps of India. It is well known that magur lays eggs in the sheltered areas of the pond or paddy fields, in old tin containers, pots, crevices, pits or holes which *have* been sometimes referred to as nests. It is reported that generally 2,000 to 15,000 fry are found in 1he nests of magur. However, experiments conducted *have* shown that fishes weighing "from 75 to 200 g can produce 1,968 to 7,380 -eggs. The eggs hatch within 20-32 hours ·after breeding, with the water temperature ranging from 24 to 28°C. Fish *larvae* start feeding on zooplankton from the 5th day after hatching.

**CULTURE:**

Culture of *Clarias* spp. is being *done* in *several* South East Asian countries, of which, considerable work has been done in Thailand. It is reported from Thailand that a 400 m' and 2.5 m deep pond can be stocked w ith 40,000 of *Clarias* and that by *intensive* feeding, 4,300 kg of fish could be *harvested* in a period of 5 months from ponds. Based on this yield a possible production of as much as 107,500 kg/ha with a food *conversion* ratio of 6:1 has been estimated. Fish wastes of canning factories and fish offal *have* been used as fish feed in this experiment. When enough of fish offal was not *ava*ilable, cooked rice mixed with *vegetables* and peanut cake was *given.* Fishes were fed with this feed at the rate of about 6-8 percent of body weight, once in the night and twice in the day. As stated earlier, enough of stress has been made by *several* fishery workers, to take up culture of these *live* fishes in India. Further, the Fish Seed Committee of the *Government* of India has also recommended intensification of their culture. Short-term feeding experiments were being conducted at the different ICAR institutes to find out the acceptability of cheaply available feeds by magur. The fingerlings of magur stocked in 5 m x 5 m x 1 m cement cisterns at the rate of 100,000/ha were *given* 6 percent of the body weight of chopped and cooked marine trash fish as feed per day. From this it is estimated that the production of magur in cement tanks could be raised to as high as 6,000 kg/ha/yr with a *survival* rate of 80.2 percent.

**CONCLUSION**

It can thus be concluded that the high yields obtained through the culture of some of the live fishes in South East Asia should encourage us to take up this culture all *over* the country, atleast on a small scale to start with. It is an established fact that the live fishes can be cultivated with much ease in derelict and unproductive ponds, marshes and swamps, where it is not possible to raise many other species of cultivable fishes. These fishes *have* been found to mature earlier than some of the carps and readily breed in natural confined in waters, as well as responding to induced breeding by hypophysation. It is also well known, that live fishes are much more hardy by nature and by virtue to possessing accessory respiratory organs, can easily withstand not only foul waters, but also can stay for varying lengths of time out of water. India still abounds in semiderelict waters and without having to spend a lot on their reclamation. We can fruitfully utilise them for live fish culture. This culture will not only give the new avenue of fish production but also proteineous foods for the community.

# Site Selection, Design & Construction of Aqua Farm

Dr. Ashish S. Mohite,
Professor & Head, Department of Fisheries Engineering,
College of Fisheries, Shirgaon, Ratnagiri.

Selection of a suitable site is the first and foremost step in the design and construction of an aquafarm. A mistake made during the phase of site selection may result in higher costs of construction and culture operation, and creates problems as well. Selection of a suitable site strongly influences the ultimate success of the resulting aquaculture enterprise. For high production and efficient management, knowledge of local area and experience coupled with scientific and engineering expertise is required.

No site will possess all desired characteristics. However the basic criteria for selecting a good site should be to obtain maximum production at minimum cost of construction and management.

**GUIDELINES FORMULATED BY THE GOVERNMENT OF INDIA REGARDING CONSTRUCTION OF AQUAFARMS**

• Select appropriate site
• Social and physical needs of community should be assessed and their activities should not be curbed in any way
• Give emphasis on environmental impact assessment
• Have separate water supply and drainage system
• Allow the ponds to dry between harvest
• Treat waste water for reducing organic load
• Provide not less than 10% of total pond area for treatment of waste water
• Resort to aeration and daily water exchange
• Incorporate Environment Management plan in all projects above 10 ha. Area

**IMPORTANT Don'ts :-**

• Do not use land fit for Agriculture for constructing aqua-farms
• Do not destruct ecologically sensitive wet lands
• Do not discharge the waste water into the open environment -
• Do not discharge the treated waste into open water courses which form source of water for other farms
• Over capitalization of aquaculture leading to intensification and super-intensification should not be encouraged

**SITE SELECTION CRITERIA**

Criteria of selecting a site mainly depends upon the following points :-

1. The species to be cultured
2. The targeted production level
3. The physiological requirement of species

"A suitable site is one that provides optimum conditions for the growth of species cultured at the targeted production level, given an effective pond design and support facilities".

To select a proper site for an aquafarm, first of all a survey i.e. reconnaissance survey should be conducted based on following points :-

i. Accessibility of the site
ii. Reservoirs/streams/canals, etc; nearby
iii. Whether ground is flat or sloping
iv. Type of soil
v. Infrastructure facilities
vi. Availability of freshwater and power supply
vii. Meteorological parameters, etc.
viii. Pollution problems

**CHARECTERISTICS OF A GOOD SITE**

i. Maximum productive area and minimum area occupied by bunds and other accessories
ii. Effective and efficient water exchange system
iii. Individual pond de-watering and harvesting
iv. Free from pollution
v. Very close to water source
vi. Leveled ground with gentle slope in one or two directions

**IMPROPER SITE LEADS TO**

1 Higher cost of construction
2 Higher cost of culture operation
3 Pollution and Environmental problems
4 Low production
5 Difficult farm management

**CRITICAL PROBLEMS IN AN IMPROPER SITE**

1. Excessive seepage
2. Lack of draining by gravity
3. High turbidity
4. Impracticability for drying of pond bottom
5. Improper water exchange

**AVOID AREA**

i. Having large rocks, Deep rooted vegetation, Broken soil
ii. Having substantial shading of surface of waters from surrounding vegetation
iii. Where adequate water source is not available
iv. Having acidic and acid sulphate soil
v. Having uneconomical topography
vi. Where the water source is polluted

**SELECTION OF A SUITABLE SITE FOR CONSTRUCTION OF AN AQUAFARM**

The site should be such that good water exchange is possible whenever required, should retain water to the required levels and should have the facility of draining completely preferably by gravity.

Following factors are to be considered in order to select a best possible site for brackish-water aquafarms.

## A. MAIN FACTORS

### 1. TOPOGRAPHY

Topography is one of the most important criteria in the process of site selection. When selecting a site for an aquaculture venture, preference should be given to locations where the gravitational flow may be used to fill the ponds, tanks, raceways, etc; as gravity flow is economical. It is also advantageous to drain the ponds by gravity flow.

Topography refers to the changes in the surface elevation of natural ground i.e. whether the ground is flat, sloping, undulating, or hilly. The best area for fish ponds/prawn ponds is where the ground is leveled (flat) or where there is a slight slope. The optimum slope is between **0.5 to 1.0 %.**

"Rectangular shaped flat areas located near the natural water resources like rivers, Canals, reservoirs, streams, etc; with an average natural ground elevation of 1 to 3 meter above the mean sea level, having minimum vegetation on it and slight sloping in one or two directions are ideal for aquaculture development".

Sites with excessive undulating topogrphy should be avoided as a lot of cut and fill would be needed during the construction, which will increase the cost of construction. Areas covered with large number of big trees and thick vegetation should be avoided as cleaning of the site will be difficult and will increase the cost. However in areas exposed to strong winds & cyclonic weather conditions, tall vegetative cover around the farm can serve as effective wind breaker.

### 2. TYPE OF SOIL AND ITS QUALITY

The type of soil and its composition at a given site has direct bearing on the productivity of pond. The site should contain soft bottom soil or mixed soil comprising of clay, sand and silt to ensure good water bearing capacity as well as production of natural food organisms. Good soil should contain a layer of impervious material thick enough to prevent excessive seepage and silty clays are excellent impervious materials.

**A sandy clayey soil to clayey loam soil** is the best soil type for fish/prawn pond construction. Clayey loam is an ideal soil as it has low permeability and also rich in organic matter. In case of mixed soils, a clay content up to 30% is desirable. Loamy soils have great fertility. Clayey loam soil also has high load bearing capacity, therefore it is the best material for constructing the embankments.

Too much organic matter in soil is harmful. Acid and acid sulphate soils should be rejected. Acid sulphate soil has a very low pH(3-4): The soil is easily recognizable by the reddish colour that may form on the pond bottom after flooding. Soil pH should be preferably between 6 to 9. The ideal pH range is 6-8.

### 3. FRESH WATER RESOURCES AND ITS QUALITY

#### (i) GROUND WATER SOURCES

The ground water source is preferred water source for aquaculture than surface waters.

**Advantages**

• more dependable and more uniform
• Free from wild fish, predatory insects, etc.
• Less pollution - Constant water temperature throughout the year

**Disadvantages**
• Limited use in some geographical area
• Ground water may also contain toxic gases
• Low dissolved oxygen and must be aerated
• May contain high concentrations of dissolved iron and other metals.
SPRINGS

Springs have all of the advantages of ground water and usually do not require pumping that saves on energy costs. Reliability of a spring must be assessed before selecting it as a main source of water. Springs may not be reliable during dry spells in summer season hence springs may be considered as supplementary source of water.

WELLS

Well water is usually the best source of water for aquaculture. The quality of well water is typically better than the surface water.

**(ii) SURFACE WATER RESOURCES**

Rivers, streams, reservoirs, lakes, ponds are the other important water resources. Surface waters are often subject to environmental regulations that may change from time to time. Rivers and streams are subject to variations in flow and the availability during dry periods may be limited.

**(iii) MISCELLANEOUS RESOURCES**

RAINWATER

Rainwater is a source of free water. Rainfall can be collected in tanks and impoundment and stored for later use. However, rainwater can't be dependable source, only it can be considered as supplementary source. Rainwater is generally of good quality, but it is somewhat acidic and poorly buffered. Pond waters prepared with a mixture of well water and rain water are usually of good quality for aquaculture purposes without much treatment other than aeration.

WATER QUALITY

The cheapest sources of fresh water are rivers and lakes. Ground water or deep well water is most reliable source of high quality freshwater as it is naturally filtered from unwanted pollutants.

The management of water quality is the most important factor in the productive fish farming. An analysis of physical, chemical and biological properties of the proposed source of water must be conducted.

**B. OTHER FACTORS**

**1. HYDRO-METEOROLOGICAL( ENVIRONMENTAL) PARAMETERS**

Meteorological parameter like rain fall and its distribution, rate of evaporation, temperature, winds, storms, etc. have a great role in the growth of fish food organisms as well as in the design of farm elements. A thorough Hydro-meteorological survey of the proposed area or the neighboring area should be conducted and engineering data for the last 15 to 20 years should be collected. The major data to be collected are average annual; rainfall, mean monthly rainfall, maximum precipitation in 24 hours, wind direction and velocity with respect to different seasons, flood mark, rainfall in the catchment area, critical velocity in the water basin, maximum and minimum temperature, relative humidity, evaporation rate, frequency and time of occurrence of storm, cyclone hail storm etc.

**2. AVAILABILITY OF SEED AND FEED:**

The availability of seed of the proposed species for culture can be met from the natural resource or hatchery.

**3. ACCESSIBILITY**

In order to dispose of catch as well as procurement of inputs for construction and management of the farm, the site should be located near transportation routes and should have an easy approach.

**4. SOCIO-ECONOMIC CONDITIONS**

Information regarding socio-economic conditions of the locality is important for managing farm efficiently. Details regarding seasonal availability of laborers, professionals like competent biologists, skilled operators, local customs, traditions, etc. should be gathered. Man power planning mainly depends upon local wages, and the availability of skilled laborers.

**5. POLLUTION PROBLEMS**

It would be unwise to select a site where industrial developments may cause air and water pollution. Industrial effluents, sewage out falls, insecticide affected agricultural land affect, the growth rate as well as acceptability of farm products.

**6. AVAILABILITY OF POWER SUPPLY**

The availability of electric power, proximity to the substation and transformers are to be considered. Preference should be given for a site where required capacity of electricity is available near by.

**7. TRANSPORTATION AND MARKETING FACILITIES**

Market with cold storage and processing plant should be closely located. Also the seasonal variation in prices in the internal market should be well studies so that harvest can be arranged in such a season to meet the high demand.

**8. SOCIAL AND POLITICAL FACTORS**

Legal restrictions, governmental regulations, security and social amenities at the site should also be given due importance during the site selection.

**9. TECHNICAL GUIDANCE**

Technical guidance from fisheries departments or private consultants help the farmers to solve common problems like excessive seepage, soil erosion, fish/prawn diseases, etc. A good technical guidance can even motivate the other farmers to take up fish/prawn culture.

**10. AVAILABILITY OF MACHINERIES AND EQUIPMENT**

Availability of earth moving machinery such as bulldozers, scrapers, hydraulic power shovel etc. should be considered for proper earth work excavation and construction of bunds.

**11. INFRASTRUCTURE FACILITIES**

Other facilities such as approach road/water ways, availability of Telephone/ TeleFax system, proximity to market and major port, public conveyance system such as Bus stand Railway station or Airport are to be considered.

**12. AVAILABILITY OF PRE-PROCESING AND PROCESSING CENTRE**

The produce from the aquaculture farm has to be preprocessed immediately and sent to market or to the processing center. Thus establishing such centers if not already in existence will be of great help in marketing the produce with supreme quality for a better price.

**13. SOURCE OF FINANCE AND INSURANCECOVERAGE**

The source of capital to finance suitable land acquisition as well as the development of the farm site has an indirect relationship to site selection. To encourage aquaculture development many agencies like FFDS, BFDA, MPEDA etc extend financial assistance in India in the form of subsidy or equity participation. Also financial institution such as Nationalized Banks, NABARD, SCICI etc. in India extend financial help to the entrepreneurs.

## DESIGN AND CONSTRUCTION OF PONDS

### ORIENTATION OF THE FARM

Orientation is nothing but an art of designing various farm elements taking advantage of natural conditions prevailing in the locality with an aim to build a good aquatic environment for species to be cultured at targeted production level. By and large total shape of the farm area should be more squarish than the oblong to minimize the cost on periphery bunds. However, larger rectangular ponds are more suitable from management and operation point of view. Therefore, a very careful study of the entire topography should be made to orient and plan the farm to minimize the length and breath of bunds and channels to get maximum productive area.

The pond orientation should take into account the direction of the prevailing wind. The longer sides of rectangular ponds should be oriented parallel to the general prevailing wind direction (most probably south to north) to increase the pond water aeration as a result of wind diffusion through increased surface turbulence.

Referring to contours (level of the ground) the larger ponds should be positioned on lower contours and smaller ponds like nurseries requiring less depth may be positioned proportionately higher levels. Farm buildings like hatcheries, office, store etc. should be laid out in higher lands in the area.

The water supply system should be straight and short with smooth bends.

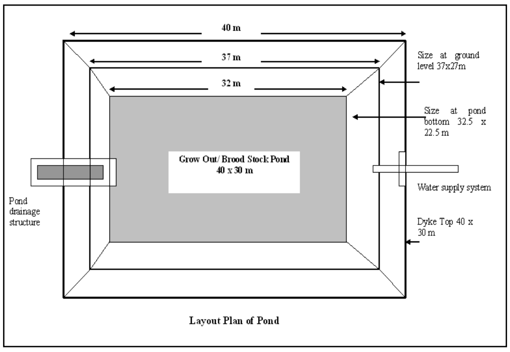
The layout of channels, dykes is filled as closely as technically possible for existing land slopes and undulation. Channels should prefer a suitable contour for making possible of gravity flow to all sections of farm area.

Farm discharge outlets along with main drainage channel should be located at lower level of site, which is also connected with other catch water drains in the farm. Used water from the culture ponds should have provision of drainage to ensure that it is not recycled back to the ponds.

The wells and tubewells should be located at suitable locations referring to the study of underground soil-water strata of the proposed site. Necessary test-borings are done to ensure the availability of water layers under the ground.

The design of pond should be such as to have maximum net water area for culture, therefore the dyke section is designed perfectly to its required size. It is always better if the farm layout and design permits complete drainage of the pond during the production process and specially in the rainy season.

## SHAPE, SIZE AND TYPE OF PONDS:



Layout Plan of Pond

Rectangular ponds are suitable for nursery and rearing purposes. The larger ponds, preferably rectangular ponds are more suitable from management point of view as they have a large water surface for the effect of the wind which maintains a higher level of dissolved oxygen.

For prawn aquaculture suitable size for nursery pond is 20 m x 20 m and 20 m x 10 m, and for grow-out ponds 20 m x 40 m, 25 m x 50 m, 25 m x 80 m. 30 m x l00m, 40 m x l00 m, 40 m x 200 m, 40 m x 250 m. Limiting the maximum width to 40 m the length of the pond may be increased as desired. Considerable increase in width only creates culture management problem.

## POND BED:

For aquaculture purpose the pond bed should be flat with a uniform slope. The pond bottom is provided with a slope between 1000:1 to 1000:5 towards the drainage outlet to facilitate the water flow during culture, harvest and drainage. A well constructed pond is normally designed to drain out the water completely.

## POND DEPTH AND WATER LEVEL:

Depth of a pond has an important bearing on the physical and chemical parameters of water. 2m water depth is desirable.

## POND EMBANKMENT (DYKE):

The design of the dyke should be strong enough to hold upto the maximum level and be safe against hydraulic pressure. The base width or bottom of dyke depends upon the depth of water in pond and top width depends on the type of soil. Embankments are generally constructed using earth.

### (1) Periphery Embankment:

Periphery dike, which is also called as **main embankment**, protects the entire farm from floods, storm surges and tides. It also acts as a road way around the farm. The design and strength of periphery dike mainly depends upon the prevailing site conditions. Side slopes of the periphery dike mainly depend upon the type of the soil available at the site.

### (2) Internal Embankment:

Dykes constructed around the ponds are generally called as *internal dikes*. They are also known as *secondary dikes*.

Design of any type of embankment depends upon type of soil, vehicular load expected on the top of embankment, slope of the embankment, designed water level of the ponds, purpose of construction, Free board, site conditions. The important design parameters are Height, Top width and Side slope.

### Free board:

Free board is the additional height of the pond dyke above maximum water level. It is generally provided as a safety factor to prevent overtopping of dike provided from wave action, heavy rainfall and for other causes. A free-board of 0.50 m to 1.00 m is usually necessary above pond water depth.

**Dikes Protection:**

A pond construction is not complete unless the pond dykes are protected against erosion due to heavy rains and wave action. Selected grass turfing to the dyke body is the most inexpensive way of dyke protection. It is often done on dyke surface in order to control soil erosion and reduce maintenance cost.

Slope of the dikes should be lined with proper methods to prevent soil erosion. Stone pitching, brick tiling, concrete slabs, lime concrete mixtures, polymer based chemicals, etc. are some examples of commonly used lining materials; however, it increases the cost.

**Top Width (Crest) of Dyke:**

The top width of a dike mainly depends upon the type of vehicular load expected on the top of the dike. The height of dike and its purpose are also important in designing the crest. Generally 1.5 m to 2.5 m of top width is adopted.

**Side Slope:**

The side slope of pond and dyke is necessary for stability of the dyke. The side slope mainly depends upon soil texture and prevailing site conditions. The flatter the slope, the more stable it is. Ideal slope is 1.5:1 to 2:1 (H:V). As it depends on the class of soil, therefore the minimum required slope for different soil textures are as given below.

| Type of soil | Side slope (horizontal/vertical) |
|---|---|
| Clayey soil | 1:1 to 1.5:1 |
| Loamy soil | 1.5:1 to 2:1 |
| Sandy soil | 2:1 to 3:1 |

**CONSTRUCTION OF DIKES**

1. The soil forming the foundation where the embankment is to be constructed must be able to support the weight of dike. Therefore top layer of the soil (10-15cm) must be removed from the site and the dike should be constructed on the under laying consolidated soil material. Swampy, muddy, plastic soil and highly organic soils should not be used as construction material.
2. Embankment should be constructed in layers, each layer not exceeding 30cm in thickness.
3. All tree roots, rocks, etc should be removed.
4. Staking on the site is to be done clearly with lime powder to distinguish the area of excavation and the area of filling.
5. Earth should be excavated and then put on the area marked for development of bund in thickness not more than 30cm. Water should be sprinkled on the top and then it should be well compacted with heavy construction equipment to minimize the settlement.
6. After consolidation and compaction of first layer is over, second layer should be put (again depth not exceeding 30cm) and it should also be well compacted and consolidated.
7. In this way, the procedure should be repeated till the designed height is reached.

8. While construction itself desired slope must be given to sides of the dike.
9. Wherever necessary slope should be protected with stone pitching, brick bat pitching, concrete lining, etc.

**POND SEALING/ LINING:**

Sometimes pond or farms are constructed fully or partly in porous soil causing water loss by seepage through dyke and basin, in that case sealing/lining of the surface of dyke and bed is felt essential. Lining the pond with impervious material or treating the soil mechanically or chemically is practiced to prevent excessive water loss.

**Compaction:**

Pond sealing by compaction is relatively inexpensive. However, its use is limited to soils having a wide range of particle sizes capable of effecting a suitable seal. Sandy and silty loam type of soils are suitable for compaction. In addition to normal compaction of dyke during construction, layer of 15-20cm of surface soil of pond bed and dyke is required to be compacted properly by manual and hand roller with minimum moisture content. The pond surface soil should be mixed with good clay soil before compaction.

Some chemicals like Tetrasodium pyrophosphate. Sodium tripolyphosphate, Sodium hexametaphosphate and Sodium carbonate is mixed to the top soil and compacted to a 15 cm thick layer for a water depth of 2.5 m. The chemical treatment is not effective if the soil is of coarse grade.

Application of cow dung and cement in clayey soil controls seepage to a greater extent. If one per cent of cow dung and 5-10 per cent of clayey soil is mixed properly with 15-20 cm of bottom soil it reduces loss of water considerably.

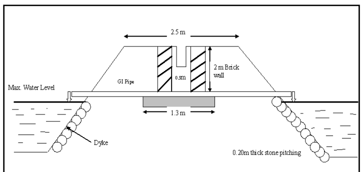
Clay percentage is increased when pond soil contains more sand. Where there is deficiency of clay soil, one per cent cement and 1-5 per cent cow dung is mixed with the pond surface soil and is rolled with watering.

**Use of Bentonite clay**:

Bentonite is also used to control the water loss from prawn/fish ponds by seepage. Bentonite is a fine texture colloidal clay, which absorbs water several times its own weight and at complete saturation swells 8-20 times its original volume. The bentonite is mixed with soil to a depth of 15 cm and the mixture is properly compacted and saturated, the particles of bentonite fill the pores in the soil and makes it nearly impervious. Bentonite powder is applied at the rate of 5-15 kg per square meter depending on the quality of soil. Bentonite when dried, return to its original volume and leave cracks in the pond area. Bentonite can also be applied when there is water in the pond. A coarse grade is suitable to use and it is uniformly applied to the water surface which settles to the bottom, swells and forms a seal.

**WATER SUPPLY AND DRAINAGE SYSTEM: -**

The simplest method of conveying water from the main source is by canal or pumping station to the ponds by allowing it to flow under gravity in channels made of earth. Usually PVC, HDPE pipe network is used when flow is under pressure and in that condition, water flow is regulated by means of valves. Use of pipe network is limited to small farms only. In case of large farms, where high flow rate is required, the cheapest way to convey the water is by gravity through open channels. Similarly, to pass out the water while exchanging or




Design of water inlets to fish pond

draining, a drainage channel network is also necessary, and is provided with suitable outlet structure fitted with screens and shutters.

The shape of the main channel may be rectangular, parabolic, trapezoidal or semi-circular. The main supply channel can be lined to prevent erosion and seepage losses. The lining is done with cement concrete in 1:2:4 or 1:3:6 proportions, R.C.C., any type of stone or bricks with cement mortar. Even lining is done with timber and plastic sheets.

**Drainage channel:**

The channel is designed so as to perform complete drainage of the ponds, as and when required. The drainage channel should be considerably lower than the pond bottom to drain the pond completely. The elevation difference between the pond bottom and water surface line in the channel should preferably be more than 20-30 cm. The drainage channel should have the capacity to carry the designed flow and the velocity of flow in the drainage channel should be such that neither serious scouring nor silting occurs.

**Pond inlet and outlet gates:**

Different types of gates are used for water conveyance system in a prawn farm. Pond inlet gates regulate the flow of water from channels into the various ponds. PVC or G.I. pipe with valves or without valves are usually fitted for free fall of water from field distributor channel into the ponds. Even open masonry drains with shuttering and screening arrangement are constructed along the field channels to act as water feeding of ponds.

The pond outlet gates are constructed in various forms such as open sluice, monk sluice, pipes made structures etc. The monk type sluices are commonly used by constructing U-shape walls with three rows of grooves. The groove facing the pond is fitted with wooden or iron framed plastic or nylon screen shutters, whereas the other two are fixed with wooden or iron frame shutters to prevent water flow. The opening of this shutter is adjusted by sliding it up or down. The G.I., R.C.C. or PVC pipes are provided from the sluice gate to the drainage channel below dyke at pond bed level. Plastic or nylon netting screen are used to prevent escape of fish / prawn from the pond.

# Roll of Soil and Water Quality Management in Aquaculture

M. M. Girkar
Assistant Professor, Dept. of Fisheries Hydrography
College of Fishery Science, Udgir, Dist. Latur.

**Introduction**

In the recent years, intensification of aquaculture practices have posed question regarding maintenance of optimum nutrients in the culture system as well as of practices on the surrounding environment. The new approach for nutrient management in the ponds gives due attention to organic decomposition. residue accumulation, microbial processing possibilities, fertilization strategies to suit different kinds of ponds; and to biofertilization and bio-filtration to achieve increased production, sustainability and environment upkeep. Aquatic environmental management is crucial when efforts are being made to increase mean national fish production through aquaculture to at least 4 tones/ha/year; diverse nutrient resources arc available recycling and utilization in fish culture.

**Water parameters**

**Dissolved oxygen**

This is the most critical and limiting factor in intensive aquaculture. Oxygen enters water through photosynthesis by aquatic plants, principally phytoplankton and by diffusion at the air-water interface.

There are distinct diurnal fluctuations in oxygen; with concentrations lowest just after dawn, and increasing during daylight hours. This is because of the photosynthetic production of oxygen (there is also usually more wind during day) to a maximum in late afternoon before decreasing again during night.

**Following are some guidelines for dissolved oxygen for fish production.**

- 5.0 mg/litre- optimum for normal growth and reproduction in tropical waters;.
- 1.0-5.0 mg/litre- may have sub-lethal effects on growth, feed conversion and tolerance to disease;
- 0.3-0.8 mg/litre- lethal to many species if sustained for a long period.

**Oxygen depletion in water is rectified by following methods.**

- **Manual-**In this, water surface is splashed with bamboo-sticks.
- **Mechanical-**A diesel water-pump is operated through this method.
- **Aerators-**Aerators are mechanical floating devices.

**Temperature**

Fishes are poikilothermic (having variable temperature).Fish metabolic rate doubles for every rise of 10°C. Therefore, temperature has a direct effect on the important factors-growth, oxygen demand, food requirement and food-conversion efficiency. At temperatures below 10°C, fish may enter a state a sluggish inactivity. Temperature also has a crucial role in stimulating gonadal maturation and spawning activity. Under favorable conditions, optimum temperature range for many coldwater and warm water fishes is 14-18°C and 24-30°C respectively.

**Turbidity**

It is a very general term that describes cloudiness or muddiness of water. Many substances including microscopic algae (phytoplankton), bacteria, dissolved organic substances that stain water, suspended clay particles, and colloidal solids make water turbid. Turbidity also causes off-flavored fish.

**Alum:** One of the most effective coagulants is alum or aluminum sulphate which has been used to clarify muddy-waters. A dose of 15 to 25 mg/litre (60 to 110 kg per acre or 0. 4 ha) should be sufficient to remove turbidity from most waters. Alum makes water acidic.

**Other coagulants:** Gypsum must be added to achieve a concentration of 100 to 300 mg/litre for effective turbidity control. For most ponds, gypsum application rates will range from about 400 to 1,200 kg per acre or 0.4 ha.

**Ammonia**

Total ammonia concentration in water comprises two forms, namely unionized ammonia and ionized ammonia. Unionized ammonia fraction is more toxic to fish and the amount of the total ammonia in this form depends on the pH and temperature of the water.

**Following are guidelines for unionized ammonia levels for fish growth.**

- 0.02-0.05 mg/litre-safe concentration for many tropical fish species;
- 0.05-0.4 mg/litre—sub-lethal effects depending on the species; and
- 0.4-2.5 mg/litre—lethal to many fish species.

**Some recommended measures to reduce effects of ammonia are as follows.**

- Aeration will increase dissolved oxygen concentration and decrease pH
- Healthy phytoplankton populations remove ammonia from water.
- Biological filters may be used to treat water.

**Nitrite**

Nitrite is an intermediate product in the biological oxidation of ammonia to nitrate, a process called nitrification. In most natural water-bodies and in well-maintained ponds, nitrite concentration is low.

**Guidelines for nitrite value for fish growth are as follows.**

- 0.02-1.0 mg/litre- sub-lethal level for many fish species;
- 1.0-10 mg/ litre- lethal level for many warm water fish species.

**Measures to maintain safe nitrite level in water are as follows.**

- Correct stocking, feeding and fertilization practices should be maintained & biofiltration should be done through special filters

**Hydrogen sulphide**

Freshwater fish ponds should be freed from hydrogen sulphide ($H_2S$). Hydrogen sulphide is produced by chemical reduction of organic matter that accumulate and forms a thick layer of organic deposit at the bottom. Unionized hydrogen sulphide toxic to fish.

**Guidelines for hydrogen sulphide value for fish growth are as follows.**

- 0.01-0.5 mg/litre-lethal to fish and any detectable concentration of hydrogen sulphide in water creates stress to fish;
- 0.1-0.2 mg/litre-prawns lose their equilibrium and may create sub-lethal n
- 3 mg/litre-prawns die instantly.

**pH**

It is a measure of hydrogen ion concentration in water and indicates how much acidic or basic the water is. The pH scale ranges from 0 to l4 with 7 as neutral. Carbon dioxide has an acidic reaction in water. The pH in ponds rises during day because phytoplankton. It decreases at night because of respiration and production of carbon-dioxide by all organisms.

**Signs of sub-optimal pH are as follows**

- increase of mucus on gill surface
- damage to eye lens and cornea
- abnormal swimming behavior
- fin fray and death
- poor phytoplankton and zooplankton growth.

**Table: 1. Effect of pH on fish**

| pH | Effect |
|---|---|
| 4 | Acid death point |
| 4-6 | Slow growth |
| 6-9 | Best for growth |
| 9-11 | Slow growth, lethal to fish over long period of time |
| 11 and above | Alkaline death point |

**Total alkalinity**

Alkalinity refers to the total amount of bases in water, expressed in mg/litre of equivalent calcium carbonate. In most waters, these bases are principally bicarbonate ($HC0_3$) ions and carbonate ions ($CO_3^2$).

**Guidelines for alkalinity for fish growth are as follows**

- 300 mg/ litre-create stress to fish;
- 75-300 mgI litre-ideal for fish;
- <75 mgI litre-create stress to fish.

**Total hardness**

Hardness is the concentration of metal ions (primarily calcium and magnesium). expressed in mg/litre of equivalent calcium carbonate.

**Waters are often categorized as follows according to degrees of hardness**

- 0-75 mg/litre - soft
- 75-150 mgi' litre - moderately hard
- 1 50-300 mg/ litre hard
- over 300 mg/ litre - very hard

**Guidelines for hardness value for fish growth are given as follows.**

- 60 mg/ litre- satisfactory for pond productivity and helps protect fish against harmful effects of pH fluctuations and metal ions;
- <60 mg/ litre- creates stress to fish.

**Carbon dioxide**

It is present in the atmosphere in very small quantity. It occurs in water in three closely related forms- (a) free carbon dioxide, (b) bicarbonate ion, and (c) carbonate ion. Each form amount present depends on the pH of water.

**Guidelines for carbon dioxide value for fish-ponds are as follows.**

- 12-50 mg/litre- sub-lethal effects include respiratory stress and development of kidney stones (nephrocalcinosis) in some species;
- 50-60 mg/litre- lethal to many fish species with prolonged exposure.

**Measures for controlling high carbon-dioxide concentration include the following.**

- Repeated aeration of water;
- Correct stocking, feeding and fertilization should regulate phytoplankton population.

**Chlorine**

To control bacteria, municipal water supplies are treated with chlorine at 1.0 mg/ litre. If municipal waters are used to culture fish, residual chlorine must be removed by aeration with chemicals such as sodium thiosulphate, or filtration through activated charcoal. Chlorine levels as low as 0.02 mg/litre can stress fish.

**Water colour**

Fish farmers pay much attention to colour of pond-water. In other words, they give more importance on the promotion of phytoplankton in pond-water. Five following objectives associated with water colour can be identified: (i) to increase dissolved oxygen and to decrease $CO_2$, $NH_3$, $H_2S$ and $CH_4$ in pond-water, (ii) to stabilize water quality and to lower content of toxic compounds, (iii) to make use of plankton as a natural feed, (iv) to provide shade and to decrease cannibalism, (v) to increase and stabilize water temperature.

**Seven types of water colour that can occur in pond are as follows**

**Reddish-brown or pinkish-red:** Blooming diatoms cause this colour. Algae species *Chaetoceros, Navicula, Nirzschia, Skeleronema, Cyclotella, Synedia, Achnanthes*, *Amphora* and *Euglena* are often found in pond-water of this colour, especially the first three species.

**Light or bright green:** This colour is due to green algae, especially *Chlorella*. In addition, *Dunalielld, Platynons, Carteria, Chalmydomonas* are also present.

**Dark green:** Blue-green algae *Oscillatoria, Pharmidiurn* and *Microcoleus* dominate.

**Dark-brown colour:** Poor pond management such as overfeeding or using large amount of trash fish causes rapid growth of dinoflagellates and brown algae.

**Yellowish colour:** Yellow water formation is due to Chrysophyta growth.

**Turbid water:** Turbid water formation may be due to suspension of zooplankton, clay particles or detritus.

**Clear water:** This water is transparent. This may be owing to lack of nutrients, presence of heavy metal, pollution of copper, manganese, iron and acid bottom clay (pH 5.5 or lower). Under these conditions, no organisms can grow properly.

**Properties of the soil**

**Texture**

Many important physico-chemical properties for fertility of fish ponds are influenced to a great extent by the proportion of different size fraction of soil. An ideal pond soil should not be too sandy to allow leaching of nutrients or should not be too clayey to keep all nutrients absorbed. When the pond is constructed on the sandy soils, heavy doses of organic manure are essential to control seepage loss of water.

**Soil pH**

The pH of the soil is one of the most important factors for maintaining pond productivity. Soil may be acidic, alkaline or neutral; the ideal range of pH is 6-8. Near neutral to slightly alkaline soil pH is considered to be ideal for fish production. Liming is the only way to improve water quality in ponds.

**Liming**

Application of lime in fish pond supplies calcium and also maintains the productivity of ponds and correcting the acidity of soil and water. Doses of lime application increase with decrease in pH of the soil to be treated.

**Table. 2: Lime doses at different pH values of soil**

| pH | Soil condition | Dose of lime (kg/ha) |
|---|---|---|
| 4-4.5 | Highly acidic | 1000 |
| 4.5-5.5 | Medium acidic | 700 |
| 5.5-6.5 | Slightly acidic | 500 |
| 6.5-7.5 | Near neutral | 2000 |

**Organic carbon**

Pond soils with lesser than 0.5% organic carbon is considered unproductive while those in the range of 0.5 -1.5% and 1.5 -2.5% are considered medium and high productive respectively. More than 2. 5% organic carbon content may not be suitable for fish production.

**Carbon to nitrogen ration**

C: N ratio of soil influencing the activity of soil microbes. C:N ratio in the range of less than 10, 10-20 and more than 20 respectively. In general, C:N ration between 10 and 15 is considered favourable for aquaculture and of 20:1 or narrower gives good result.

**Nutrient status of the soils**

Nitrogen, phosphorus and potassium are the major nutrients required by phytoplankton. Productivity and physico-chemical properties of soil can be improved with the application of organic and inorganic fertilizers. Pond soil with 30 ppm, 30 – 60 ppm, 60-120 ppm and more than 120 ppm available phosphorus ($P_2O_5$) are considered to have poor, average, good and high productivity respectively. Ponds with less than 250 ppm available soil nitrogen are considered to have low productivity while its availability of more than 250 ppm and >500 ppm are considered to be medium and highly productive respectively.

***References:-***


1. Hand book of Fisheries Aquaculture II edition (2011).Indian Council of Agricultural Research, New Delhi.
2. Water quality for pond aquaculture by Claude E. Boyd, Department of Fisheries and allied aquaculture, Auburn University, Alabama, USA.
3. Aquaculture pond bottom soil quality management (2002) by Claude E. Boyd Department of Fisheries and Allied Aquacultures Auburn University, Alabama, C.W. Wood, Department of Agronomy and Soils Auburn University, Alabama, Taworn Thunjai, Department of Fisheries and Allied Aquacultures, Auburn University, Alabama

# Modern Techniques of Management of Nursery, Rearing Practices of Carp Culture


| Shri Shardul Sham Gangan | Shri Vinay P. Sahasrabuddhe | Shri Sharad D. Patil |
|---|---|---|
| Asstt. Research Officer | Senior Research Assisstant | Research Officer |
| TMBRS, Mumbai | TMBRS, Mumbai | TMBRS, Mumbai |


## Introduction

Fish is considered as major source for human consumption and ranked high in terms of nutritious value. Worldwide demand for fish is increasing rapidly day by day. This demand is met through the fish landings from marine resources as well as freshwater resources. India is having large coast line of 8440 km out of which 720 km are shared by Maharashtra state. Due to over exploitation of marine fishery resources the production from capture fisheries is decreasing, which forced the development of aquaculture practices to meet increasing fish demand. But again, higher stocking densities, use of sub quality seed etc. created problems of regular disease outbreaks especially in brackish water aquaculture. In this scenario production from freshwater resources is getting importance to overcome the problem of food security in India. From last three decades marine fishery landings are stagnant therefore to meet the increasing demand for fish in the country, inland fish farming sector has increased by 11 times in the last 50 years.

Accordingly to the newly released data, world aquaculture production of food fish reached 62.7 million tonnes in 2011, up by 6.2% from 59 million tonnes in 2010. Based on the preliminary data for several major producers and projections for others, the world aquaculture production of food fish in the year 2012 is estimated at around 66.6 million tonnes. Aquaculture contributed 40.1% to the world total fish production. In 2010, aquaculture production of food fish 3.7 million tonnes and in 2011 is 4.5 million tonnes. In 2030 the aquaculture production in India is expected to grow up to 8.5 million tonnes. (Source FAO).

In early years, freshwater fish farming is in the primitive stage. In which fish seed collected from the natural sources and stocked in the ponds. This activity was very limited to fulfil the daily need of the family. But now the freshwater fish farming has taken bigger step and this is not only the supplementary but is considered as main stream economical business. Therefore many farmers and investors are attracted for investing in this sector.

Freshwater fish farming is playing major role in the economic uplift of the farmers of Maharashtra state. By introducing the farm pond scheme in the state, government is intended to increase the income of the farmer by rearing fishes in farm pond up to table size and selling them in the local market. Simultaneously the water farm pond is utilized for the agriculture crops in the rabbi season. Due to increase in the number of farm pond in the state, the demand of Indian Major Carp fish seed is also increasing. In context of this there is an urgent need of some farmers should get acquainted with modernized nursery rearing practices. In this view this article is written to know the modern techniques of nursery, rearing practices of Indian Major Carp.

**Modern techniques of nursery rearing -**

Availability of good quality seed is the key to success in any aquaculture. Hatcheries are the major source of seed supply of freshwater fishes like IMC. But this practice requires certain infrastructure and natural resources. Hence, can't be developed everywhere due limited availability of required resources. Therefore by procuring fish spawns from established breeding centres and rearing those in the nursery ponds will fulfil the requirement of the fish farmers around that region.

**Nursery rearing practices are having following stages -**

1. Nursery pond preparation.
2. Nursery pond fertilization.
3. Fish seed stocking.
4. Feed management.
5. Fish seed harvesting and transportation.

1. **Nursery pond preparation -**

For better survival and growth of the fishes it is very necessary to have good plankton production in the pond, and it is only possible with good pre stocking management of pond. There are few important steps in the pre stocking pond preparation, those are

a. Dewatering of the pond
b. Application of bleaching powder
c. Drying of pond
d. Application of lime

**a. Dewatering of the pond –**

It is necessary to drain out the pond water every year for the nursery rearing. It will help in removing the unwanted fishes and other animals grown during the culture period. Also the unutilized feed accumulated at pond bottom, gets exposed to sunlight, causing complete decomposition and release of toxic gases. Dewatering is done with the help of the electric pump or diesel pump.

**b. Application of bleaching –**

Immediately after dewatering of the pond, next day apply bleaching powder at the rate of 200 to 250 kgs per ha. This will help killing small insects, frogs, unwanted fishes. The effect of bleaching water will remain for three days. Precautions should be taken by wearing the hand gloves for protecting the hand from burning while applying the bleaching powder.

**c. Drying of pond –**

After applying the bleaching powder, allow the pond to dry at least for 10 to 15 days. Drying of the pond should be done till the pond bottom soil completely dry and soil get cracks. If possible, half feet depth ploughing should be done; this will helps the bottom soil turn upside, helps in removing the toxic gases from the soil which ultimately helps in easy and quick release of nutrients from the soil to pond water.

**d. Application of lime -**

For better growth of plankton and fishes it is necessary to have the pH of water around 7 to 7.5. Agriculture lime is used for the application to nursery ponds. This will help in maintaining the water pH. Agriculture lime used at the rate of 200 to 250 kg per ha. Lime should apply to the pond water after the pond gets filled with rain water with the depth of 2 to 3 ft.

2. **Nursery pond fertilization -**

Pond fertilization is a most important and an integral part of the modern nursery management. Recently developed pond management techniques are very useful for getting adequate plankton bloom in the nursery ponds. In the recent technique of nursery pond management, the activities generally start seven days before the stocking of spawn. Seven day before the stocking liming should be done by applying agriculture lime. This will help in maintaining the pH and releasing the nutrients from the soil easily. Agriculture lime should be applied at the rate of 3 to 3.5 kg per 100 square meters. After two days of application of lime, Ground nut oil cake (GNOC) will be applied at the rate of 7 to 7.5 kg per 100 square meters. Before application of GNOC, it should be kept in wet condition for two days. Same day Single Super Phosphate (SSP) should be applied at the rate of 3 kg per 100 square meters. A day after fertilization, Ecomarine (available in Tablet form) is to be given at the rate of 2 tablets per 100 square meter. Ecomarine helps in digestion of wastes and converts them into micronutrients during culture period, it eliminates sludge and bad odours, stabilizes plankton level and pH. It works for 24 hours. These tablets will reach to the pond bottom and work efficiently on soil as well as water. After two days of fertilization, Biomarine (available in liquid form) will be applied at the rate of 50 ml per 100 square meters. Biomarine helps removing organic wastes and restores ecological balance of the pond, reduces sludge volume during pond preparation, creates natural food source, adds nutrition to soil and removes unwanted microorganism from pond. For 100 meter square area take 200 to 300 gm of molasses, 200 gm of GNOC, 100 gm of rice bran, 2 to 3 gm of yeast and add 1.2 lit of pond water and keep it for 24 hours and add 50 ml of Biomarine in the morning i. e. around 6 – 7 am and mix uniformly and broadcast the solution at 11 to 11.30 am in the pond. Six days before stocking Toximar (Natural Zeolite) should be applied at the rate of 250 gm per 100 square meter. This will reduce toxic gases like $NH_3$, $H_2S$ and $SO_4$ from the pond and eliminates bad smell from the pond. One day before stocking of the fish spawn in the nursery pond it is necessary to apply the oil emulsion to eliminate the unwanted insects from the pond water. The emulsion will be prepared with the 1 lit Diesel, 5 gm detergent and 100 ml pond water. After mixing all the ingredients thoroughly, when the atmospheric condition is calm and in no rainy condition, broadcast this mixture on the pond water at the rate of 750 ml per 100 square meters. This fine layer of diesel will kill most of the insects within 4 hrs of application.

After this the nursery pond is ready for the stocking of fish spawn. Application of Biomarine can be repeated as per the availability of the plankton bloom in the nursery pond water only within first ten days.

3. **Fish seed stocking -**

Type of fish seed

1. 7 to 8 mm length - Spawn
2. Up to 25 mm length - Fry
3. From 25 to 45 mm length - Semi fingerling

4. From 50 to 70 mm length - Fingerling
5. From 70 to 150 mm length - Advance Fingerling

Generally farmers procure fish fingerling from the rearing unit. While stocking the spawn in the nursery pond proper acclimatization procedure should be followed. When seed is transported from long distance, the polythene bags should be kept in the pond water for 30 to 45 minutes. After that open the bag and pour pond water slowly in the bag containing the fish spawn. Repeat this activity till the water gets filled up to 60 percent of volume of bag. Then tilt the bag slowly and allow the fish spawn swim themselves into the pond water. After releasing all the spawn rinse the bag slowly with the pond water to remove the fish spawn from the corner of the bag. Normally stocking of fish spawn should do in the cool hours of the day i.e. late night or early in the morning. Stocking density depends on the productivity of the pond. Generally 50,000 nos of fish spawn stocked for 100 square meter area. And the nursery period from spawn to semifingerling is 20 to 25 days.

4. **Feed management -**

During the nursery rearing period fish spawns are fed with the powdered GNOC. Weight of the fish spawn at the time stocking is 1.4 mg (6 to 6.5 mm length). Feeding schedule is as given below.

| **Period** | **Feed per day in terms of weight (g) of spawn at the time of stocking** | |
|---|---|---|
| | **Alikunhi (1957)** | **Feed qty. for 1 lac spawn (in gms)** |
| First 5 days after stocking | Double | 280 gm |
| $6^{th}$ to $10^{th}$ day after stocking | Three times | 420 gm |
| $11^{th}$ to $15^{th}$ day after stocking | Four times | 560 gm |
| $16^{th}$ to $20^{th}$ day after stocking | Five times | 700 gm |
| $20^{th}$ to $25^{th}$ day after stocking | Six times | 840 gm |

Ground nut oil cake is used for feeding, applied in the slurry form. It is consumed by the fish spawn and it also act as a fertilizer for the production of the plankton. Powdered GNOC is used for first 10 days and for remaining period GNOC is soaked in the water and slurry will apply. Above feeding quantity can be dividing into two parts and can be given twice in a day preferably in the morning and evening.

5. **Harvesting -**

After reaching the harvestable size i.e. 40 to 45 mm (in 22 to 25 days depending on the availability of the natural food) semi fingerlings harvested with the help of drag net (mesh size is 8 to 10 mm) and acclimatized for 8 to 12 hours before selling to the other fish farmers. One day before harvesting, the supplementary feeding to the fish seed has been stopped.

**Economics of nursery rearing -**

In the economics of nursery rearing the excavation cost of the pond is not taken in the account. Also considering the manpower, Plastic pool (8000 lit. Capacity) with shower facility and drag net are available while calculating the economics. Expenditure incurred for nursery rearing in the 600 square meter is as follows.

**Particulars of practices**

| | | |
|---|---|---|
| 1. | Water spread area | : 600 Sq. mt. |
| 2. | Culture period | : 25 days |
| 3. | Culture frequency | : 2 crops |
| 4. | Stocking density | : 3 Lacs / crop |
| 5. | Survival rate | : 33 % |
| 6. | Size of seed | : 40 to 45 mm |
| 7. | Expected no. fish seed | : 2 lac |
| 8. | Selling price | : Rs. 1.04 / semifingerling |
| 9. | Total feed required | : 100 kg |
| 10. | Total production cost | : Rs. 45,415/- |
| 11. | Total selling cost | : Rs. 2,08,000/- |
| 12. | Net profit | : Rs. 1,62,585/- |

**Recurring expenditure**

| | | |
|---|---|---|
| **1.** | **Pond preparation (including fertilization)** | |
| | 30 kg Bleaching powder @ Rs. 25/- per kg | : Rs. 750/- |
| | 30 kg lime @ Rs. 12/- per kg | : Rs. 360/- |
| | 10 lit Diesel @ Rs. 62/- per lit | : Rs. 620/- |
| | Washing powder 1 pack | : Rs. 35/- |
| | Biomarine, Ecomarine & Toximar (1 pack each) | : Rs. 5,000/- |
| | 100 kg GNOC @ Rs. 50/- per kg | : Rs. 5,000/- |
| | SSP, Molasses, Rice bran, Yeast etc. | : Rs. 2,000/- |
| **2.** | **Fish stocking** | |
| | 6 Lacs Fish spawn @ Rs. 3000/- per lac | : Rs. 18,000/- |
| **3.** | **Fish Feed** | |
| | For two crops 100 kg GNOC @ Rs. 50/- per kg | : Rs. 5,000/- |
| **4.** | **Fish harvesting and selling** | |
| | Fish seed harvesting cost | : Rs. 2,000/- |
| | Seed packing cost | |
| | 15 kg Polythene bags @ Rs. 260/- per kg | : Rs. 3,900/- |
| | 5 Oxygen cylinder (refilling) @ Rs. 250/- per cylinder | : Rs. 1,250/- |
| | Others (Sutal, strainers etc.) | : Rs. 1500/- |
| | | ==================== |
| | | **Rs. 45,415/-** |
| | | ==================== |

**Production cost and net profit ratio (C:B ratio) = 1:3.58**

Adoption of this modern technique of nursery rearing by single farmer from each taluka of district can fulfil the seed requirements of the farmers around the region.

# Advances in grow-out culture techniques of fresh water fishes

Somnath R. Yadav,
Assistant Professor, Dept. of Aquaculture
College of Fishery Science, Udgir, Dist. Latur.

## 1. Culture of Carps:

Carp contributes the major source of animal protein for millions of people in Asia.It is the most cultured group of fish species in the world with 40% production by volume. China and India are the main countries producing carps through aquaculture. Carp contributes more than 85 % of total aquaculture production in India, Hence, India is known as Carp country. India possesses 2.3 million ha of potential freshwater resources in the form of tanks and ponds, but utilizes only about 40% on the average for carp farming. Carps belong to the family Cyprinidae which is typically a freshwater group with very wide distribution. There are about 1600 species in the family cyprinidae making it the largest family of fish. Despite large number of species of carps only 29 species of carps is cultured globally. There are only six species, three Indian and three Chinese carps which are cultured on a large scale. Together they are called major carps since they grow to relatively large size All cultured major carps are naturally found in large river systems.. They are Catla, Rohu, Mrigala, Silver carp, Grass carp and Common carp. All the major carps grow to about 1m in length. Generally, Chinese carps grow to a larger size than Indian major carps. Under culture conditions they are harvested in their second or third year, often at a weight approaching 2-3 kg. Now days, a wide range of technology is available for seed production and culture of the carps.

### 1.1 The food and feeding habits

The food and feeding habits of major carp species differ from each other which make them suitable for culture under polyculture or composite fish culture system

| Species | Feeding habit |
|---|---|
| Silver carp | Zoo- and phytoplankton, filter feeder, prefers phytoplankton, surface feeder. |
| Grass carp | Omnivorous, prefers higher aquatic plants and submerged grasses |
| Catla | Plankton feeder, prefers zooplankton and surface feeder |
| Rohu | Omnivorous planktophage; predominantly a column feeder |
| Mrigal | Omnivorous, prefers detritus, predominantly a bottom feeder |
| Common carp | Omnivorous, predominantly feeds on benthic worms; a bottom feeder |

### 1.2 **Grow-out culture**

Presently in India carp poly-culture or composite carp culture is practiced by semi-intensive or modified extensive type of system in ponds and pen but rarely in cages and raceways. At some places, Carp culture is integrated with other type of Integrated farming system like Cattle cum fish culture, Poultry cum fish culture, Paddy cum fish culture, horti cum fish culture, etc. The carps are also cultured under mixed farming cultured system incorporating fresh water prawn, cat fishes like magur and singhi, etc.

Poly-culture is thought to have originated in China. Polyculture is farming of two or more compatible species with different feeding habits in the same pond to maximize utilization of all the niches (food and space) of a pond. A concerted experimental effort occurred in India to develop suitable polyculture system using both Indian and Chinese carps. The basic species combination in the Indian composite polyculture system was catla, rohu, mrigal, silver carp, grass carp and common carp. At a stocking density of 5000Nos., / ha (120-250 kg/ha) the yield was nearly 9 MT/ha/yr, when fertilized and provided with simple supplementary feed such as mixture of rice and oil cake. Both in India and China two or three species of either Indian or Chinese carps are polycultured. The dominate species in India is rohu and in China it is silver carp. Whereas, in Andhra Pradesh where only two species of Indian major carps namely rohu and catla are cultured. Rohu is the dominant species in polyculture which is stocked at 80% of the stocking density, catla being stocked at 20%. The pond area often exceed 1ha and the ponds are stocked with 6-12 month old (100-150g) juveniles@ 5000/ha. Ponds are generally fertilized with poultry manure and inorganic fertilizers. They are provided with supplementary feeds such as simple mixture of rice bran and oilcake. Production in Andhra Pradesh averages about 8000 kg/ha with a range of 5300-14620 kg/ha. Fish are harvested when they are more than 1.5 kg in size.

1.3 **Pre-stocking preparation**

Control of aquatic weeds and eradication of predators and pest fishes are one of the important steps for achieving higher production. The ponds should be dried until the bottom soil cracks. Application of lime @ 200-500 kg/ha and ploughing the soil removes obnoxious gases, oxidizes the organic matter in ponds, sterilizes the soils and kills unwanted animals.

After filling the ponds to a depth of 1.5m the ponds should be manured with cow dung @ 3-4 tones/ha as a basal dose 15-20 days before stocking. Alternatively, poultry dropping @ 1.5-2.00 ha/ha can be used. If mahua oil cake is used for eradication of predatory and weed fish the basal dose of organic manure is avoided. 15-20 days after application of manures the ponds are ready for stocking.

The carp culture ponds are stocked with surface, column and bottom feeders at proper ratios to utilize all the pond niches efficiently. 30-40% of surface feeders, 30-35% of column feeders and 30-40% of bottom feeders should be stocked. Grass carp may be stocked if terrestrial grasses or aquatic weeds can be supplied from outside.

The grow–out ponds are stocked with fingerlings of 8-10g after proper acclimatization. A stocking density of 5000 fingerlings/ha is recommended to get a production of 3-5 tonnes/ha/yr. The density could be raised to 8,000 – 10,000 figerlings/ha for achieving production of 5-8 tons/ha/yr. The stocking density depends on the level of management and input use.

1.4 **Post stocking management**

The management of carp, ponds after stocking involves intermittent liming and fertilization, water management and health care.

In average production ponds cow dung is applied @ 500 kg/ha/fortnight, along with 15 kg/ha single superphosphate and 10 kg/ha area. However the dose and frequency of fertilization depends on plankton production and water quality. Other manures such as poultry manure or duck droppings can be used at half the dose of cow dung.

Supplementary feeding is provided to the stocked fish. At high stocking densities natural food produced through fertilization will not be sufficient. Supplementary feeds could be simple mixtures of rice bran and oil cake in a ratio of 1:1. The quality of supplementary feed can be improved by mixing fishmeal and soya bean meal with vitamin and mineral mixture to the simple mixture of rice bran and oil cake. Commercial fish pellets are also available which may give better yields. The carps are fed @ 5% of the body weight for first month which is gradually decreased to 3-2%. The biomass of the fish should be assessed monthly and feed ratio should be adjusted accordingly. The daily ratio is split into two doses and fed in the morning and evening. The mixture is made into dough by adding correct quantity of water and making in to balls.

The balls are kept in feeding trays at different places in the pond. In Andhra Pradesh simple mixtures of rice bran and powdered ground nut oil cake are filled into gunny bags with small holes, which are hung in the ponds on poles at different places. Fish will nibble at the holes and get feed. When grass carp is stocked in the ponds aquatic weeds such as Hydrilla, Ceratophyllum, Najas, duck weeds or tender terrestrial grasses should be provided.

1.5 **Harvesting**

The carps take about 10-12 months to grow to marketable size when fingerlings of 8-10 g are stocked. In this period catla grows to a size of about 1 kg, while, rohu and mrigal attain a size of about 600-750g. Silver carp grows to more than 1 kg while grass carp can grow to a size of 3-5 kg if fed at 100% of its body weight. The fish are usually harvested by large seine nets by repeated dragging. If the ponds are drainable a finally drain harvested in carried out. A production of 3-5 tones/ha/yr can be obtained through scientifically managed semi-intensive culture of carps. Based on the production cycle harvesting may be Single stocking – Single harvest, Single stocking – Multiple harvesting, Multistocking – Multiharvest or rotational type of culture

**1.6 Advances in carp culture**

**A. Incorporation of medium carp species**

The technology of carp farming has evolved with incorporation of compatible medium carp species in the major carp based production system @ 5 – 15 %. This system has shown to increased yield production levels comparable to major based production system. In this system, species like *L. calbasu, L. gonius* and *P. sarana* are incorporated as bottom dwelling components while species like *L. fimbriatus* and *P. gonionotus* used as column feeders.

**Advantages:**

a. Increase in production yield
b. Widen scope for the farmers to diversify species spectrum
c. Initial higher growth of medium carp give opportunity to the farmer to utilize seasonal ponds effectively
d. Medium carps are marketed at smaller size (250 – 300 gm)
e. In perennial ponds, medium carps can be harvested after 5-6 months of the culture allowing major carps to grow further
f. Two crops of medium carps are possible along with major carp crop by restocking after five to six months

**B. Weed based carp culture**

Another system has been evolved for control of growth of aquatic weed and to utilize weed infested water is known as "Weed based system of carp culture". In this system grass carp is the main component introduced at the level of 40 to 50 % of total stock. Grass carp is voracious feeder for submerged vegetation. Fecal matter of fish contains partially digested organic matter which acts as a rich fertilizer besides being used as feed for other carps especially common carp. Main feature of this system is carps can be grown well without provision of supplementary feed. Weed based carp culture 3 – 4 tonnes of carp production is possible if stocked @ 5000 fingerlings/ ha saving cost of fish feed.

**C. Use of biofilm and periphyton production for carp culture**

Low cost technology has been developed for enhancing growth of carp through use of sugarcane bagasse as a plant substrate for bacterial biofilm production. Bagasse are suspended in water with supplementation of fertilizers. Bagasse supplemented with cattle dung and urea is found to favor the production of zooplankton and increased production of fish by 50 %. This high production of fish is attributed due to bacterial biofilm promoted on surface which apart from providing food for zooplankton and fish, contributed to improved water quality by reduction of ammonia.

As like biofilm production, periphyton can also be grown on vertical bamboo poles approximately submerged surface area equal to the pond surface area for enhancing growth of carps. Periphyton produced on bamboo poles contains several algal, zooplankton and some microbenthic species.

**D. Intensive carp culture**

Intensive aquaculture relies on technology to raise fish in artificial tanks at very high densities. In this system water quality parameters (temperature levels, oxygen levels, Ammonia, etc), stocking densities, and feed are set at the optimal level to promote growth, reduce stress, control disease, and reduce mortality. Due to the complete control of these factors, intensive aquaculture produces high yields. Intensive aquaculture has a very high start up cost and requires much labor and currently, only rich countries have developed this into a profitable business.

Although intensive aquaculture is completely mechanized and self-contained it can have a detrimental impact on the environment. The biggest problem caused by intensive aquaculture is the difficulty in properly dealing with the nutrient rich effluent. Effluent contains high levels of both organic and inorganic nutrients like ammonia, phosphorus, dissolved organic carbon, dissolved organic nitrogen and dissolved organic phosphorus. If not disposed of correctly the effluent could cause a number of problems including eutrophication, and hypernutrification.

There are many solutions have been developed to reduce the negative effects to the environmental caused by this effluent. The most effective solution is the use of aquaponics. Aquaponics is the combination of intensive aquaculture (fish farming) and hydroponics (growing plants without soil) . Aquaponic systems use the nutrient rich effluent from fish tanks as fertilizers for produce. The advent of aquaponics has made the aquaculture industry into a sustainable and eco-friendly business.

Recirculation aquaculture systems (RAS) represent a new and unique way to farm fish. Instead of the traditional method of growing fish outdoors in open ponds and raceways, this system rears fish at high densities, in indoor tanks with a "controlled" environment. Recirculating systems filter and clean the water for recycling back through fish culture tanks.

Fish grown in RAS must be supplied with all the conditions necessary to remain healthy and grow. They need a continuous supply of clean water at a temperature and dissolved oxygen content that is optimum for growth. A filtering (biofilter) system is necessary to purify the water and remove or detoxify harmful waste products and uneaten feed. The fish must be fed a nutritionally-complete feed on a daily basis to encourage fast growth and high survival.

2. **Culture of Magur (*Clarias batrachus*)**

Indian Magur (*Clarias batrachus*) is the most popular catfish owing to its good taste and texture. Being an air breathing fish, it can survive in poor water quality conditions and can be cultured at very high stocking densities. This fish can be sold live and hence fetches higher price than carps. The techniques for breeding, seed production and grow out culture of Indian magur have been standardized. A few farmers have already adopted these techniques in different parts of the country.

Grow out culture is carried out in earthen or stone pitched ponds. Since magur may migrate out during rainy season, fencing should be provided around the ponds. Culture ponds of 0.1 to 0.2 ha are normally used for culture where good quality fingerlings are stocked density @ 50,000 – 70,000 /ha. The ponds are fertilized in a similar manner as carp ponds. The fish are fed mixtures of groundnut oil cake, rice bran, and fish meal/trash fish @ 3-5% biomass in the form of dough placed in baskets or in pellet form at different places in the pond. The feed should contain 30-35% protein. Ponds should be covered with nets to protect them from predation by birds. Broken pipes or tiles are provided as shelters to reduce cannibalism. Water loss through evaporation should be compensated periodically. Magur attains marketable size of 100-120g in 7-8 months. Harvesting by netting is difficult, hence ponds needs to be drained and fish handpicked. Average production of magur from this system is 3-4 tones/ha/7-8 months.

3. **Culture of stinging catfish (*Heteropneustis fossilis*)**

   *Heteropneustis fossilis* commonly known as singhi has a good potential as aquaculture candidates. This is an air breathing fish which can thrive well in shallow derelict water bodies with poor water quality. Singhi can be grown in monoculture or poly culture with carps and magur. It is stocked in well prepared ponds and fed with compounded diets or slaughter house waste/trash fish, silkworm pupae. Its production potential has been estimated to be 4-15 tons/ha in 4-12 months culture. Other culture practices are same as culture of magur *(Clarias batrachus)*.

4. **Culture of murrel**

   The snake-head or murrels are a group of air-breathing fishes which by virtue of the presence of accessory respiratory organ, can thrive well in fallow derelict swampy waters normally considered as adverse low oxygen environments condition. Generally, Murrel inhabits in ponds, streams and rivers, preferring stagnant and muddy water of plains at 1 to 2 m water depth. Murrel feeds on fish, frogs, snakes, insects, earthworms, tadpoles and crustaceans. It undertakes lateral migrations or other permanent water bodies, to flooded areas during the flood season and returns to the permanent water bodies at the onset of the dry season. Three species of murrel viz Giant murrel (*Channa marulius*), Stripped murrel (*C. straitus*) and Spotted murrel (*C. punctatus*).

   Earthen ponds or ponds with cement pasted at the sides filled with clay at the bottom (25 cm) are used for culture with maximum depth of water 4 ft. Stocking density of fingerlings of equal size (8 cm-10 cm; 5.8-12.0 g weight) is carried out @ 12,000-15000/ha in month of September to November. Fingerlings are fed with boiled chicken intestine @ 5-10% body weight depending upon biomass, average body weight, environmental condition and health status. Water is supplied from a bore well daily to adjust the water loss due to seepage and evaporation. Water is completely removed once in 3-4 months and murrels are observed for disease and deformities. By careful observation only healthy individuals are released back in to ponds. After 8 months culture period the murrels reach a maximum weight of 800-900g with 90-95% survival.

5. **Culture of Pangas**

   *Pangasius pangasius* (Pangas) is the only genus found in Indian water bodies This fish is mainly estuarine habitant, displaying long migration from estuarine to upper stretches of river. Pangas is hardy species can withstand wide fluctuations of temperature, salinity and turbidity. It feeds on offals, gastropods, lamellibranchs, insects, plankton and even vegetable matter. Because of the preference towards molluscans, exercises biological control over many helminthes causing infestations and diseases; for which molluscans are known vectors.

   Pangas is seasonal spawner. It performs long migration in rivers. Spawning season June to August but sometimes may breeds early in the monsoon. Preferably breeds in flooded river and inundated areas as well as rocky belt of river. The larvae and fry washed off to downstream of tidal zone and spends few year there. After maturing, again migrate to fresh water for spawning.

As it is hardy species and withstands low oxygen level, it is suitable for culture in sewage fed ponds and low line fellow waters. Preliminary experiments indicated possibilities for culture of pangas with IMC, where the fish is compatible with major carp and does not adversely affect the growth at very low rate of stocking. In composite fish culture, pangas is stocked to control molluscans (Vectors). Apart from natural food, it accepts well compound pelleted feed. It grows swiftly at early stage in nature as well as in ponds. This cat fish attains 1 – 1.3 kg in second year and 3-4 kg during third year.

*Pangasius sutchi* (Sutchi catfish) is one of the fast growing catfishes under Pangasidae family is widely cultured in Asian countries. Vietnam is larger producer of fish supplying Sutchi cat fish and its fillet to European market. Sutchi catfish entered in India through Bangladesh in mid 90's. As shrimp farming activity in Andhra Pradesh is affected due to disease, many farmers diverted their farming towards this cat fish. About 17,000 ha in Andhra Pradesh is under the culture of this fish. This fish grows to 1 – 1.5 kg during one year with minimum 10 -15 tonnes / ha production. As this fish can tolerate higher density and production, the farmers are lured for higher production. Many agriculture farmers find this fish as suitable for Agriculture based farmed ponds both earthen and polythene lined.

6. **Culture of Tilapia (Aquatic chicken)**

Tilapia belongs to the family Cichlidae under order Perciformes. The tilapias have recently been classified into three genera, based on parental incubation of eggs. The species of the genera Sarotherodon and Oreochromis are mouth brooders, while Tilapia incubates eggs in a lake or pond bottom built-in "nest". There are about 70 species of tilapias, of which nine species are used in aquaculture worldwide. Important commercial species include: the Mozambique tilapia (*Oreochromis mossambicus*), blue tilapia (*O. aureus*), Nile tilapia *(O. niloticus*), Zanzibar tilapia (*O. hornorum*), and the red belly tilapia *(O. zilli*).

In India, tilapia (*Oreochromis mossambicus*) was introduced in 1952, with a view to filling up unoccupied niches, such as ponds and reservoirs. The species spread all across the country within a few years due to its prolific breeding and adaptability to wide range of environmental condition. Overpopulation of the species affected the fisheries of several reservoirs and lakes. Introduction of *O. mossambicus* not only resulted in reduction of average weight of major carps, but also posed threat to species like mahseers (*Tor tor* and *T. putitora*), which are on the verge of extinction. Therefore, The Fisheries Research Committee of India imposed ban on tilapia propagation in 1959.

During late 1970s, Nile tilapia was introduced to India. In 2005, River Yamuna harboured only negligible quantity of Nile tilapia, but in two years time, its proportion has increased to about 3.5% of total fish species in the river. Presently in the Ganges River system, proportion of tilapia is about 7% of the total fish species.

However, tilapia holds vast promise to become an important species for aquaculture in India, considering the demand for more fish. Some private organizations has successfully cultured and marketed some varieties of tilapia, and reported neither escapes to natural water bodies nor any ecological threats. In the Kolkata Wetlands, some farmers are producing mono sex tilapia on commercial scale in waste water.

As the demand for fish is increasing, diversification of species in aquaculture by including more species for increasing production levels has become necessary. Introduction of tilapia in our culture systems is advantageous because it represents lower level in food chain, and thus its culture will be economical and eco-friendly. Mono sex culture of tilapia is advantageous because of faster growth and larger and more uniform size of males. The development of Genetically Improved Tilapia (GIFT) technology is based on traditional selective breeding and is meant to improve commercially important traits of tropical farmed fish which is a major milestone in the history of tilapia aquaculture. Other varieties like ‘red tilapia’ also hold promise. There is high potential of export of tilapia to US, Europe and Japan.

In populations of tilapia, males grow faster and are more uniform in size than females. For this reason, the farming of monosex populations of tilapias which achieved either by manual sexing, direct hormonal sex reversal, hybridization or genetic manipulation, has been reported as solutions to the problem of early sexual maturation and unwanted reproduction.

Manual sexing which entails elimination of females based on sexual dimorphism observed in the urogenital papilla, is simple but is time consuming, requires qualified personnel and usually results in 3-10% errors. Hybridization between different species did not effectively solve the problem of unwanted reproduction mainly due to difficulty in sustaining production of all-male hybrids. *O. hornorum* is the only known species which consistently produces all male fry when crossed with *O. niloticus* or *O. mossambicus*. The main problem is the maintenance of the pure lines. Hormonal sex reversal involves the addition of steroids in feeds for a short period during the fry stage. In this method, fry can be collected at the yolk sac or first feeding stages, no later than one week after released from the female, and fed with feed containing the sex reversal hormone. Production of ‘supermales’ through genetic manipulation ia the solution for ensuring production of 100% male.

Cage culture of tilapia avoids problems with over breeding because eggs fall through the cage meshes. The fish derive most of their nutrition from the surrounding water; however they may also be fed supplementary feeds. Typical stocking rates at harvest are 10 kg/m3maximum. Average production levels are variable in different systems and countries. Under intensified cage culture production levels of 100-305 kg/m3 are reported.

The main advantage of tilapia culture in ponds is that fish can be grown very cheaply through fertilization. Many different types of ponds are used for tilapia culture. The most widespread, but most unproductive are low input ponds with uncontrolled breeding and irregular harvesting; yields are typically 500-2000 kg/ha/yr of uneven sized fish. If monosex fish are stocked and regular manuring and supplementary feeding is practiced yields can be up to 8000 kg/ha/yr of even sized fish. Polyculture of tilapia with other native fishes in freshwater ponds is also widely integrated with agriculture and animal farming.

Intensive tank culture avoids problems with overbreeding because there is no space for males to set up territories. It requires a constant supply of water, either gravity fed or pumped. Usual maximum stocking rates in tanks where the water is changed every 1-2 hours would be around at 25-50 kg/m3.

**References:**


Azad, I. S., K.M. Shankar and C. V. Mohan. 1997. Evaluation of *Aeromonas hydrophila* biofilm oral vaccine of carp, p. 181-186. In H. Flegel and Ian Mac Rae (eds.) Diseases in Asian Aquaculture III. Fish health section, Asian Fisheries society, Manila, Philippines.

Shankar K.M., C. V. Mohan and Nandeesha M. C, 1998. Promotion of substrate based Microbial Biofilm in Ponds- a low cost technology to boost Fish Production, Naga, . p. 18-22.The ICLARM Quarterly.

M. A. Wahab, M. E. Azim, M. H. Ali, ,M. C. M. Beveridge, and S. Khan ,1999, The potential of periphyton-based culture of the native major carp calbaush, *Labeo calbasu* (Hamilton), Aquaculture Research, Volume 30, Issue 6, pages 409–419

Azim, M.E., Wahab, M.A., van Dam, A.A., Beveridge, M.C.M., Verdegem, M.C.J., (2001). The potential of periphyton-based culture of two Indian major carps, rohu Labeo rohita (Hamilton) and gonia Labeo gonius (Linnaeus). In: Aquac. Res. 32, 209-216.

P. Keshavanath, T.J. Ramesh, B. Gangadhar, M.C.M. Beveridge, A.A. Van dam, P.A. Sandifer, 2001, On-Farm Evaluation of Indian Major Carp Production with Sugarcane Bagasse as Substrate for Periphyton, Asian Fisheries Society, Volume : 14, Issue : 4, Page : 367-376

Pada Anak Bijo, 2007 Feasibility Study Of A Recirculation Aquaculture System, UNU – Fisheries Training Programme

Republic of the Philippines Department of Agriculture , Bureau of Fisheries and Aquatic Resources, 2008, Culture of Pangasius spp., p. 1-6.

Handbook of Fisheries and Aquaculture II edition (2011), Indian Council of Agricultural Research, New Delhi.

Guidelines for responsible farming of tilapia, dahd.nic.in/dahd/WriteReadData/Tilapia_policy_guideline

http://ecourses.iasri.res.in

Commercial Murrel Culture, http://www.scienceandsociety-dst.org/Murrel.PDF

# Importance of Artificial Feed in Aquaculture

V. B. Sutar
Assistant Professor, Dept. of Fisheries Hydrography.
College of Fishery Science, Udgir, Dist. Latur.

**Introduction**

Over the last decade, spectacular growth has taken place in aquaculture. Most production in developing countries is realized from open-water extensive, improved extensive and semi-intensive practices using poly culture farming technologies. In contrast, the bulk of high-value freshwater and marine carnivorous finfish in developed countries is produced by intensive farming systems using high-cost nutrient inputs in the form of "nutritionally-complete formulated diets".

It is undeniably agreed that global aquaculture production will continue to increase, and much of the increased production in developing countries achieved through the growth of semi-intensive, small-scale pond aquaculture. Nutrition and feeding will play an important role in the sustained development of this aquaculture. Therefore, it is crucial that fertilizers and feed resources continue to be produced and advanced. Sustained development of aquaculture, however, must take into account and ensure that the needs of competing users are met, and that environmental integrity is protected. Therefore, sustainable aquaculture management should address provision of inputs based on local circumstances, and balance maximizing profitability with social and environmental costs.

Feed cost is considered to be the highest recurrent cost in aquaculture, often ranging from 30% to 60%, depending on the intensity of the operation. Any reduction in feed costs either through diet development, improved husbandry or other direct or indirect means is therefore crucial to the development and well being of the industry. Importance has been given to simple feed formulations, utilization of non - conventional feedstuffs and feed processing. In this regard the aspects related to feeds and feeding which are increasingly becoming important to the aquaculture industry, in particular feeds and feeding in relation to the environment and the aquafeed industry.

Some of the major issues in the fields of aquatic animal nutrition and feeding that are critical for sustainable aquaculture production in both industrialized and developing countries are:

- availability and cost of feed resources and development of aqua feeds;
- increasing competition for resources with other users (e.g. agriculture and livestock industries);
- forecasting of local and global market supply and demand; and
- maintenance of environmental quality and sustainability of aquaculture systems.

Aquaculture development is also confronted with the choice between using established culture of herbivorous/omnivorous species under extensive or semi-intensive systems or developing more intensive systems to meet increasing production demands. Similarly, issues and conflicts, such as the demand for food verses availability of marine resources, productivity verses environmental quality, and choice of species verses biodiversity, warrant critical examination.

For many years water quality has been the most important limitation to fish production. Advances in life support technology have been substantial in recent years, and nutrition is increasingly regarded a key limitation to increased production efficiency as well as the growth and propagation of "new" species. Feeding of artificial diet balanced in all nutrients has assumed foremost importance in aquaculture industry. Artificial feeding is an essential practice in an aquaculture operation accounting for over 60% in total input cost.

**Nutritional composition of fish diets**

Generally, fish diets tend to be very high in protein. Foods for fry and fingerlings frequently exceed 50% crude protein. As growth rate decreases and fish age, protein levels in diets are decreased accordingly. Protein levels on grow-out diets often approach or exceed 40% crude protein, while maintenance diets may contain as little as 25-35%. In addition to decreasing the protein content of the food as fish grow, the particle size must also be changed. Many fish require live food when they are hatched because their mouth parts are so small. Some fish are large enough to place on a fry diet immediately without having to bother with the expense and labour needed for live foods.

Fish meal should be a major protein source in fish diets. There are essential amino and fatty acids that are present in fish meal but not present in tissue from terrestrial plants or animals. Low cost formulations in which fish meal has been eliminated and replaced by less expensive proteins from plant sources i.e. soybeans are not recommended for fish. Fish meal and fishery by-products have high lipid content and therefore rancidity can be a problem if foods are not properly stored.

In addition to the concern for essential amino acids that may be present in fish meal, fish require long chain fatty acids (C20 and C22) that are not found in tissue from terrestrial organisms. Fish meal, shrimp meal and various types of fishery by-products are the source for these essential fatty acids. In addition, crustacean by-products serve as a source of carotenoid pigments that are excellent for colour enhancement. There is a high oil content associated with carotenoid pigments, so vitamin E supplementation is recommended when these are used.

Most fish require dietary ascorbic acid (vitamin C). This becomes very important if fish are reared in a poorly lit area where algae cannot grow, or if they are so crowded that they cannot consume any natural food items that might be in the water. Ascorbic acid added to fish foods should be phoshorylated to stabilize the vitamin and increase storage time. In addition, vitamins A, D, E and B complex should be added to fish foods. The concentration of vitamin E is often inadequate, especially in diets that are high in fat. If fish are housed in natural systems with algae and phytoplankton, and stocking rates are not too great, then vitamin supplementation seems to be less important, presumably because of the availability of natural food items.

**Feed storage**

Because fish feeds usually contain relatively high amounts of fish meal and/or fish oil, they are very susceptible to rancidity. In addition, ascorbic acid is highly volatile, but critical to normal growth and development of most species of fish. For these reasons, fish feeds should be purchased frequently, ideally at least once a month and more frequently if possible. Feeds should be stored in a cool, dry place and should never be kept on hand for more than three months. Refrigeration of dry feeds is not recommended because of the high moisture content of that environment. Freezing is an acceptable way of extending the shelf life.

**Types of feed**

Commercially milled fish foods are usually sold as dry or semi-moist pellets or as flakes. Pellets are typically the most complete diets. They are cooked, and, if marketed as a complete ration, the nutrition in each particle should be uniform. Disadvantages include the potential for rapid sinking unless the pellet is extruded. In addition, the pellet size is very important. It may be impossible to manufacture a particle small enough for some fish, especially juveniles of many species. For larger animals, a very small pellet may be unacceptable. Semi-moist diets are soft and compact. Many of these are expensive, but they tend to be high quality diets and may be an excellent choice for some species.

Flakes have been used extensively in the ornamental fish industry for many years and have the advantage of being soft enough for very small fish to consume. They also sink very slowly. Unfortunately, the volume required to meet the nutritional needs of the animals may be deceptively high.

Technology associated with rearing of live foods is improving rapidly. This is having a positive impact on larval rearing, a frequent bottleneck for commercialization of "new" species. Rotifers are the smallest live food that is routinely used for larval rearing. Newly hatched brine shrimp are larger, but still quite small, and are commonly used in fish hatcheries. Cultured live foods can provide a source of high quality nutrition, but care must be taken to avoid perpetuation of infectious disease. Use of wild caught food items is also risky because of the potential for disease introduction.

**Management of feeding**

Proper management of feeding in aquaculture practice is important for resulting in maximum yield, feed utilization 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 of fish, 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.

**Nutritional diseases**

Nutritional disease is often a diagnosis of exclusion. Other explanations for the problem are ruled out and then the feeding program is critically evaluated. Several examples of nutritional disease merit mention. These include starvation, scoliosis and nutritional anemia. Each is discussed briefly below.

Starvation is usually the result of poor husbandry and, in many cases, is a sequel to environmental problems. A poorly designed or maintained system is likely to develop water quality problems with related morbidity or mortality among the fish. In an effort to correct the water quality problems aquarists may cut back on feed to the point where the animals are in a negative caloric balance and begin to lose weight. If the problem becomes chronic, starvation can result.

The classical cause of scoliosis, or "broken back disease" in fish is ascorbic acid deficiency. Improvements in feed manufacture, including phosphorylation of vitamin C, and feed storage, have decreased the incidence of nutritionally derived scoliosis. Still, ascorbic acid deficiency must be considered as a possible cause of scoliosis and a thorough review of feeding practices is warranted when evaluating such cases.

Nutritional anemia is caused by folic acid deficiency. The diagnosis is often based initially on history, with multiple units developing similar signs at the same time. When suspected, a sample of feed should be frozen for later analysis, but all affected ponds should have the feed changed immediately to a fresh lot. The problem is caused by bacterial contamination of feed, so it is not related to particular brands or formulations.

**Conclusion**

Feed preparation must be done on logical approach for simple formulations that should be location specific and resource oriented using a large proportion of alternative protein sources with due consideration for less expensive feeds to support sustainable and economically sound aquaculture. Establishment of regional feed centres should be given due priority to understand and identify farmers' feed related problems for their development that may go a long way to village level production of improved farm made feeds through small feed mills, particularly by small farmers who account for more than 80% in India.

**References**


De Silva, S.S. and Anderson, T.A. 1998. In: Fish Nutrition in Aquaculture, London, UK, 287 pp.

Lovell, T. 1988. *Nutrition and Feeding of Fish*. Van Nostrand Reinhold, New York, NY 260 pp.

Roberts, R.J. 1989. Nutritional pathology of teleosts, In: *Fish Pathology*, R.J. Roberts (Ed), Balliere-Tindall, London Pp. 337-362.

Winfree, R.A. 1992. Nutrition and feeding of tropical fish, IN*: Aquariology: The Science ofFish Health Management*. J.B. Gratzek (ED).Tetra Press, Morris Plains, NJ Pp. 197-206.

# Common Diseases of Freshwater Fishes and Their Treatment

Dr Gaurav Rathore, Principal Scientist,
Aquatic Environment and Health Management Division,
Central Institute of Fisheries Education, Mumbai.

Fish diseases may cause severe losses on fish farms through reduced fish growth and death of fish. It leads to increased feeding cost caused by lack of appetite and waste of uneaten feed. Affected fish become vulnerable to predation and are more susceptibility to poor water quality. Most of the common diseases of freshwater fish are caused by bacteria and parasites.

**Bacterial Diseases**

**Motile *Aeromonas* septicaemia (MAS)**

MAS is a common infection of motile aero monad in mainly freshwater fish. Motile aeromonads generally comprises of *A. hydrophila, A. sobria*and *A. caviae***.** Of these *A. hydrophila* is of great importance for carp culture. *A. hydrophila* is a Gram-negative aerobic bacilli characterized by active motility. Motile aero monads are often ubiquitous in the freshwater aquatic ecosystem, but become more abundant in waters with a high organic load. As a result the fish are constantly exposed to infection. Disease outbreaks are common when fish are under stress from crowding, low oxygen, high temperatures, etc., and significant losses from such outbreaks can occur. Pathologic conditions attributed to members of the motile aeromonad complex may include dermal ulceration, tail or fin rot, ocular ulcerations, erythrodermatitis, hemorrhagic septicemia, red sore disease, red rot disease, and scale protrusion disease. Chronic motile aeromonad infections manifest themselves primarily as ulcerous forms of disease, in which dermal lesions with focal hemorrhage and inflammation are apparent. Skin lesions begin as small hemorrhages within scale pockets that can rapidly expand to larger areas. Affected scales are eventually lost and ulcers form. Aeromonas infection may also include any or all of the following external signs: exophthalmia(popeye), abdominal distention(swelling of the abdomen), and pale gills. Scaled fish often accumulate edema (fluid) in their scale pockets. This condition, called lepidorthosis, creates a roughenedor bristled appearance.

**Columnaris disease**

Columnaris disease is a common bacterial infection caused by *Flavobacterium columnare* that affects the skin or gills of freshwater fish. This pathogen has a worldwide distribution and can probably infect most freshwater fish and cause large mortalities. Disease risk factors include physical stress, low oxygen, organic pollution, hard water, increased temperature and high nitrite. Columnar is is primarily an epithelial disease. It causes erosive/necrotic skin and gill lesions that may become systemic. It is often present as whitish patch with a red periphery on the head and back (saddleback lesion) along with fin rot, especially the caudal fin. The epithelium of fin rays may slough, leaving a ragged appearance. Lesions can rapidly progress to ulcers, which may be yellow or orange due to masses of pigmented bacteria. Ulcerations spread by radial expansion and may penetrate into deeper tissues, producing abacteremia. Gill infections are less common but more serious. Columnar is begins at the tips of the lamellae and causes a progressive necrosis that may extend to the base of the gill arch. Disease diagnosis can be done by wet mounts of affected fins/gills or isolation of causative agent on cytophaga agar.

**Enteric septicemia of catfish (ESC)**

ESC is one of the most important bacterial diseases that affect catfish including *Pangassius* spp.ESC is caused by *Edwardsiella ictaluri*, and is generally a seasonal disease, with outbreaks occurring when water temperatures are around 24 – 28 ° C during the day, which is optimum for the bacterium's growth.ESC is seen in two forms, depending on mode of transmission:

***Acute (septicemic) form:*** In this form, bacteria are ingested through gut enter the bloodstream and colonize internal organs, causing necrosis and acute mortality. Clinically affected fish may sometimes hang head up in the water and exhibit corkscrew spiral swimming, usually followed by death. Abdominal distension, exophthalmos, or pale gills and hemorrhages in the muscles are also seen. Small (1 – 3 mm), de-pigmented foci known as petechiae are seen on the dorsum, flanks, jaw and operculum. Internally, the peritoneal cavity contains bloody or clear fluid, hemorrhage and necrosis of the liver, and splenic and renal hypertrophy.

***Chronic (encephalitic) form:*** In the nervous route, bacteria invade the olfactory organ via the nasalopening and migrate up the olfactory nerve to the brain, where the infection spreads from the meningesto the skull and finally to the skin, forming the hole - in - the - head lesion. This is a raised or open ulcer on the frontal bone of the skull.

***Edwardsiella tarda* Infection or Edwardsiellosis**

It is an economically important bacterial disease affecting large number of freshwater fish species.It is mostly associated with high water temperatures and organic pollution. *E. tarda* is also an uncommon zoonotic pathogen,mainly causing enteric disease in humans. Fish affected by edwardsiellosis shows signs of spiraling movement and die with the mouth agape and opercula flared which may be due to the development of anaemia leading to oxygen insufficiency. The fish reveal gross lesions on the skin, pale gills, tumefaction of the eye, excessive mucus secretion, scale erosion and ulcers in a few cases. Swelling and bleeding of the anus leading to reddening is oftennoticed.In mild infections, the only manifestation of the disease is small cutaneous lesions (3–5 mm in diameter) located on the postero-lateral parts of the body. As the disease progresses, abscesses develop within the muscles of the flanks or caudal peduncle. These abscesses rapidly increase in size and develop into large cavities filled with gas and, in the acute stage, are visible as convex, swollen areas. Loss of pigmentation over the lesions is common. If the lesion is incised, a foul odour is emitted. Necrotic tissue remnants may fill up to one third of the cavity. As the infection progresses, affected fish lose control over the posterior half of the body (Mohanty B R and Sahoo, 2007). The name 'emphysematous putrefactive disease of catfish' (EPDC) has been aptly chosen since it describes the gross appearance of infected fish.

**Epizootic ulcerative syndrome**

Epizootic ulcerative syndrome (EUS) is a seasonal epizootic condition of great importance in wild and farmed freshwater and estuarine fish.

- Cause- Oomycete *Aphanomyces invadans*

- Over 50 species of fish affected by EUS, but tilapia, milk fish and Chinese carp are resistant.
- EUS occurs mostly during periods of low temperatures and after periods of heavy rainfall. These conditions favors sporulation of *Aphanomycesinvadans*, and low temperatures have been shown to delay the inflammatory response of fish to fungal infection.
- Early signs of the disease - loss of appetite, fish become darker. Infected fish may float below the surface of the water, and become hyperactive with a very jerky pattern of movement. Red spots may be observed on the body surface, head, operculum or caudal peduncle. Large red or grey shallow ulcers, often with a brown necrosis, are observed in the later stages. Large superficial lesions occur on the flank or dorsum. In highly susceptible species, such as snakehead, the lesions are more extensive and can lead to complete erosion of the posterior part of the body.
- Control of EUS in natural waters is probably impossible. In outbreaks occurring in small, closed water-bodies, liming water and improving water quality, together with removal of infected fish, is often effective in reducing mortalities.

**Common Antibiotics used in treatment of bacterial fish diseases**

- **Florfenical:** Dose**-** 10 mg/kg of body weight/day for 10 days in feed. Withdrawal period: 12-15 days.
- **Oxytetracycline:** Feed: 75 mg/kg of body weight/day for 10 days. Withdrawal period-21days
- **Oxolinic acid:** Feed: 10 mg/kg of body weight/day for 10 days.
- **Sulfadiazine - Trimethoprim or Romet:** Feed: 50 mg/kg of body weight/day for 5 days.

**Parasitic Diseases**

- **Ichthyophthiriosis (Ich Infection caused by *Ichthyophthiriusmultifiliis*):** Ich is one of the most common diseases of freshwater fish. Virtually all freshwater fish are susceptible to infection and up to 100% mortality may occur. Ichtrophozoite feeds in a nodule formed in the skin or gill epithelium and affected fish shows white nodules. The disease can be easily diagnosed by the presence of a ciliate encysted within the host's epithelium in the wet mounts. Formalin prolonged immersion (25 ppm) is usually effective; three treatments on alternate days. For pond fish, the treatment of choice for ich is copper sulfate.
- **Trichodinosis:** Trichodinosis is a protozoan infection caused by *Trichodina* species. It is usually a mild disease with chronic morbidity or mortality. Trichodinids mainly inhabit the gill or skin surface of the fish. Heavily infested fish are anorexic, lose condition, and usually experience low - level (1% per week) mortality. Trichodinids exhibit a characteristic circling motion on tissue surfaces in wet mounts. Formalin is effective drug for treatment.
- **Lerneaor Anchor worm Infestation:**Lernea are highly modified copepods that possess anchor - like processes for securing themselves to the host. The copepod attaches to a fish, mates, and the male dies. The female then penetrates under the skin of the fish and differentiates into an adult. Heavy infections can lead to debilitation and secondary

bacterial or water mold infection. Diagnosis of copepod infestation/infection is based on identification of typical parasitic life stages on fish. Organophosphate treatment is usually effective; prolonged immersion treatment should be repeated every 7 days for 28 days. Treating with potassium permanganate after removal of adults can be curative. In other countries, Organophosphate (trichlorphon or dichlorvos) baths have been commonly used. Insect growth regulators (diflubenzuron, and enamectin) and pyrethroids are also used. Currently, the most popular drug is enamectin.

- **Argulus Infestation or Fish Lice:**Argulus is an important genus of branchiuran crustaceans. They cause focal red lesions on skin and focal color change (especially darkening) on skin of affected fish. Parasites feed by inserting their stylet into the host and sucking body fluids with the proboscis like mouth. Fish can display violent erratic swimming or other behavioral abnormalities because of the irritation caused by the stylet. Diagnosis is easily made by morphological identification of the parasite. Branchiurans are differentiated from copepods by having suckers and large compound eyes. Organophosphates are usually an effective treatment. Adult fish lice continue to molt, making them susceptible to chitin synthesis inhibitors, such as diflubenzuron (0.025-0.05 ppm).

**Common Chemicals used in treatment of fish diseases**

- **Copper sulphate:** Can be used as herbicide, moluscicide, and for treatment of external protozoa and external fungi. Used when the pond water alkalinity is in range of 50-250ppm. Drug dose (ppm) is pond alkalinity/100 for prolonged immersion. In low alkalinity, even low doses of copper sulphate are toxic to fish. It causes oxygen depletion due to its herbicide effect.
- **Potassium Permanganate:** Used for treatment of external protozoa and bacteria, but has limited effect on external fungi. Dose: 2ppm for prolonged immersion and 5-10ppm for short term bath (upto 30 minutes). It causes oxygen depletion due to its effect on phytoplanktons.
- **Formalin:** Used for treatment of external protozoa and external fungi. It does not have effect on crustacean parasites. Dose: 25ppm for prolonged immersion and 50-100ppm for short term bath (upto 30 minutes). It causes oxygen depletion due to its effect on phytoplanktons.

**References**

1. Austin B & DA Austin (2007). Bacterial Fish Pathogens: Disease in Farmed and Wild Fish 4th eds. Springer Praxis , New York , 552 p,1- 552 p.
2. Noga, Edward J. (2010). Fish disease: Diagnosis and treatment / Second Edition Edward J. Noga.—2nd ed. pp 1- 538.
3. Mohanty B R and Sahoo P K (2007). Edwardsiellosis in fish: a brief review; J. Biosci. 32; 1331–1344.
4. Tekedar H.C., Waldbieser G. C., Karsi A., Liles M. R., Griffin M. J., Vamenta S., Sonstegard T., Hossain M., Schroeder S. G., Khoo L and Lawrence M. L. (2013). Complete Genome Sequence of a Channel Catfish Epidemic Isolate, *Aeromonas hydrophila* Strain ML09-119. Genome Announc. 1(5):e00755-13. doi:10.1128/genomeA.00755-13.

# Breeding and Seed Production Of Magur

S. R. Yadav
Assistant Professor, Dept. of Aquaculture
College of Fishery Science, Udgir, Dist. Latur.

*Clarias batrachus* commonly known as Magur found in derelict water bodies, swamps and other shallow fresh water bodies of India and other Asian countries. Magur fish is hardy nature and can tolerate low dissolved oxygen concentration because of presence of accessory respiratory organ for aerial respiration. This fish is becoming popular among the fish culturist because of high consumer preference, can be cultured in shallow water bodies in adverse conditions, sold in live condition in market, required less culture period, tasty with high meat portion, and having medicinal properties. Even though there are some constrains encountered in magur farming are lack of hatchery produced as well as natural seed, male has to be sacrifice for seed production, low fecundity and problems in larval rearing and lack of proper feed for grow-out purpose.

This species have clear sexual dimorphic characteristics and can be differentiated by shape of muscular papilla at vent region. Males have pointed and elongated papilla while females with round button shaped papilla. After one year age, they become sexually mature and spawn once in a year. The fecundity is reported in range of 3000-7000 depending on size of female.

Maintenance of proper brood stock is pre-requisite for successful seed production in captivity. Brood stock is stoked @ 2-3 fishes /$m^2$ in specially prepared cement tanks (12m X 5m X 1M) or earthen pond of 200-500 sq.m. In cement tanks, a soil base of 5-10 cm thickness is provided in the tank. Out let is provided at 0.5 m from below with continuous water flow of 2 liters/minute from top In earthen ponds water level is maintain at one meter and water exchanged @ 20-30 % monthly intervals to ensure conductive environment. Proper nutrition is another important thing in brood stock management since gonadal growth is depends upon good protein diet and hygienic condition. A mixture of fish meal, ground nut oil cake, soyabean meal and rice bran with vitamins and minerals, resulting in 30% protein levelis fed to the brood fishes @ 2-3 % of the body weight daily in split two doses.

Magur usually breeds during monsoon season during June-August. Selection of brood fish for breeding operations based on the visual operation of bulged belly and oozing ova on little pressure. The selected spawners are transferred to large plastic trough. Males are generally selected ensuring age and well developed vascular papilla since they do not spermiate on applying pressure as like carp. They either bred through hormone administration or environmental manipulation.

The species can be bred by providing congeal environment either in the pond itself or stimulating condition of paddy field in the cement cisterns. Specially designed ponds of 0.04 -0.10 ha are prepared with several pits at the bottom (15-25 cm deep) to be used as nests by fishes. A continuous trench of 50 cm dug-out along the margin of the pond. Brood fishes are released in the trench during December-January and fed with mixture of fish meal, ground nut oil cake, soyabean meal, rice bran at 2-3 % of body weight. During this period, the pond bottom is kept exposed and paddy is grown there. During monsoon (June-July), pond bottom is inundated with rain and water level is maintained at 25 cm. The brood fish moves in pair and congregates in pits and spawn there. Water level in the ponds is reduced is reduced after 8-10 days and spent fishes goes back to trench leaving behind fry in pits, which are subsequently scooped out.

Females are induced bred through commercially available synthetic hormones, i.e. ovaprim/ovatide/WOVA-FH @ 1.0 to 1.5 ml/kg body weight. The above hormone injected to the fishes on the dorsal side of the body during evening hours in a single injection schedule. The latency period between injection and stripping of female is 16 hours at 28-30$^0$C. The male fishes are held separately in a tank/container before artificial fertilization.

Before the females are stripped male fishes with gravid testes are sacrificed and testes are taken out and macerated in normal saline (0.9% NaCl). The spermatozoa become inactive in this medium and this extract can be maintained for few hours in refrigerator. After 16 hrs of latency period female fish is stripped and ova are collected into a dry enamel tray. Before fertilization milt (Spermatozoa) extract medium is activated by addition of freshwater. Sperm becomes active and motility of sperm can be confirmed in microscope. Sperm preparation thus obtained will be sufficient to fertilize the ova stripped from two females. Sperm extract is sprinkled over the ova and gametes are mixed gently with bird and allowed 2-3 minutes for fertilization. After repeated washing with fresh water, fertilized eggs are transferred to hatching tray for incubation. The average fertilization rate of 75% can be achieved by adopting this technique. The assessment of fertilization can be observed after 6 hours in binocular microscope.

CIFE (Central Institute of Fisheries Education) has developed a model hatchery for seed production of catfishes. This hatchery comprises of two units i) Hatching-cum larval rearing unit ii) Fry rearing unit

i) Hatching cum larval rearing unit:

This is a flow through unit containing a series of Galvanized Iron trays and each tray measures l.25x 0.5 xO.20 mm. There is a common 0.5 inch PVC perforated pipe running over the trays at a height of 1 .5 ft. to facilitate water showering in each tray. Water flow is maintained at 1 liter 1mm during incubation of eggs. Besides this artificial aeration from air blower is provided continuously in all the trays. Each tray has capacity to receive eggs from two females. After hatching (24-26hrs) the water flow is regulated at 2 litres /mm tiH yolk sac absorption, which normally takes 3-3.5 days. The unfertilized eggs and other debris are siphoned out twice a day from the tray to provide hygienic condition and to avoid microbial contamination.

Feeding schedule commences from 3 day onwards. Boiled and mashed poultry egg yolk and finely sieved plankton can be given to larvae at 3 times a day. Artemia nauplii can also be given once in late evening hours. Larval rearing is continued for 7 days i.e. till the hatchings attain aerial respiratory mode. During this period of rearing larvae grows up to 10-12 mm in size. At this stage trays are harvested by siphoning the larvae which are termed as “early fry”. Normally on an average of 70 % survival during 7 days of larval rearing can be achieved using this technology.

ii. Fry Rearing Unit:

This unit consists of rectangular FRP (Fiber reinforced plastic) tanks measuring 9' X 2' x l .5'. Each tank is provided with 3 air diffuser stones and air is supplied from 1 H.P. air blower continuously.

Early fry of 10-12 rmm in length are shifted from larval rearing unit and are stocked @ 4000-5000 in each FRP tank. Rearing of early fry to fry is observed to be very crucial. The stock of early fry is fed twice morning and evening with sieved plankton, which is collected from specially prepared nursery pond. This is supplemented with egg custard or encapsulated egg preparation once a day preferably in noon hours.

**Water quality management:**

A steady water level of 9 inches is maintained and every day FRP tanks are cleared off fecal matter, dead fishes, debris, etc by siphoning and 10-20% water is exchanged. The water quality was observed to be in the range of DO 4-6 ppm; pH 7.-8.2; total alkalinity 120-140 ppm.

**Harvesting:**

After 10 days of rearing the seed attain size over 20-22 mm in length and at' this stage tanks are harvested by siphoning. Before harvesting random samples are collected and seed is physically counted to assess the fry production. The experiments at CIFE revealed th3t mortality of weak seed (fry) regularly occurs during the course of 10 days rearing. The fry obtained will be hardy and on an average 40% survival can be realized in this unit. The fly can be disposed off after ensuring further rearing up to fingerlings or else the survival of fly in grow out pond is uncertain. Hence, it is advised to subject the fry to further rearing up to fingerlings.

**Nursery pond management:**

Cement pond with earthen bottom is preferable to earthen ponds. However, complete cemented nursery ponds can also be used. The size of pond can vary from 50 - 150m2 with maximum water level of 80cm.

**Fertilization:**

Before fertilization nursery can be limed with 100kg/ha to ensure alkaline conditions. Organic fertilizer like cattle dung @ 500kg/ha and 100 kg/ha of groundnut oil cake along with SSP @25 kg/ha can be applied as slurry after thorough mixing. If the water source is deep tube well then natural plankton from any water body can be collected and inoculated. it is advisable to prepare pond a week before stocking with fly to ensure production of natural fish od organisms.

Note: At fertilization water level of 25 - 30 cm has to be maintained.

**Stocking of fry:**

The seed (fry) stocking can be done after proper acclimation to avoid sudden shock due to wide fluctuations in pH and temperature levels. The stocking density can be between 400-500 fry /$m^2$. They are reared for 30-45 days to achieve a size of over 7 cm or 2 grams.

**Water Management:**

As the rearing period progress, every week 10 cia or 4 inches water needs to be filed. However, at stocking, a water depth of 25-30 cm has to be maintained. By end of rearing period the pond water level should be above 75cms and not to exceed 90cm.

**Feed and Feeding:**

Fry are to be feed with ground trash fish and rice bran mixed at 7:3 ratio or formulated pellets commercially available shrimp starter feed can also be applied. The rate of feeding to be applied is shown below and feed ration is split in 2 doses and given in, morning and evening.

| Period | Quantity of Feed (Kg/one lakh fry/day) |
|---|---|
| I week | 1.0 |
| II week | 2.0 |
| III week | 3.0 |
| IV week | 4.0 |
| V and Vl week | 5.0 |

**Harvesting:**

After 30-45 days of rearing fingerlings attain more than 5-7 cm and weigh over 2 grams. At this stage nursery pond can be harvested by draining and all the stock of fingerlings can be collected at the drain pipe. The survival rate of over 50% can certainly be achieved by following proper management practices.

**References:**

Handbook of Fisheries and Aquaculture II edition (2011), Indian Council of Agricultural Research, New Delhi.

Training manual (2005), Hatchery technology and Grow out Techniques of scampi and Magur, Central Institute of Fisheries Education, Kakinada Centre

# Cage Culture Practices in Reservoirs

Dr. B. R. Chavan
Principal Investigator and Associate Research Officer
Marine Biological Research Station, Ratnagiri-415612

## Introduction

Cage culture is when fish are reared from fry to fingerling, fingerling to table size, or table size to marketable size while captive in an enclosed space that maintains the free exchange of water with the surrounding water body. A cage is enclosed on all sides with mesh netting made from synthetic material that can resist decomposition in water for a long period of time and is sold under the brand name Netlon. Cages are generally small, ranging in freshwater reservoirs from 1 square meter ($m^2$) to 500 $m^2$. Several small cages combined in a battery, as described below, are suited for even intensive culture.

The origins of cage culture are a little vague. It can be assumed that at the beginning fishermen may have used the cages as holding structures to store the captured fish until they are sent to the market. The first cages which were used for producing fish were developed in Southeast Asia around the end of the 19th century. Wood or bamboos were used to construct these ancient cages and the fish were fed by trash fish and food scraps. In 1950s modern cage culture began with the initiation of production of synthetic materials for cage construction.

Fish production in cages became highly popular among the small or limited resource farmers who are looking for alternatives to traditional fishing. Cage culture is advantageous for farmers as it offers the farmer a chance to utilize existing water resources. Therefore, the farmers/fishermen do not have to invest on infrastructure development for fish farm. Fish are reared in cages from fingerling or advanced fingerling stage up to marketable size.

## The importance of inland cage farming to Asia:

Asia, excluding the Middle East, harbors 56.2 percent of the world's current population and is expected to reach 4.44 billion people, by year 2030 (http://earthtrends.wri.org/pdf_library/data_tables/pop1_2005. pdf). There is less land per person in the Asia-Pacific Region than in any other part of the world; at least ten major countries in the region have less than 0.10 ha compared to the world average of 0.24 ha (UNEP, 2000). Inland water resources in Asia are also rather limited. Although Asia is blessed with the highest quantity of usable freshwater, the per capita availability is the lowest of all continents (Fig. 1).

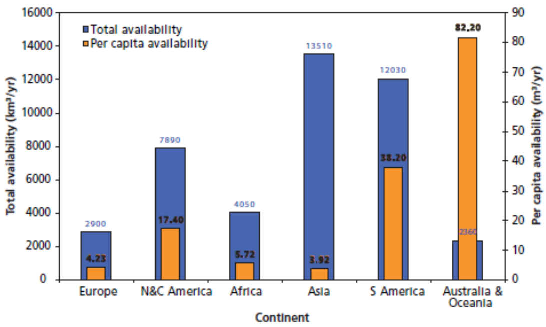



**Fig. 1 Total and per capita water availability in each continent**

**Site Selection**

Site selection is the most important part of the cage culture. Proper selection of a site will reduce most of the problems arise with cage culture and operational cost.

The selection of site for cage culture is very important, as success often depends largely on proper site selection. Potential sites vary according to the size and shape of the reservoirs where cages are to be installed. The critical issues in selecting sites are the following: The depth of the water column should be at least 5 m. Water quality and circulation should be good, free from local and industrial pollution. In large and medium-sized reservoirs, sites should be in sheltered bays for protection from strong winds. In small reservoirs, the cage should be anchored in the deeper lentic sector to avoid the current flow through sluice gates and irrigation channel. They should be safe from frequent disturbance from local people and grazing animals. There should be access to land and water transportation. They should be devoid of algal blooms to avoid fouling. They should be free of aquatic macrophytes and high populations of wild fish, which can cause oxygen stress. Cages should be placed where they will not hinder navigation. They should be at a distance from bathing and burning ghats. Sites should be secure.

**Types of Cages**

Major two types of cage are used in cage aquaculture: fixed (stationary) and floating. The fixed cage is the most basic and widely used in shallow water with a depth of 1-3 metres. It consists of net bag fitted to posts and is normally placed in the flow of streams, canals, rivers, rivulets, shallow lakes and reservoirs, not touching the bottom. Fixed cages are comparatively inexpensive and simple, but their use is restricted. Floating cages, on the other hand, are supported by a floating frame such that the net bags hang in water without touching the bottom. Floating cages are generally used in water bodies with a depth of more than 5 m. Enormous diversity in size, shape and design has been developed for floating cages to suit the wide range of conditions of fish culture in open waters. Generally floating cages are designed with 6*4*2 m or 6*3*2.5m (fig.2)

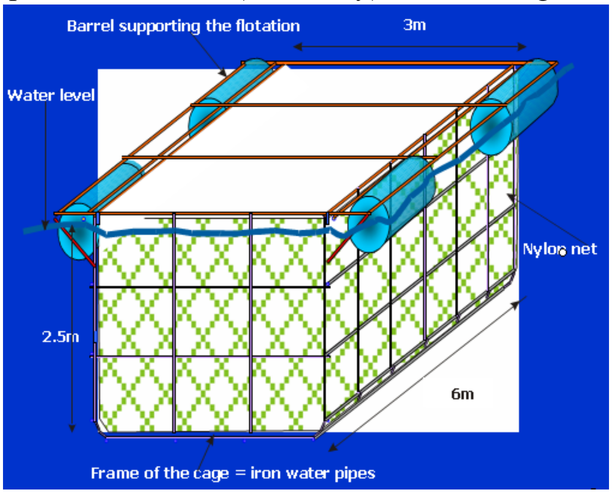


Fig. 2 Floating cage with nylon mesh net

**Monitoring water quality**

Dissolved oxygen - Dissolved Oxygen (DO) concentration and its availability are critical to the health and survival of caged fish. In general, warm water species such as catfish and tilapia need a dissolved oxygen concentration of 4 mg/l DO (or ppm) or greater to maintain good health and feed conversion. Dissolved Oxygen levels below 3 mg/l can stress fish. If this level goes below 2 mg/l can increase the mortality of fish.

Temperature – The most important physical factor controlling the life of a cold-blooded animal like fish is temperature. It is critical in growth, reproduction and sometimes survival.

Each species of fish has an optimum temperature range for growth, as well as upper and lower lethal temperatures.
pH- Uptake and release of $CO_2$ during photosynthesis and respiration affect on pH in a pond and due to this, it fluctuates daily. The lowest level of pH appears at or near dawn whilst the highest is at mid-afternoon. The desirable range of early morning pH for fish production is from 6.5 to 9. Acid death point of the fish is approximately pH 4 and the alkaline death point is approximately pH 11. Slowed growth of fish, reduced reproduction, and susceptibility to disease increasing can be caused if the pH is not at the optimum range. Other - Turbidity, Nitrate and Phosphate levels, COD, Alkalinity, and Salinity are also affecting on fish culture in cage.

**Cleaning Net cages.**
Cages should be cleaned with soft brush fortnightly to remove algae, sponges and other organisms. Floating macrophytes that waves sometimes push against cages should also be removed. Any dead fish should be removed from cages immediately and disposed of in a pit. Covering dead fish with lime helps contain any disease. Deaths should be recorded to facilitate later analysis of disease outbreaks.

**Stocking in fry to fingerling rearing cages**
Recommended stocking density for cages are 225 - 285 fry/ $cm^3$ and for the cages in the ponds are 114 fry/ $cm^3$. Recommended size of the fry is 1.5 – 3.0 cm for carp species. The recommended stocking density for tilapia is 150 fingerling with 50 gram size.
Survival rates in well-placed and well-managed cages are typically 80 to 90 %. Feeding is the most important management practice that a fish farmer does each day. Simply stated, no feed will mean no growth. Without growth there will be no profit. On the other hand improper feeding can be adversely affected to the culture species.

**Feeding methods**
Respective feed types are mixed with hot water and prepared as dough. Feed dough is provided using feeding trays and the daily ratio is adjusted depending of fish consumption.
Feed should match to the feeding habit of the fish and it should prefer the artificial feed that we provide from the outside. Quality of the feed is very important because most of the times the fish will not receive natural food. Therefore feed must be a nutritionally balanced diet which has adequate protein and energy levels, is balanced in amino acids, and in essential fatty acids, and is supplemented with a complete array of vitamins and minerals.
Dry food (pellet) are used for the grow out practices, while for rearing of fry to fingerling, ground nut oil cake and rice bran (1:1) with 1 % mineral mixture are used as feed.
Feeding fish twice per day at the adequate rate depending on water temperature, species, size, culture and density is recommended. Feeding ratio can be determined through the sampling that was carried out periodically or applying standard growth tables. Dry food consumption has also to be monitored through feeding trays and the daily ratio has to be adjusted depending on the fish consumption.

**Cage Maintenance**
Algae or bryozoa, a grey jelly-like mass, may sometimes accumulate on the cage. It should be raked off with a stick or broom periodically to ensure adequate water circulation through the

cage. Cage floating structures may have to be adjusted or replaced during the growing season.

**Fish stock monitoring.**
Routine checks of fish health help prevent massive fry loss. Fish health can be easily checked by monitoring fry response when feed is applied. Signs of ill health include surfacing, lesions, rashes, spots,
lumps, excessive mucus formation, woolly mat formation, bulging eyes, and fin and tail erosion. Appropriate prophylactic measures should be applied as necessary and at least fortnightly. Remove the fry from the cages and soak them for 2 minutes in a 5-6% salt solution followed by 5-8% potassium
permanganate solution to eradicate ecoto-parasites. A 20-30% potassium permanganate solution may be spread on the water surface inside the cages. At times, a lime solution may be spread inside the cages to clear the water.

**Problems**
Fish are difficult to observe in cages. Sampling to observe may stress the fish and led to secondary infections. Therefore, the observation during the feeding, when the fish come up to eat at the water surface, is critical. This day to day observation is essential to keep the healthy fish culture and increase the harvest. Stress comes from the water body. Accumulation of the feed, organic materials, livestock waste and pesticides in the water body may be harmful to the fish. These factors change the optimum water condition and affect on the caged fish. These things can be avoided by doing an appropriate site selection and a proper maintenance of the cage.
Human errors. Poor cage construction, stocking poor quality fingerlings, high or low density stocking, poor quality of feed, improper feeding methods, ignoring regular monitoring of fish, poor handling of the fish, improper site selection and inadequate cage maintenance can be considered as human errors.
Bio-fouling. It is very common in cage culture. Biofouling is caused by organisms that attach themselves to the structure or to the net cage and restrict water exchange. Biofouling can be reduced by cleaning cages at the right time and applying anti bio-fouling paint on the cage.
Accumulations of waste: This can happen mainly due to the uneaten feed. Waste accumulation can control by the following practices: To facilitate water exchange, use a mesh size as large as possible and select the areas where gentle breeze action can circulate water through the cage. Ideal exchange rate is one cage volume per every 30 to 60 seconds. Place the broad side of a cage into the prevailing wind to aid water exchange

Feed only as much as the fish will consume within 15 minutes. If fish do not consume the feed in 15 minutes or stop feeding, reduce or stop feeding until fish respond willingly to the feed.

**Advantages and Disadvantages**
Cage culture has some distinctive advantages compared to other fish culture methods which include: Many types of water resources can be used, including lakes, reservoirs, ponds, streams and rivers. Low capital cost is required (Can be installed in an existing body of water). Harvesting is simple. Observation and sampling of fish is simple and therefore only

minimum supervision is needed. Easier handling, inventory and harvesting of fish. Better control of fish population. Efficient control of fish competitors and predators. Effective use of fish feeds, reduced mortality, High stocking rate, total harvesting and swift or immediate return of investment and less manpower requirement

**Disadvantages**

Stock is vulnerable to external water quality problems eg. Algal blooms, low oxygen levels. Growth rates are significantly influenced by ambient water temperatures. Feed must be nutritionally complete and kept fresh. Low Dissolved Oxygen Syndrome (LODOS) is an ever-present problem and may require mechanical aeration. The incidence of disease can be high and diseases may spread rapidly. Vandalism or poaching is a potential problem

**Good Fish Cage Culture Practices**

Stock fry or fingerlings in a cage with appropriate size for the mesh to avoid fish escapes. Clean the nets regularly. Review the cage structure regularly. Monitor health status of the fish visually and send samples to laboratory if a problem is detected. Adjust the quantity of feed according to consumption after monitoring through feeding trays. Be aware of the, salinity, pH and temperature changes of the water body.

# Fish Culture in Agriculture Tank – Scope And Potential

A.S. Kulkarni
Assistant Professor, Dept. of Fisheries Resources, Economics, Statistics & Extension Education
College of Fishery Science, Udgir, Dist. Latur.

Agriculture tanks are essential Components of integrated rain fed agriculture. They store rainwater and keeps balance in the locality enabling early sowing of crops. These tanks stores either harvest rain water or pump water from a seasonal water stream or bore well. The agriculture tanks are covered with plastic sheet (Silpolin) or without sheet. Provision of plastic sheet is dependent on water retention capacity of the soil.

Under the scheme of Govt. of Maharashtra, agriculture tanks of various sizes i.e 60m x 60 m x 3m, 45m x 45m x 2.8 m, 40m x 40m x 3m, 30m x 30m x 2.8m , have been constructed with subsidy. Around 69,228 agriculture tanks have been constructed under Rashtriya Krishi Vikas Yojana (Flagship project of Maharashtra State) and National Horticulture Mission (NHM) in almost all parts of the state.
In both cases i.e. with plastic sheet or without plastic sheet, fish culture practices can be carried out. Agriculture tanks not only acts as water storage tank for irrigation of horticulture / agriculture crops but also provides additional income to the farmers through fish culture.

**Advantages of Agriculture tank**

1. The agriculture tanks water resources are useful to carry fish farming practices and provides additional income to the farmer.
2. Nutrient rich water from fish culture is available for irrigation and enhances productivity of agriculture and horticulture crops.
3. Employment generation for unemployed rural youth directly and also provides enterprises to fish seed supplier, feed manufacture, fish merchants etc.

**Technology of fish culture in agriculture tank**

Depending upon water retention period, fish culture method can be done. If water availability is for 4-6 months then fish seed rearing is possible. In this method, carp spawn can be reared to fry stage in 20 – 25 days or carp fry can be reared to fingerling size in 60-90 days of period. In case of fry rearing, after attaining fry stage i.e. 20 - 25 mm size, half of the fry can be sold out and rest fry seed can be grown to fingerling stage. As there is tremendous demand for fish seed, this fish seed can fetch good price and provide good returns.

In case of water availability for more than 8-10 mouths, grow out production of carp is carried out. In this fingerlings of 100-150 mm or yearlings ( 100-200 gm weight) is stocked and can be grown to market size (1 kg). Fingerlings are stocked @ 10,000 to 12000 nos./ha. Stocking density. In grow out production marketable size fishes are harvested at proper interval. Pattern of multiple cropping means only marketable size fishes are harvested and sold in the market. This helps to get good price and due to removal of table size fish, rest fishes can grow at fast rate. Indian major carps i.e. Catla, and Rohu are candidate species for culture in agriculture tank.

Management aspects in Fish culture in agriculture tank are significant to achieve the success. They are as follows.

**1. Water quality management:**

Water quality should be maintained throughout culture period by monitoring important water quality parameters viz. Dissolved oxygen, CO2, pH, Total alkalinity and total hardness etc.

The plankton population should be maintained by regular and appropriate fertilization regime. Application of manures like cow dung @ 1- 2 tonnes, Ground nut oil cake @ 200 kg/ha and single super phosphate @ 50 kg/ha is required at prior to seed stocking and later on phase mannuring is to be followed as per the plankton available in the tank.

**2. Feed Management:**

For proper growth of fish, Supplementary feed is to be provided twice a day regularly. This Feed includes mainly rice bran and ground nut oil cake. Other ingredients such as as Soybean Cake, cotton seed oil cake, maize can be used. The supplementary feed is provided @ 2-3 % of body weight of total fish present in the tank. Mineral mixture and vitamins should also be incorporated in the feed to maintain good health. Now a days commercial feed for freshwater fishes are also available in the market as per the protein/fat requirement.

**3. Health management :**

Fishes are checked at regular interval by random sampling and health conditions are examined by seeing body appearance, color and behavior of fish. If any infection is observed then infected fishes are either to be removed or treated immediately.

**Scope and Potential**

Agriculture tanks are being constructed on large numbers in the Maharashtra state and emerging as good water resources. These resources would be the best resources for fish culture practices. The water storage capacity is huge so that fish culture can be carried out on large scale. High levels of fish production is possible by adopting modern and scientific tools and techniques such as high stocking density, intensive feeding, appropriate fertilization regime, aeration, multiple harvesting etc. Fish production is based on management adopted. Fish farming in agriculture tank is associated with other agriculture and allied practices. The output of one practice would be input for other practice e.g. cattle dung from animal husbandry is useful as manure in fish pond and nutrient rich water from fish pond is irrigated for horticulture or agriculture which enhances productivity and provides high yield .

These practices are complementary and supports to each other. There is scope of getting high profit by minimizing the cost of production though reducing expenditure in the form of inputs. Most of these inputs are available at the farm itself.

There is tremendous potential for fresh water aquaculture especially in agriculture tanks as different types of fish can be cultured on large scale. Fish farming in agriculture tank has ample scope to create employment opportunities directly and indirectly for unemployment youth. It also helps to provide protein rich food for their own family as well as society to maintain health standards. Considering the more number of available agriculture tanks can produce large quantity of fish and would increase the total fish production of the Maharashtra state.

**Need of Transfer of Technology**

As the agriculture tanks are existing on large numbers in entire Maharashtra state. Practices of fish culture in agriculture tank are done in few numbers due to unawareness and lack of technical knowledge among the farmers. To popularize fish farming techniques, it is essential to strengthen extension functionaries of state fisheries departments, fisheries institutes, KVKs and NGOs. These organizations collectively can play significant role of transfer of technology by conducting various training and demonstrations, farmers meet, camp, exhibition etc.

Overall, fish farming in agriculture tank can play key role in fulfilling protein requirement of the population and would also beneficial to improve socio-economic conditions of the farmer.

# Breeding Techniques of Freshwater Ornamental Fishes

M. M. Girkar,
Assistant Professor, Dept. of Fisheries Hydrography
College of Fishery Science, Udgir, Dist. Latur.

Ornamental fish keeping is the second largest hobby in the world next to photography. With the changing mode of life styles and increasing mental tension, watching the serene beauty of fishes splashing the naturally preserved habitat of an aquarium tank is the best method of relaxation for both mind and body. It is to be noted that most of ornamental fish have much higher value than food fish, and may provide a good alternative livelihood for fishermen. Ornamental fish culture also ensures socially equitable distribution of benefits along the value chain as this activity is time bound, labour intensive and livelihood options of vulnerable sections of the society like housewives and unemployed youth. In India, especially in the major cities, it is easy to find a number of large aquaria's with great diversity of fish, both domesticated and wild caught, being sold at a reasonably higher cost. However, it is surprising to note that, expect a few species most of them are exotic in origin, predominantly South American. The ornamental fish sector plays a vital part in international fish trade contributing positively to rural development in many developing countries, with a positive impact throughout the value-chain. About 600 ornamental fish species have been reported worldwide from various aquatic environments. Indian waters possess a rich diversity of ornamental fish, with over 100 indigenous varieties, in addition to a similar number of exotic species that are bred in captivity. The growing interest in ornamental fish keeping has resulted in a steady growth in the ornamental fish trade, along with rapid developments in breeding techniques, display systems and accessories. An estimate carried out by Marine Products Export Development Authority of India shows that there are one million fish hobbyists in India.

Fresh water aquarium fishes are broadly grouped into two categories on the basis of breeding behavior:-

1) **Egg layers-** Oviparous e.g. barbs, danios, rasbora, goldfish, tetras, betas, gouramis etc.
2) **Live bearers –** Ovo-viviparous, e.g. guppies, platies, mollies & swordtail

**Some other categories of egg layers with-**

- no care-non-guarders
- Egg layers with care- guarders
- Eggs buriers,
- mouth incubators,
- nest builders and egg carriers on the basis of the parental care.

**Breeding of live bearers:-**

**Guppy:-**

Guppy *Poecilia reticulate* is a live bearing fish, originated from South America, north of Amazon but it us seen worldwide.

Male guppy may reaches up to 2.5–3.5 cm in length, and female is usually larger when fully grown. Guppies thrives in a large well planted tanks with a steady temperature within a range of 20-25$^{0}$C.During summer, a special cooling care has to be maintained to sustain guppies, as the water temperature in many places rises up to 37$^{0}$C, even more during peak summer.. Gravid females need to remove from community tanks as soon as they start swelling with developing young ones and are placed in breeding tanks (30 x 20 x 20 cm), indivually or in pairs. Tank should be provided with plants like *Cabomba* or *Hydrilla* and with aeration during laying of young ones 20-200 nos. For mass breeding of guppies, a tank of 100 x 100 x 60 cm is ideal.

**Breeding of platies, swordtails and mollies:-**

These all are close relatives of guppies and have originated from Central and North-Eastern South America. Adult live bearers of platies and swordtails take 6-8 weeks and of mollies 12-16 weeks to mature. Fertilization is internal and gestation period is 4 weeks. Platies, swordtails and mollies are quite hardy fishes but in no case they should be neglected with standard aquarium conditions. They breed well in most types of water, so long as it is not too soft or acidic. Most of the mollies appear to benefit from addition of a little salt or common salt to water 0.5–1g/lit., ensure that salt level is maintained at every partial water change.

**Breeding of egg layers:-**

Most of the families of tropical aquarium fishes are egg layers, wherein fertilization takes place externally.

**Egg- scatters laying non adhesive eggs:-**

Zebra fish is considered an egg scatteres,laying non-adhesive eggs. Large egg scatters are grouped under genus *Danio* and other smaller under genus *Brachydanio*. The important danio include-they giant danio, pearl danio and zebra danio.

Like many aquarium fishes, zebra danio also eat away their own eggs and spawn after breeding. As the precautionary measures, aquarium bottoms are loaded with round pebbles layer of 6-8 cm diameter. Before setting up breeding pair in any aquarium tank, parents are to be well fed with live food like smaller zooplankton.

During breeding male: female ratio should be maintained at 2:1 or 3:1. Female is introduced in the breeding tank one day earlier than males. Eggs are of smaller size and remain hidden behind pebbles. They require hatching time of two–three days under favorable temperature. As soon as tiny hatchlings are observes in the aquarium tanks, parents need to be removed. Hatchlings take two days to absorb yellow yolk sac. After two days, they are fed with infusorians for 4 days. Subsequently rotifers and smaller zooplankton can be fed for a week, after which they can be provided powdered formulated feed.

**Egg-scatterers laying adhesive eggs:-**

Gold fish, *Carassius auratus*, is considered an egg-scatterer laying adhesive eggs. It is well adaptable for aquaria and open-outdoor cement cisterns. Gold fish varieties in the market are common gold fish, fringe tail, lion head, oranda, comet, shubunkin, telescopic eye, veil tail and red cap. At the time of maturity, when secondary sexual characters appear, male and female gold fishes are selected and kept in circular glass tanks (24'x 12"x 15") or ferrocement tanks (3.5 ft x 2.5 ft) after disinfecting containers with 1 ppm solution of potassium permanganate ($KMnO_4$). Water should be mixed preferably with 50% groundwater and 50% filtered pond water. Containers could be kept in such a place, where it can receive some early morning sunshine and no sunlight afterwards. Some artificial nests need to be provided. Various types of sterilized natural submerged aquatic plants like *Hydrilla*, split plastic ropes with one end tied or burnt to make it blunt and even polythene strips are found suitable for this. Nests should float close to water surface, and the additional nests should be spread on the bottom of spawning tanks for the eggs that sink down. The water temperature should be maintained between 20 and 30°C; ideal temperature is 27-28°C.

Spawner and muter in l: 2 are released into, breeding tank late in the evening. Egg laying usually takes place within 6-12 hr of placing males and females together. The moment spawning is over, nests are transferred to a different container, or alternatively, the parent fish is transferred from breeding tank. If this is not done, the parents are most likely to eat away eggs to compensate post-spawning loss of energy.

Generally, female lays about 2,000-3,000 eggs. Healthy eggs are golden transparent at the beginning and gradually transparent area decreases. Unfertilized eggs remain opaque and continue to remain as such with arrested growth. These dead eggs become pale-white, and hair-like aquatic fungi would grow on all sides, giving it appearance of a small powder-puff.

Under ideal conditions, within three days, eggs hatch out with a hatching rate of 80-90%. Nest materials are taken out from tank when young larvae start floating. Generally, tiny larvae remain clinging to nest, so precautions have to be taken while transferring nests from brreding pool.

**Egg depositors:-**

Rasboras, group of small shoaling fishes, about 50 species from East Africa, South and East Asia, lay their eggs on the underside of the flat levels as such, are called egg-depositors. The very common ones are *Rasbora daniconius* (slender rasbora), *R. heteromorpha* (harlequin), *R. panciperforara* (glow light rasbora) and *R. trilineata* (scissor tail). They are ideal for a well-planted community aquarium where a shoal of 5-10 individuals look very attractive as they swim actively at the upper regions of the water. A temperature between 25 and 28°C is optimum for their breeding.

The smaller rasbora lays up to 100eggs/female while larger female lays up to 250 eggs per female. But in general rasboras including harlequin are often fairly difficult to breed. Like barbs they require soft, slightly acidic (pH 5.5) water and temperature at 28°C. After conditioning male and female, they are placed in a tank planted with flat leaved plants. Rasboras in general and harlequin in particular prefer peaceful and quiet environment for breeding and low lighting levels. The male and female brooders are placed together in a breeding tank for a week. If they do not respond then they should be separated and reintroduced again later. Once spawning has occurred, as indicated by the sliminess of the female fish, remove both parents from the breeding tank. The hatching takes 24-36 hours, and resultant hatchlings become free swimming after 3-5 days. At this stage, the tiny hatchlings should be fed infusorians and newly hatched brine shrimp. As they grow bigger they should be fed zooplanklon, like *Moina* and *Daphnia*. Adult rasboras feed on good quality dried foods.

**Egg-buriers:-**

Among the egg-buriers, killi fishes, *Aplochelius panchax*, *A. lineatus* and *A. blochii* are important. They lay their eggs in a soft peat at the bottom of the tank. In an aquarium, they lay their eggs in dense planted environment. They are good jumpers; therefore, they should be kept in covered aquarium. The eggs are capable of remaining viable even after dried condition and hatching may be possible even after some weeks or even months, when again placed in water. In drought conditions, parents may die but eggs remain alive until the next rains. They rarely grow over 3-4 cm in total length, and are short-lived.

**Breeding of nest-builders:-**

Among nest-builders, gouramis and their relatives are most popular. The so called labyrinth or anabantid fishes consist of four families and almost 70 species of freshwater fishes from tropical Africa and South-east Asia. They possess an accessory respiratory organ, the labyrinth, which is an extension of gill-chamber, situated behind eyes/gills region of the head. Many of the anabantids are bubble nest-builders and incubate their eggs in floating nests; made especially by male fish.

The dwarf gourami (*Colisa lalia*) comes from eastern India, where it lives in still and heavily weed-infested waters. It may reach a length of 5 cm. Female is less brightly coloured and has more rounded dorsal and anal fins than male.

For breeding, males and females are kept separately in different tanks for a few weeks and fed with live-foods. When female's abdomen becomes grossly distended with eggs, it is transferred to a smaller breeding tank with water level of 5-6" (12.7-15.24 cm) , temperature range of 28-30°C, total hardiness of 100-200 ppm and pH of 7.0-7.5 and with plenty of fine-leaved plants such as *Cabomba, Myriophyllum* or other floating plants. After 1-2 days, a matured male is introduced in the breeding tank. Transparent perforated plastic-sheet or a glass is used to cover over the tank to keep humidity and temperature at the high level, which help maintain the bubble nest in a good condition. Male soon begins to build a bubble nest, and after making the nest. courtship usually ends with both fishes embracing near the nest, resulting deposition of a large numbers of eggs in the nest. After the making of the bubble nest if female does not lay eggs then male becomes very aggressive and may even kill female.

After breeding, female is removed. The male guards eggs, which remain attached to floating bubble nest. Within 24 hours, hatching takes place. The moment the try begin leaving nest, the male is also removed from the tank. After 36 hours, when young-ones remain in free-swimming stage, they are provided infusoria as Starter feed. After a week, the fry start taking newly hatched artemia and small cladocerans. During this stage, fry require vigorous feeding. Subsequently when they grow little bigger they can be stocked in bigger cement-tanks for further growth.

Siamese fighting fish or betta, *Betta splendens*, is native of shallow and warm waters of Thailand, Malaysia and Vietnam. Like gouramis, this fish breathes atmospheric air, so it can be kept in very small container with water having pH of 7.0. Bettas accept all kinds of foods, preferably animal-protein supplemented diet. Adult fish attains 6-cm length. Cultured betta is white, orange, green, blue, crimson and black in colour. Fish exhibits sexual dimorphism, male's dorsal, caudal, anal and ventral fins are longer and may become extremely veil-shaped. After attaining sexual maturity males become aggressive for their territories. If the female does not spawn after male forms bubble nest; male even kills female. It is this characteristic that has given the species its name fighting fish.

The fish gets sexual maturity at approximately three months, but ills best to attempt breeding with fishes that are 9-12 months old. Allow one male to every two or three females; taking care to choose females that are at least of the same size as the male. Males are kept in small aquaria with a capacity to hold 2-5 litres of water. Since fighters have a labyrinth organ, aeration is not necessary. Regular maintenance required is only to change 50-75% of water in a week. Less aggressive females are also kept together in one aquarium containing 25-50 litres of water. Another breeding tank containing 50 litres of water (depth 15 cm) is required along with fine-leaf plants *Myriophyllum* or *Cabomba*. No aeration or filtration is required at this stage. The tank has to be partitioned into two halves with fine meshed net- in one portion, mature female is placed and in the other is placed mature male. Water temperature of 27°C is considered optimum.

Male starts building bubble nest quickly, and once this is underway, partition net is removed. At this crucial point, the female should be accepted by the male, otherwise male starts vigorous display of chasing, which ultimately ends in fin-tearing of female. If the fin-tearing occurs, the female is removed, and the same type of female is replaced after a few days. Fighter often spawn in early morning, and up to 15 eggs may result from one embrace and this is repeated many times during a period of a few hours to give a final brood of 200-300 eggs, although broods of 600 and more eggs have also been recorded. As the eggs are shed and fertilized, they sink to tank-floor. The male fish then collects them in his mouth and spits them into the bubble nest. At the end of spawning, the female is removed, but the male is left, as he guards nest for several days. However, about three days after spawning, the male is removed as well, since it may eventually eat young-ones. Eggs hatch after 36-48 hr. The smaller fry become free swimming after five or six days, when they accept infusoria or egg-yolk milk several times a day. After three or four days, the fry generally accept fine dry foods. Development of labyrinth organ in the small fry takes place when they are about three to four weeks old. At this time, it is vital that the air above the tank remains warm and humid, and hence a glass or plastic-sheet is recommended. If the air is too cool, it may lead to death of fish. The males and the females should be separated before they mature and start fighting.

Another nest-builder is angelfish (*Pterophyllum scalare*), which originated from Amazon region of South America. It grows up to 6" length in waters having pH of 6.5- 6.9, alkalinity of 50-100 $CaCO_3$ mg/litre. Angelfish accepts flake food alone and requires live-plants like Amazon sword- plants (*Echinodorus*). Minimum water capacity of tank for breeding a pair of angelfish should be 60-70 litres. From matured angel group, those with straight top and bottom fins without any bowing or bends are selected; they should be healthy, strong, robust and active. In the beginning, 6-8 potential breeders are selected which can be set in a 100-litre tank and they are fed well with a good selection of live-foods. This fish does not exhibit sexual dimorphism. Experienced fish-keepers, however, learn to recognize visible differences in shape and size between male and female angelfishes after watching spawning behavior exhibited during courtship. The breeding season of different species varies widely, a brief account of which is

**Breeding biology of the Asian Arowana:-**

Asian arowana or Dragonfish (*Scleropagesformosus*) is one of a few living members of the *Osteoglossinae*sub-family within the order-*Osteoglossiformes.* Asian arowana is morphologically distinct from the "typical teleosts" due to its large body size and a few salient features. It is known to grow to 100 cm in total length and live up to 43 years old.

Asian Arowana possess a fascinating collection of interesting characters that are important for the study of basal vertebrate breeding biology, mating behavior and mate preference. The Asian arowana differs from many other teleosts also in its large egg produced and high parental care they exhibit. Due to the fact that it is located very near to the basal groups on the phylogenetic tree of life, although not traditionally used in behavioural and genetic studies, this species provides a good model to study the evolution of mating system theories. In contrast to most other teleost breeding systems, Asian arowana probably exhibits the most extreme and unique end of high parental care where relatively few (20-80), extremely large eggs (12-15 mm in diameter) are produced and is thought to be mouth brooded by the male that will last for 40-50 days.

The most interesting and distinct difference between the Asian arowana and its related species in the *Osteoglossidae* family is the presence of natural occurring colour strains which is not found in any other species in the family. Unlike the rest of the family species member that only have one colour form, the Asian arowana possesses at least 6 known naturally occurring colour strains. These colour strains have distinct phenotypic differences after maturation and in their natural habitat and they are isolated geographically.

It is not surprising why the species is not well studied: the long generation time, low fecundity, lack of sexual dimorphism and restriction in sample collection in the wild and most importantly, the difficulty in the culture of this fish; all make its analysis very difficult. In addition to this, conventional breeding occurs regularly only in earthen outdoor ponds and not in artificial holding tanks. As breeding in fish tanks are rare , documentation through direct observations of the temporal and spatial scope of the arowana breeding activities is almost impossible in the dense pond water. There is no documentation of artificial fertilization of this species, probably due to the large eggs and low fecundity and lack of available specimens. This lack of basic biological information of the Asian arowana becomes a bottleneck to use Asian arowana in many scientific studies; including its phylogeny, its behavioral studies, population structure and genetics, demographics and most importantly its reproductive biology. These also indirectly compel us to study the mating system using molecular tools.

**Feed for breeding and maintenance**

Ornamental fish feeds, which are available in the market, are being imported from Singapore, Hong Kong, Korea, Thailand and many other countries. However, an entrepreneur if desires can prepare required feed by using locally available ingredients mostly from various agricultural byproducts. Mostly groundnut oil-cake, wheat-bran, soybean meal, tapioca floor, vitamin mineral mix and oil are used during ornamental fish feed preparation. These ingredients with different combinations containing 40-45% protein resulted higher growth and survival. Also incorporation of 1.25 ppm 3, 3',5-triiodo-L-thyronine ($T_3$)

stimulated growth and disease resistance in gold fish. However, high doses did not give any beneficial effect in terms of survival.

**Nutrient requirements of ornamental fish:-**

Like all fishes, ornamental fishes too require proteins, lipids, carbohydrates, vitamins and minerals. Young ones can be fed on 40-50% proteins,4-6% lipid and 40-50% carbohydrates. The adult or brood fish can be fed with 30-35% proteins, 6-8% lipids and 40-50% carbohydrates. In addition to this, 1% vitamins-minerals could be added.

The feed ingredients of ornamental fish feed are generally selected on the basis of availability, nutrient composition and physical properties. Ingredient should be of very good quality and free from pathogens.

**The Ten Commandments for the breeding of a new species**

1. The breeding season of fish chosen
2. The breeding habit, viz., egg scatterer, egg guarder etc.
3. The feeding habit of the species.
4. The sexual dimorphism and size at first maturity
5. The water quality parameters required for breeding
6. The requirements of egg scatterers if they are so
7. The exact spawning and courtship behavior
8. The attitude of parents to the eggs and young ones
9. The breeding intervals of the species, life span of the fish.
10. The feeding habits of the hatchlings and young ones.

***References:-***


1. Hand book of Fisheries Aquaculture II edition (2011).Indian Council of Agricultural Research, New Delhi.
2. CMFRI (Indian Council of Agricultural Research) P.B.No.1603, Marine Drive North Extension, Ernakulam North, P. O. Cochin, KERALA Course Manual (2009). Recent Advances in Breeding and Larviculture of Marine Finfish and Shellfish.
3. Souvenir International seminar on Ornamental fish breeding, farming and Trade from 26-27 January, 2014 at Cochin.

# Ornamental Fish Trade: Present Status and Scope

S. N. Kunjir
Assistant Professor, Dept. of Fisheries Resources, Economics, Statistics & Extension Education
College of Fishery Science, Udgir, Dist. Latur.

**Introduction**

Ornamental Fish had occupied a significant position in global trade portfolio due its popularity amongst people with aquarium hobby. The ornamental fish sector plays a vital part in international fish trade contributing positively to rural development in many developing countries. About 600 ornamental fish species have been reported worldwide from various aquatic environments. Indian waters possess a rich diversity of ornamental fish, with over 100 indigenous varieties, in addition to a similar number of exotic species that are bred in captivity. The growing interest in ornamental fish keeping has resulted in a steady growth in the ornamental fish trade, along with rapid developments in breeding techniques, display systems and accessories. An estimate carried out by Marine Products Export Development Authority of India shows that there are one million fish hobbyists in India.

**Ornamental fish trade - Global scenario**

The aquarium fish trade is a large, biodiverse, global industry (Tlusty et al., 2013) worth around 15–30 billion US$ (Penning et al., 2009) and involving 5300 freshwater and 1802 marine fish (Hensen et al., 2010; Rhyne et al., 2012a). The industry is growing at a rate of about 8% annually. Talking about the ornamental fishes in the world trade, 60% of the fishes are of freshwater origin, 30% marine and 10% brackish water origin. Of the freshwater fishes, 60% are wild caught fishes and the rest 40% are bred varieties. Globally there is a steady increase in the ornamental fish trade due to the enhanced popularity. The demand for ornamental fish in the industrialized nations is being met by imports, the volume of which is increasing year by year. The largest import markets for tropical fish are U.S.A, Japan and Western Europe and the individual market share are USA, Japan, Germany, UK, France, Singapore and others. 60.3% of the suppliers to these countries are Asian countries like Singapore, Malaysia, Indonesia, China, Philippines, Sri Lanka, Thailand, Taiwan, India and others. The biggest exporter of ornamental fishes in the world is Singapore followed by Malaysia, Indonesia and Czech Republic.

**Ornamental fish trade -Indian Scenario**

In India, there are two major segments in the ornamental fish trade sector, viz. collection, rearing and export of native (wild caught) varieties and breeding, rearing and selling of exotic species. However, India's contribution to the international trade of ornamental fish is very low compared to major exporting countries. Out of more than 300 species exported from India, around 90% were sourced from the wild in the early stages of the industry.

A look into the ornamental fish trade scenario in India indicates that more emphasis is given to the exotic ornamental fishes in the domestic markets. The exotic ornamental fishes occupy all the domestic market segments in India to the tune of 70-80% and the share of indigenous ornamental fishes is about 10%. The common exotic varieties in the domestic market include gold fishes, angels, guppies, mollies, etc. The domestic market of ornamental fish in India is almost completely held by home hobbyists (99%), with only 1 % by public aquaria and research institutes.

The present trend of domestic market appears to be promising with a steady growth rate in the recent times. The demand is increasing day by day since more and more entrepreneurs are attracted to this field especially to the wholesale and retail markets but the production is not coping with the demand. More than 200 species of fresh water ornamental fishes are bred in India for the domestic market. Most of the priced varieties are imported from other countries. The marine ornamental fish market in India is still in its infancy. Now there is only domestic market for this sector, that too only in a limited and controlled way. A few entrepreneurs trained in marine fish ‘keeping have recently stepped into the arena, especially in the coastal cities. But their share in the total domestic trade is negligible and also no regular supply of these fishes to the domestic trade. Lack of proper knowledge in maintaining the system including water quality maintenance is the major decelerating factor of Indian marine ornamental fish trade. India is a treasure trove of fish fauna. More than 600 freshwater fishes are reported from India. Yet, the awareness regarding the indigenous ornamental fishes and shellfishes is limited and resources have not been tapped to the optimum economic benefit. At present, only about 220 species of live ornamental fishes are being exported from India. As far as the export of ornamental fishes is concerned, 85% of our total export is made up of wild caught fishes of freshwater origin, majority of which come from North Eastern region. The remaining are either tank raised bred and reared varieties of exotic species.

If the resources are judiciously tapped with the application of natural resource management, the country can increase its export earnings several fold and generate additional employment opportunities especially in the rural sector like Sri Lanka, Malaysia, Thailand, etc. with very limited resources and infrastructure are far ahead of us in this sector. The important ornamental fish collection centres in India are North Eastern states. By virtue of access to international airport, Kolkata has become the major trade Centre in India.

**Market diversity of Indian ornamental fish trade**

Singapore, USA, China Hong Kong SAR (Special Administrative Region), Malaysia and Japan are India’s favourite top five market destinations and accounts for about 70% of total exports from India. India’s favourite market destination is Singapore accounting for almost 42.85%, followed by Japan (13.88%) and Malaysia (9.97%). USA and China, Hong Kong, SAR, both accounting for 7.5% each. Others include Germany, United Arab Emirates, United Kingdom, Thailand and Netherlands.

During the year 2010-11, India Exported Ornamental Fish for 1.26 Million USD which is only about 0.3% of the Global trade. Port wise export of Ornamental fishes from India during the last 5 years is given in Table.1.

Table 1. ORNAMENTAL FISH PORT WISE EXPORT IN INDIA

Q: Quantity in tons, V:Value in ‘ Crore, $:USD(M)

| Port Name | | 2006-07 | 2007-08 | 2008-09 | 2009-10 | 2010-11 |
|---|---|---|---|---|---|---|
| CALCUTTA | Q: | 102.550.56 | 9 | 11 | 10 | 36 |
| | V: | | 1.98 | 2.68 | 2.76 | 3.34 |
| | $: | | 0.49 | 0.60 | 0.58 | 0.74 |
| CHENNAI | Q: | 281.570.35 | 33 | 22 | 22 | 8 |
| | V: | | 1.30 | 0.87 | 0.99 | 0.63 |
| | $: | | 0.32 | 0.20 | 0.21 | 0.14 |
| MUMBAI | Q: | 110.370.08 | 12 | 17 | 3 | 3 |
| | V: | | 0.46 | 0.58 | 0.55 | 0.66 |
| | $: | | 0.12 | 0.13 | 0.12 | 0.15 |
| JNP | Q: | 00.000.00 | 0 | 0 | 0 | 0 |
| | V: | | 0.00 | 0.00 | 0.00 | 0.01 |
| | $: | | 0.00 | 0.00 | 0.00 | 0.00 |
| MANGALORE/ICD | Q: | 40.190.04 | 10 | 10 | 14 | 8 |
| | V: | | 0.62 | 0.58 | 0.82 | 0.40 |
| | $: | | 0.15 | 0.13 | 0.17 | 0.09 |
| TRIVANDRUM | Q: | 20.090.02 | 2 | 2 | 2 | 2 |
| | V: | | 0.04 | 0.05 | 0.12 | 0.15 |
| | $: | | 0.01 | 0.01 | 0.02 | 0.03 |
| KOCHI | Q: | 190.780.17 | 23 | 8 | 6 | 10 |
| | V: | | 1.36 | 0.63 | 0.19 | 0.35 |
| | $: | | 0.33 | 0.14 | 0.04 | 0.07 |
| DELHI | Q: | 00.000.00 | 0 | 0 | 0 | 0 |
| | V: | | 0.10 | 0.03 | 0.07 | 0.00 |
| | $: | | 0.02 | 0.01 | 0.02 | 0.00 |
| CALICUT | Q: | 00.000.00 | 0 | 0 | 0 | 0 |
| | V: | | 0.00 | 0.00 | 0.00 | 0.00 |
| | $: | | 0.00 | 0.00 | 0.00 | 0.00 |
| BANGALORE | Q: | 00.000.00 | 0 | 0 | 0 | 3 |
| | V: | | 0.00 | 0.00 | 0.00 | 0.17 |
| | $: | | 0.00 | 0.00 | 0.00 | 0.04 |
| Grand Total | Q: | 755.551.23 | 89 | 69 | 56 | 70 |
| | V: | | 5.85 | 5.43 | 5.49 | 5.69 |
| | $: | | 1.45 | 1.23 | 1.16 | 1.26 |

(Source-MPEDA)

Major Centers of Ornamental fish exports in India are Kolkata, Chennai, Mumbai, Kochi and Bangalore. Kolkata along with adjoining districts has become the major ornamental fish producing zones of India and a major export centre. About 90% of Indian exports are from Kolkata followed by 8% from Mumbai and 2% from Chennai. (Ghosh et al., 2003). Most of the ornamental fish activities are concentrated in 5 Indian states viz. West Bengal, Maharashtra, Karnataka, Tamil Nadu and Kerala.

**Current position and scope of Ornamental Fish Diversity in India**

All the North-Eastern States, namely, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, are gifted with vast aquatic resources which are harbouring diverse ornamental fishes with immense commercial importance. The ornamental fishes are diversified over 37 families, 114 genera and 10 orders. Out of the total 274 fish species reported from this region, around 250 species (91 per cent) possess ornamental value. The major species having a large number of ornamental fishes belong to the Order Cypriniformes, followed by Siluriformes and Perciformes. It is estimated that nearly 200 species of ornamental fishes are exported from India, out of which 85 per cent are from the North- Eastern states (Nair, 2004). The market opportunities for the local ornamental fish species are rising gradually in both domestic and international markets. The price of native ornamental fishes varied from Rs 3 to Rs 50 per piece across the domestic market. Most of the native ornamental fish species from the North-Eastern region were highly preferred by the hobbyists across the globe (e.g., *Anabas testudineus, Botia, Danio*, etc.). Many of the highly preferred native ornamental fish species (e.g., *Balitora brucei, Botia berdmorei*, etc.) are becoming less abundant in the natural condition because of their over-exploitation or degradation of water bodies and need urgent attention for their sustainable utilization. Interestingly, due to lack of steady supply of common ornamental fishes, many new species (e.g., *Ailia coila, Anguilla bengalensis* etc.) were emerging as ornamental fishes and the trade opportunities in these species were expanding, which was an added advantage to sustaining the agribusiness opportunity of this industry. This category of potential ornamental fishes is a ready reference for an entrepreneur to explore the entrepreneurial opportunities. Although North-Eastern states produce a bulk of the India's ornamental fish exports, the region still remains relatively untapped for the development of ornamental fisheries.

Perhaps the opportunity of gainful employment underlines at all the levels of activities in the ornamental fish industry, viz. production, marketing and exports. Besides, the corporate sector must share the 'corporate social responsibility' through active participation in various conservation measures involved in the ornamental fisheries.

The Western Ghats, extending for over a length of 1600km. World conservation monitoring centre has identified Western Ghats as one of the important freshwater biodiversity hotspots. Western Ghats forms a major source for varieties of freshwater fishes in India. *Puntius sp. Parambassis thomassi* (Glass fish), *Horabagrus brachysoma*and *Horabagru nigricollaris* (Yellow cat fishes) have already secured a position in the national and international markets as ornamental fishes while the rest of the species have tremendous potential for their introduction as ornamental species. The water bodies of Kerala are blessed with more than 200 fish species resources. 104 species are potentially usable as ornamentals fishes with respect to attractive nature fascinating appearance and brilliant colouration, which could promote them as ornamental fishes in the domestic and international trade.

**Reference :**

B. Madhusoodhana Kurup, 2014.Current status and future of Indian ornamental fish industry. Souvenir. International Seminar on ornamental fish breeding, Farming and trade. Cochin.

# Integrated Fish Farming: With Agriculture & Animal Husbandry

S. N. Kunjir
Assistant Professor, Dept. of Fisheries Resources, Economics, Statistics & Extension Education
College of Fishery Science, Udgir, Dist. Latur.

**Introduction**

Integrated farming may be defined as sequential linkages between two or more agri-related farming activities with one farming as major component. When fish becomes the major commodity in the system it is termed as integrated fish farming (IFF). The integration of fish farming with agriculture and animal husbandry is considered as sustainable farming system, which offers greater efficiency in resource utilization, reduces risk by diversifying crop, provides additional income and food for small scale farming household.

The IFF is well recognized in Asian countries like China, Malaysia, India, Vietnam, Indonesia, Philippines and Bangladesh having tropical climate, and later countries like Hungary, Germany, Ghana accepted IFF as an alternative land use, livelihood option and is also promoted as strategy to improve nutritional standards.

The present types of IFF methods adopted by farmers are based on traditional knowledge and experience without proper planning, shortfall of latest technology and management techniques. With the practice of scientific IFF, the farmers need specialized training, introduction of high-yielding varieties, multi-cropping knowledge and innovation in farming to extract maximum output from the small land holding. In addition, marketing of produce, proper utilization of internal resources, mechanized farm machinery; climatic change and update knowledge of world trade criteria are some of the challenges faced by farmers. To overcome these constraints IFF is the only alternative to enhance production and productivity from existing agricultural land and water.

**Fish species in IFF**

- Indian major carp and exotic carp
- Medium and minor carps (*Labeo calbasu, L. gonius, Puntius sarana* and *Labeo fimbriatus, L. bata*)
- The carp species are also cultured under mixed system of freshwater prawn (*Macrobrachium rosenbergii, M. malcolmsonii*) or catfish magur (*Clarius batrachus*), singhi (*Heteropneustes fossillis*) or anabas (*Anabas testudinius*,) and murrels (*Channa marulius, Channa striatus, Channa punctatus*), *Ompok* and *Mystus* species with proper composition and ratio for optimum utilization of the organic resources.

**Types of IFF systems**

Integrated fish farming can be broadly classified into two, namely:

1. The agri-aquaculture based system:
   It includes paddy-fish, horticulture-fish, mushroom-fish, Seri-fish, vermicompost-fish system with aquaculture as major component whereas other agriculture practices taken as minor components.
2. The livestock-fish system:
   It includes cattle-fish, pig-fish, goat or sheep-fish, poultry-fish, duck-fish, rabbit-fish.

**Agri-aquaculture based system**

Paddy-fish system:

In paddy-fish integration, paddy fields retain water for 3-8 months in a year. The culture of fish in paddy fields, which remain flooded even after paddy harvest, serves an off-season occupation and additional income to the farmer. This system needs modification of rice fields, digging peripheral trenches, construction of dykes, pond refuge, sowing improved varieties of rice, manuring, stocking of fish at 10,000/ha and finally feeding of stocked fish with rice-bran and oilcakes at 2-3% of body weight. Fish culture in rice fields may be attempted in two ways, viz. simultaneous culture and rotation culture.

1. Simultaneous Culture

   For simultaneous culture, rice fields of 0.1 ha area may be economical. Normally four rice plots of 250 $m^2$ (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 dikes enclosing the rice plots may be 0.3 m high and 0.3 m wide and are strengthened by embedding straw. The ditches have connections with the main supply or drain canal, on either side of which, the rice plots are located, through inlet-outlet structures of the dikes. The depth and width of the supply or drain canal may be slightly smaller than that of the ditches. Suitable bamboo pipes and screens are placed in the inlet and outlet structures to avoid the entry of predatory fish and the escape of fish under culture. The ditches serve not only as a refuge 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 to 25 cm depending on the type of rice and size and species of fish to be cultured.

2. Rotational culture of rice and fish

   Through this practice, fish and rice are cultivated alternately. The rice field is converted into a temporary fishpond after the harvest. This practice is favoured over the simultaneous culture practice as it permits the use of insecticides and herbicides for rice production. Further, a greater water depth (up to 60 cm) could be maintained throughout the fish culture period.

Fishponds receive the crop residues as pond input. The ecological benefits are weed control, consumption of some pests and molluscs and bioturbation of soil-water interface.

**Advantages of paddy cum fish culture**

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-born diseases of human beings.
11. Rice fields may also serve as fish nurseries 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.

<u>Horticulture-fish system</u>:

The success of a horticulture-fish system depends on the selection of plants. The plants under vegetable and fruit varieties should be of dwarf type, less shady, evergreen, seasonal and remunerative. Dwarf varieties of fruit bearing plants such as mango, banana, papaya, and citrus are suitable. Pineapple, ginger, turmeric and chilly are used as intercropping plants. Seasonal varieties (summer) brinjal, tomato, gourd, cucumber, okra, watermelon, carrot, peas etc. and (winter) cabbage, cauliflower, carrot, beat, raddish, turnip and spinach are grown for better profitability. Plantation of flowers like tuberose, rose, jasmine, gladiolus, marigold, and chrysanthemum provides more remuneration to the farmers. Farming of oilcrops, black mustard, yellow mustard, sunflower, pigeon pea, soybean; green fodder *bajra*, berseem, *jowar* is also carried out on the broad middle portion of the dykes where the nutrient rich pond water irrigates these plants. In mixed culture practice of grass carp, rohu, catla, mrigal, silver carp and common carp in 50: 15: 15:10:5:5 ratio at a density of 7,500/ha yielded fish to the tune of 4,000-5,000 kg of fish fed with dyke grown green fodder.

<u>Mushroom-fish system:</u>

Four types of mushroom popular in India, belong to *Agaricus bisporus* (white button), *Volvoriella sp*. (paddy straw), *Pleurotus* sp. (oyster) and *Calocybe indica* (milky). Mushroom cultivation requires high degree of humidity, which is fulfilled from aquaculture environment. The paddy straw after mushroom cultivation becomes rich in protein; Compost of mushroom bed known as spent mushroom substrate could be used in aquaculture and agriculture.

<u>Sericulture-fish system:</u>

Sericulture in rural India is an agro-industry to produce silkworm and silk from cocoon. The process of cultivation starts with mulberry plants. In return, the waste product from sericulture practices like silkworm pupae, faeces and wastewater from processing facilities could be used as a nutrient input in aquaculture. In this integration, worm eats the mulberry plants leaves converting to cocoon releasing nutrient rich faeces ingested by fish directly. 75% of mulberry leaves consumed by the silkworm will produce huge quantity of excreta. Remaining 25% unconsumed leaf debris with the generated excreta are dumped in fishpond consumed by fish. Mulberry planted dykes yield leaves at 30 tonnes/ha/year; when fed to silkworm, produced 16-20 tonnes of waste supplied to silk worm. In 1 ha mulberry-fish project, a production of 2-3 tonnes/ha/year of fish is expected from this IFF system.

Vermicompost-fish system:

Compost that is prepared with the help of earthworm is called vermicomposting. Some commonly used earthworms in India are *Eisenia foetida*, *Eudrillus euginea*, *Perionyx excavatus*, *Lumbricus rubellus, Pheretima elongata, Lampito maurita* etc. Owing to its high nutrient content and minerals, this becomes fertilizers in fishponds. Fresh earthworms contain 8-10% protein and dry earthworm 56-66%. Earthworm with higher nutritive value and energy content is used in chopped condition as feed of carnivorous catfish like magur, singhi, murrels, *Anabas* sp. and freshwater prawn. It has been seen that 1 kg of earthworm produces 10 kg of compost in 60-70 days.

Aquatic weed-fish system:

Aquatic weed-based fish system integrates various types of aquatic plants as feed source for herbivorous fish. Grass carp the exotic fish, directly consumes duckweed belonging to family Lemnaceae commonly known as *Lemna, Wolffia, Spirodela* and water fern Azolla. In aquatic weed-fish polyculture system, herbivorous fish (grass carp; 50%) with other fish (rohu, catla, mrigal, silver carp, common carp; 10% each) in stocking density of 6,000-8,000 fry/ha, fetches production over 5-6 tonnes/ha/year of marketable size fish. Azolla, is a nitrogenous biofertilizer on the water surface in fishponds producing nitrogen, phosphorus and potassium. Due to high protein content (13.0-30.0%), use of Azolla as feed ingredients is of special interest in aquaculture system. *Spirulina*, is a blue green algae with high biomass production rate known as “wonder gift of nature”. It has crude protein content (62.5-71.0%) on dry weight basis. Being an aqua-product, *Spirulina* incorporated diets show higher growth and play important role in augmenting the pigmentation of ornamental fish.

**Animal husbandry-fish based system**

Cattle-fish system:

Fish farming using raw cow manure is one of the common practices all over the world. A healthy cow weighing 400-450 kg excretes over 400-500 kg of dung and 3,500-4,000 litres of urine on annual basis. Due to its quick sinking ability, the nutrients available are responsible for increase in natural food organisms detritus and beneficial bacteria in fishponds. Edible non-digested feed of cow dung is consumed directly by fish. The faeces and urine is extremely beneficial for filter feeding and omnivorous fish such as catla and silver carp. A unit of 5-6 cows can provide adequate quantity of dung and urine to produce 3,000-4,000 kg of fish per ha per year. With these types of integration, 9,000 litres of milk and fish harvested from the system became most popular among rural household. The shed of cattle, built on the dykes or near the pond helps in easy disposal of urine and dung into pond simplifying handling problem. The fresh dung and urine collected separately can be applied periodically @ 10 tonnes/ ha/year to culture ponds.

Pig-fish system:

A floor space of 3-4 $m^2$ is required for a pig weighing 70-90 kg. The popular exotic pig breeds that are preferred by farmers for rearing are White Yorkshire, Landrace and Hampshire. The pig dung and urine is utilized for fertilization of culture ponds. A full-grown pig provides 500 to 600 kg of dung in a year and excreta of 40-45 pigs provides required quantity of manure to fertilize 1 ha pond. Pigs attain slaughter size (60-70 kg) within 6 months.

In fishpond, the application of pig dung enhances nutrient for dense bloom of phytoplankton and zooplankton. Polyculture practice of fish with Indian major carp and exotic carps is undertaken in fish-pig farming ponds. Fish harvest results in 3-4 tonnes/ha without any feed and fertilization in 12 months culture period at the stocking rate of 8,000-8,500 fingerlings/ha.

<u>Goat-fish system:</u>

Goal/sheep farming is an age-old practice by rural people for meat, milk and manure. Goats are selective feeders and relish on green fodder berseem, napier grass, cowpea, soybean, cabbage, cauliflower leaves, lettuce. Leaves of shrubs, Acacia (babul), *Azadirachia indica* (neem), *Ziziphus mauritianci* (ber), *Tamarindus indica* (tamarind), *Ficus religiosa* (papal) and mulberry, are consumed by goats. Goat excreta is a very good organic fertilizer applied directly in fish pond as manure. An adult goat weighing about 20 kg discharges 300-400 g excreta on daily basis. For manuring 1 ha water area, 50-60 goats herd are needed. This integration could produce 3.5-4 tonnes/ha/year of fish without supplementary feed or fertilizer in pond. These types of IFF produce fish and 750-900 kg goat/sheep meat.

<u>Rabbit-fish system:</u>

60 varieties and breeds of rabbits are recognized throughout globe. Important meat producing breeds are Soviet Chinchilla, Grey Giant, White Giant, New Zealand White etc. whereas wool types breeds are Russian Angora and German Angora.

Rabbits are reared in cage, hutch and floor system. The manurial potential of excreta of rabbit with high nitrogenous content l0 times higher than cow dung.

<u>Poultry-fish system:</u>

Poultry fish system provides poultry droppings and litter into fishpond and acts as a fertilizer source for production of fish. In fish-poultry system, birds have to be housed in intensive, semi-intensive and extensive system. Birds are reared in pens and about 0.3-0.4 $m^2$ space is provided for each bird. The floor is covered with litter prepared with chopped straw, dry leaves, sawdust or groundnut shells. Selection of birds depends on the utility such as meat type (broilers), egg type (layers) or fancy type, and is integrated with fish. Egg production and weight gain and local breed are important criteria for selection. Marketing of broilers starts after 5-6 weeks of rearing when birds weigh 1.2- 1 .5 kg. One adult chicken produces about 25-30 kg of compost poultry manure in a year. For 1 ha water-bodies 1,000 birds produce sufficient manure with 90,000-100,000 eggs and over 1,500 kg of meat per year while broiler rearing provides over 1,500 kg meat/batch. At least 5-6 batches can be reared in a year. A production of 3,000-4.000 kg of multispecies fish could be harvested from such system.

<u>Duck-fish system:</u>

Duck-fish integration is very common in some parts of Indian states like Andhra Pradesh, Odisha, West Bengal, Bihar, Kerala, Tamil Nadu, Karnataka and North-East states like Asom, Manipur, Tripura, Mizoram etc.

In duck-fish integration, the houses are built in the middle of the pond or on the pond dykes or in a centralized system or in floating house. In pond dykes, the house is built with sufficient sunlight and protection from rain. In open water system large number of ducks are left in large water-bodies like lakes and reservoirs during daytime while they are kept inside the sheds during night.

Day-old ducks are available for rearing in duck shed. Once the ducks attain a size of more than 150 g. they start searching food from the ponds. During growing period, duck consumes snails, earthworm, aquatic insects, aquatic weeds and predatory fishes. Duckweed *Wolffia* is consumed by ducks during younger age whereas Lemna, Spirodela and Azolla are preferred during grown up stages. It has been advantageous that fish fry (1.5-2.0 inch or 3.8-5.04 cm size) may be stocked in pond when one-day-old ducklings are reared in the IFF.

The duck starts laying eggs after 6 months of age and continues for 2-3 years depending on the duck species, nutrition, health and environment. Since egg laying is in the nighttime, there is no possibility of an egg laid when birds are in ponds.

Multi-species culture of fishes with rearing period of one-year yield fish ranging from 3,000-4,000 kg/ha/year is expected from this types of IFF in addition to 4,000- 6,000 eggs and 500-750 kg duck meat on annual basis at the stocking rate of 200-300 ducks for 1 ha pond. The income generated from eggs and meat covers the rearing and feed cost of duck whereas the monetary value obtained from fish sale becomes profit in these types of IFF without any investment for fish.

**Reference:**

Ayyappan, S., Moza, U., Gopalakrishnan, A., Meenakumari, B., Jena, J. K. & Pandey, A. K. 2011. Handbook of fisheries and aquaculture. Directorate of Information and Publications of Agriculture, Indian Council of Agricultural Research, New Delhi, 22.

# Different fishing crafts & gears used in inland water

A. T. Markad
Assistant Professor, Dept. of Fisheries Engineering
College of Fishery Science, Udgir, Dist. Latur.

India is one of the leading countries in the world in inland water fish production with tremendous scope for further increment. India stood second in inland fish production next to China. The inland fishery resources of the country are diverse and vast including 29000km of river systems, 3.15 million ha reservoirs, 0.72 million ha upland lakes and 0.19 million ha of brackish water and lagoons. These inland water resources harbor rich and varied aquatic species including commercially important fish species suchas Indian major carps, mahaseer, minor carps, snow trouts, peninsular carps, catfishes, prawns, crabs,featherbacks, murrels and a number of exotic species.

In fact, the success of fisheries in a country depends upon proper harvesting of its fish fauna and can be achieved through applying proper fish harvesting using modernized fish harvesting tools and methods. Number of fishing crafts and gears has been designed in India but probably remained static and shown little or no change or improvement in India unlike in other maritime countries.

**Inland crafts:**

Before the advent of mechanization man living on the shores of oceans and banks of estuaries, was nourished by the fish that could be captured by using what even the craft that he would use. In most countries usually indigenous, non-mechanized and locally built crafts are in vogue. These crafts have been design to suit the local conditions the population captured.The types of fishing crafts of India falls under two general categories. These are non-mechanized and mechanized fishing crafts. The categories of fishing craft types comes under non-mechanized are catamaran, dugout-canoes, plant built canoes, masula boat, built up boats. The mechanized crafts are line boats, trap boats, dol-netter, Gillnetter and trawlers. Some of the important fishing crafts used in inland waters in India as well as in other countries arediscussed below.

1. **Coracle:**


Coracle is one of the major fishing craft used in peninsular India. These are dominant in the reservoirs of South India like Tungabhadra (Karnataka), Mettur(Tamil Nadu) and NagarjunaSagar (Andhra Pradesh). Coracles are large wide mouthed circular flat bottomed baskets. It measures about 4 m in diameter at the mouth, the bottom being smaller. The coracles are simple, inexpensive, durable and easy to maneuver.

2. **Thermocol craft**:

Easy and simplest craft used in the inland waters, wherein thrmocol sheets are tied together to form a platform. Such crafts are used in gillnet operations in the reservoirs.

3. **Inflated Rubber tubes**:

Inflated rubber tubes are widely used by the marginal fishermen in the fishing operations. These are generally used in the small water bodies to undertake small scale fishing operations such as gill net operation, line fishing, etc.

4. **Catamaran:**

Catamaran is constructed by tying wooden logs together with the help of ropes and are propelled by split bamboo oars and sails. Size varies from 6.5-7.5 m and design as well as number of logs varies according to region. Catamaran arecommonlyused in NizamSagar and HussainSagar reservoirs of Andhra Pradesh and Mettur reservoir of Tamil Nadu.Bamboo mast is used with triangular sail.

5. **Dugout boats:**

Small dugout canoes are operated in the reservoirs of Madhya Pradesh, Tamil Nadu, Bihar, Manipur and Tripura. Single logs of trees like Mango and Aini are scooped for its construction. They are propelled by paddles and sails. Sails are either square or sprit type. No rudder is used. Steering is by means of big paddle on one side.

6. **Plank built boats:**

These are also called ***dinghis*** and are predominantly used in the different fishing operations in the Indian reservoirs.These boats are built with planks sewn with ropes and are propelled by means of paddles and occasionally sails. These boasts are used in the different fishing activities ranging from gill net and cast net operation to the transportation of material.

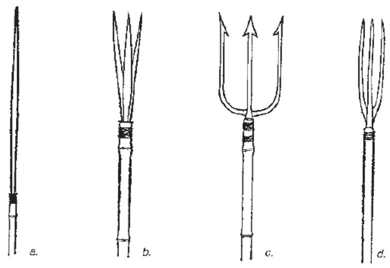
7. **FRP boat:**

FRP boats are getting famous pertaining to its cost effectiveness, ease of preparation, durability, etc. FRP boats are constructed in moulds as per the requirement. These boast are used with or without outboard engines. These boast can be used in large scale commercial operations as well.

**FISHING GEARS:**

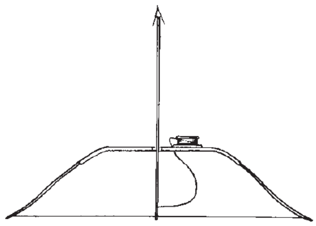
Selection of fishing methods and gears are influenced by various factors such as nature of fish stock, characteristics of raw material from which gears are fabricated and standard of living of the community. The fishing methods used are results of experiences gained over a period of time and are related to the topography of fishing ground.

1. **Spears:**



The fishing spear in its simplest and most primitive gear and has certainly been known for over 10000 years. Using a spear in water, is not as easy as it is on land. The refraction of light in the water must be allowed for, and it needs experience to compensate for it exactly. Spears range from the simple pointed hardwood stick to the more complicated many-pronged spears. When a fish is speared it can escape from a simple point by vigorous wriggling and twisting, but escape can be prevented by barbs. Barbs are a feature used not only for fishing spears but also for the construction of various other gear. Without a barb, a spear is more generally called a lance. The fishing spear may have a single barb on one side; there may also exist several such barbs arranged in a row along the point of a spear.

2. **Bow and arrows:**



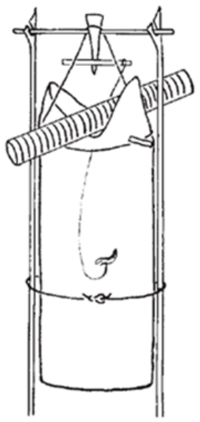
A small arrow is shot from bow and on release it is projected at much higher velocity than a spear thrown by hand. Generally, slow-swimming fish were preferred for this method and shots were usually made from 5–6m away, as shooting a fish from a greater distance than this was considered too difficult. As in spearing, shooting fish with a bow and arrow requires clear water and an appropriate allowance for the refraction of light. Not only fish are shot with bow and arrow; but sometimes also crabs and other water animals, even sea mammals, are hunted. In modern times, archery became a sport.

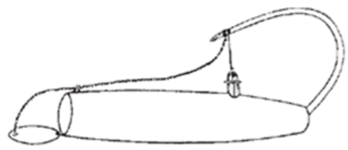
3. **Traps:**

a. **Mechanical traps:**

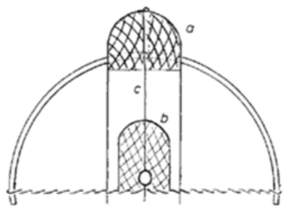
These are similar to mouse traps where the victim itself releases a mechanism which prevents its escape.

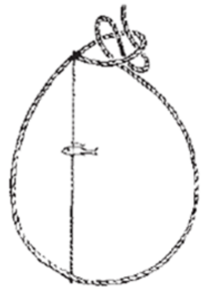
1. Gravity traps or box traps
2. Bent rod traps
3. Torsion traps
4. Snares





2.



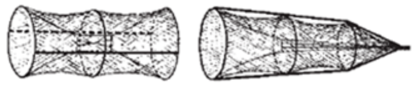


In gravity traps, weight is suspended which when released by the fish prevents its escape. The elastic power of a bent rod is made use of in bent rod traps. In torsion traps, the strength of twisted twine is used to close the trap.

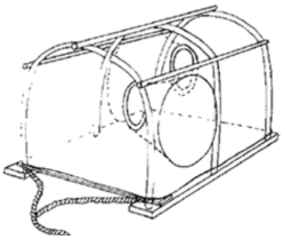
b. **Baskets traps:**

These traps mostly have small entrance and are made of wood, wire, netting, plastic, etc. Fyke nets are made of netting and are normally used in shallow water. These traps consist of cylindrical or cone- shaped bags mounted on rings and are provided with wings or leaders which guide the fish towards the opening of the bags.

1. Pots (made of wood or wire or plastic, mostly without wings and leaders)



2. Conical and drum-like traps (made of netting with hoops and frames; mostly with wings and leaders; sometimes fyke nets combined in a catching system)

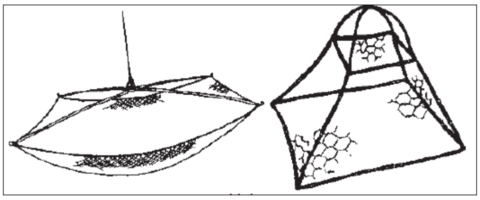


3. Box-like traps (made of strong, mostly iron, frames)

**4. Dip Net:**

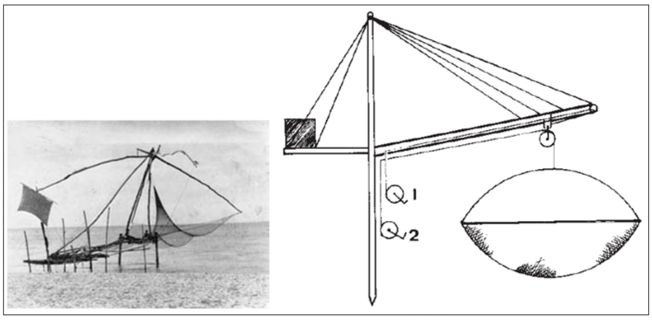
The manner of capture in dip nets is to bring the prey over a flat or more or less bag-like netting and then by lifting the gear submerged at the required depth either by hand or mechanically i.e. by levers, beams and winches from the shore or from a boat. The opening of the gear faces upwards.

**a. Hand dipnets:**



Small dip nets are operated with hand with no fixed installation. These are mostly used to catch crabs.

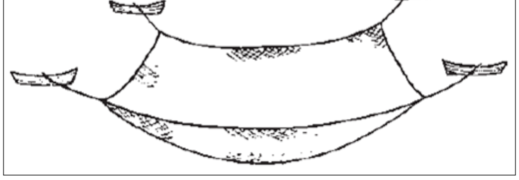
**b. Chinese dipnets**



Larger dip nets which cannot be operated by hand are handled by stationary but mostly mechanized installations situated along the shore. Chinese dip nets operated along Kerala backwaters is a famous example of a mechanized dip net. This operates on the principle of a lever.

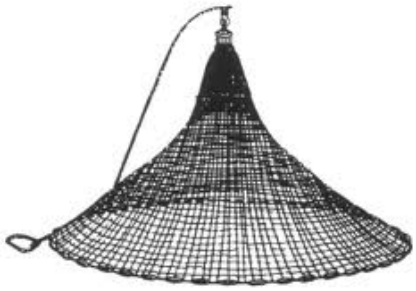
It is a stationary lift nets used in Asia and usually called 'Chinese lift nets' or Chinese Dip Net, work on the lever principle. The net is balanced by counterweights so that it can be pivoted for dipping and lifting. Such nets set on the beach may be found on the South Indian Malabar coast, where they were apparently brought by the Portuguese. During the night, lamps are hung at the crossing point of the rods to attract the fish. Depending on the current, this fishing lasts until noon. After the netting has been skillfully folded, the fish are removed by means of a long-handled scoop net. This has to be carried out very quickly as otherwise the crows which abound there steal the fish from the net.

**c. Blanket nets**



These are larger lift nets which cannot be stretched by frames or rods but are held by some other means like rammed-down piles on the shore or in shallow water. They can be operated as a stationary gear or on a boat as movable gear.

**5. Cast Net:**



A quite different type of falling net is represented by the cast nets. Generally these are circular nets which, as the name implies, are thrown. They have to be thrown or cast with great skill in order to fall flat upon the water's surface. Then, quickly sinking by reason of their weighted edges, they fall over the fish that has been seen or is supposed to be there. Hand cast nets are today widely used all over the world.

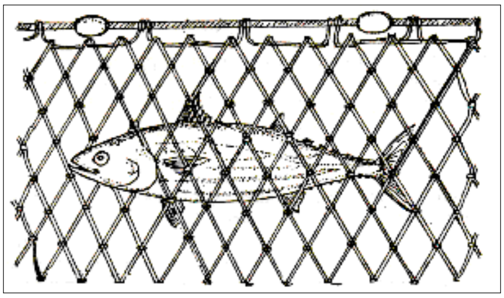
Cast nets usually have a central retaining line, which is held in the hand for hauling the net. But there are some cast nets without central line. Then, the fisherman must dive in water after casting, in order to haul the net. Even if there is a central line, the fishermen may dive in to arrange the nets in the right position at the bottom of the water to prevent any fish, which are perhaps not quite covered, from escaping during the hauling the net.

**6. Drag Net:**

This group contains all bagnets or net walls which are towed through the water on or near the bottom or even pelagically for an unlimited time. The manner of capture is by filtering the passive prey by the active moved gear.

Drag net is a wall like structure and was mostly used for fishing in ponds. To keep the net in vertical position, head rope is provided with floats and the foot rope with sinkers. The length and height of the drag net varies according to the size and depth of the water reservoir. The fisherman holds the foot rope in foot and raises the head rope over the water. The net is dragged in the water body and the stretched net restricts the escape of the fish to the other end of the pond. Ends of the net are brought close from both the sides and the fishes are collected.

**7. Gillnet:**



It is a highly selective fishing gear and fishes are caught by gilling. They are vertical walls of netting kept erect in water column by means of floats and sinkers and set perpendicular to the direction of movement of target fish. Because of its selective nature, gill netting is one of the most suitable fish catching methods from the conservation and stock regulations point of view. It is a passive fishing method and the gear can be operated from even the most primitive craft. Gill nets and entangling nets are suitable for sparsely distributed and scattered fish populations. However, only quality fishes like seer, tuna, pomfret, lobster, mullets, salmon, sardine, mackerel, etc. are caught by this method.

Gill net is a long wall of webbing kept suspended in water by means of floats on the head rope and sinkers on the foot rope. The mesh size of the net is calculated in such a way that the fish can pass its head but not the body. A simple gill net may consist of the following parts, as illustrated in following figure.

**8. Line fishing (Hand Line):**

Hand line fishing operation, barbed hook is fixed to the long monofilament line and placed in the water body. Hooks are generally baited with earthworm, mussel or similar meat. Flexible bamboo orfibreglass pole (fishing rod) may be used to hold the line. The baited hooks are place in the water body. Fishes lured by the bait gasp the bait along with hook and gets entangled. The barb of the hook prevents the escape of fish.

# Proper Handling and Transportation of Fish

A.T.Tandale
Assistant Professor, Dept. of Fish Processing Technology and Microbiology
College of Fishery Science, Udgir, Dist. Latur.

Fish is a quickly perishable commodity and is spoiled if it is not properly preserved. The place of consumption is generally at a distance from the landing or catching point, and fish if it is to be marketed fresh, needs fast transport and cooling facilities. During peak period large quantities of fish are caught and need proper preservation so as to be available in lean period, and have to be transported to market at long distance from consumption.

Fish flesh is mainly composed of protein, fat, mineral and vitamins, with a high percentage of water. Fish is very valuable source of protein which is easily digestible due to percentage of connective tissue. All the essential amino acids present in fish flesh in sufficient quantities. It is also a rich source of iodine, phosphorous and vitamin A, B and D. Fish, therefore, is a very valuable food. When alive in water, fish carries large number of bacteria on its body, gills and in the gut. Soon after the death of the fish, these bacteria start reproducing and attack various organs, so that the preservation of the fish has to be done without loss of time.

**CAUSES OF SPOILAGE OF FISH:**

Fish spoils mainly due to three factor: bacterial action, enzymatic action and chemical action. Of these, spoils due to chemical action occurs in fatty fish only, like sardines, mackerels, catla etc. the oil of such fishes is oxidized by atmospheric oxygen resulting in discolouration of the fish. The body of fish becomes brownish in colour, and has a bad odour due to certain decomposition products of fat. This is also called 'rancidity', and can be controlled to some extent by soaking the fish in antioxidants, or by glazing it. Quite a large number of fish are spoiled due to action of digestive enzymes which remain active even after the death of the fish and soften the flesh by autolysis. Bacteria are the most important in causing spoilage. A large number of bacteria present on the body, gills and gut, the fish find a good medium for development due to high moisture (75-80%) contents in the fish flesh. More bacteria are added during handling and storage in unclean places. Fishes get cuts abrasions during catching operations, leading to haemorrhage. These provide an ideal condition for bacterial activity which is most destructive to the fish.

During spoilage, enzyme and bacteria act upon various proteins and non-protein nitrogenous compound of fish flesh, breaking them into simpler substance like ammonia, carbon-di-oxide, various amines and volatile fatty acids. In advanced stage of putrefaction, certain compounds like indole and hydrogen sulphide with foul odour are also produced. Spoilage occurs in stages probably due to action of different groups of bacteria. Fresh fish flesh is slightly acidic with pH of 6.4, but a spoiled one becomes alkaline with pH exceeding 7.6. Thus the stage of spoilage can be estimated by measuring the pH of the flesh. However, for a layman, a fresh fish can be recognized by the following characters:

(1) The flesh of the fresh fish should be stiff and not flabby and soft.
(2) When touched, finger prints are not left on the surface.
(3) The eyes are glistening and not opaque.

(4) The gills are bright red in colour.
(5) The smell of the slime and gills is fishy.
(6) The vent should not be protruding.

**RAW MATERIAL COLLECTION SYSTEM:**

Fisherman or farmers rarely deliver their catch to the industry directly. The collection of raw materials passes through a private channels, the structure of which varies from area but in general can be divided as follows:

1. Primary landing/ collection centre
2. Secondary landing/ collection centre
3. Higher secondary landing/ collection centre
4. Final stage of delivery to industry

Most of the landing, collection and wholesale centers are not properly equipped or not provided with adequate facilities for fish handling. The sanitary conditions are also not good. In most cases, there are no supply of clean water and ice. The facilities for preservation are also unsatisfactory. The problem of landing, collection, and distribution are summarized as follows:-

1. Lake of landing facilities.
2. Over flooding of landing and sales areas during rainy season.
3. Dirty floor or earthen floor.
4. No facilities of washing or inadequate washing system.
5. Insufficient auction yard or none at all.
6. No packing space.
7. No access for vehicles.
8. No proper weighing equipment.
9. No Insufficient storage of ice or none at all.
10. No chilling system.
11. Irregular supply of electricity or non chilling system.
12. Inadequate drainage system.
13. Lack of quality consciousness.
14. No insulation or refrigerated transport to distribute the raw material in good condition to the processing plant.

**HANDLING, PRESERVATION AND TRANSPORTATION OF FISH**

In India the marine captures fish production is very large and it is landed at specific places (Harbour/ landing center). Such large captured raw material needs various preservative techniques for keeping them in good condition for longer duration. While in case of fresh water fish production, reservoirs, dams, culture site etc. are located at different places and whatever catch we get do not need to preserve by using various preservative methods such as drying, salting, freezing, canning etc. as harvested material easily get sold in nearby local market. Some time fish farmers also harvest the fishes as per the demand. Apart from this also fresh water fishes can be transported to any part of the country for selling within four to five days. So special consideration should be given to such method that would be suitable for four to five days journey period and that is nothing but icing.

**Use of ice:** Lowering of temperature to about $O^0$c is the most effective method of preventing putrefaction and extending the life of the fish. Hence, large amount of ice is used to lower the temperature of the fish. Large fishing vessels are provided with such facilities. Alternate layers of ice and fish must be arranged to bring down the temperature of flesh to about $O^0c$. In the large fishes, ice must be applied in abdominal cavity after gutting. Antibiotics like Aureomycin and Terramycin can be incorporated in the ice to inhibit the growth of bacteria under the guidance of expert. Chilled fish have to be stored properly at a constant temperature nearing the freezing point, and the atmosphere should be saturated with water vapour to prevent dessication.

The most important principle of preservation of fish is cleanliness and sanitation. This is the most essential requirement to keep the bacteria in check. The fish soon after caught should be washed with clean, cold water to remove bacteria slime, blood, faeces etc. The fish must be gutted to remove the alimentary canal and other internal organs and washed. This would check the effect of digestive enzymes and bacteria of the gut, which cause spoilage of the fish. The fish should be stored and handled under sanitary conditions. The warm climate of the tropical countries provides the most suitable condition for the multiplication and growth of the bacteria. If the temperature is low, the growth is slowed down. Hence, fish are kept at low temperature to prevent the spoilage.

**Handling and Transportation of fish:**

The mode of transportation of fresh fish depends upon the distance to be covered, quantity of fish, facilities available for quick and safe dispatch and expense involved. Road, rail and water transport are used to carry fish to distant places from landing or collecting centers. In case of marine transport, mechanized boats with insulated fish hold are in use. But on land, road transports are mainly used as it considered the safe and speedy. The time required to reach the destination varies widely according to location.

Conventional containers for transportation include, bamboo baskets, wooden boxes or second hand tea chest made of plywood, thermacol boxes, Aluminum or galvanized iron vessels are also used. Recently plastic containers have become very common as they are non corrosive, reusable non-conducting, light weight and are available in variable size. Usually banana leaves, seal leaves, hogalmat and hessian are used as insulating material which affects the keeping quality of raw material.

**Bamboo baskets:**Bamboo baskets are more commonly used for transport of fish, they can be made in large, shallow or deep types in varying sizes, suitable for holding 40-100 kg material. Containers can be wrapped in gunny and sewed after packing fish and ice (1:1). Maximum duration of transportation of iced fish is 16 hrs.

**Disadvantages:**

1. Do not possess adequate mechanical strength.
2. Get deformed under stacking loads.
3. Fish in lower stacks gets crushed.
4. Sharp edges of bamboo may cause bruises on fish.
5. Poor insulated properties.
6. Less durable.
7. Not hygienic, and pilfarege during transport is easy.

To improve the functional properties of bamboo basket, it can be lined inside with 200/300 gauge polythene and exterior wrapped gunny and firmly secured by sewing.

**Boxes:** Boxes made up of wood or plywood can be used for transportation of iced fish (1:1) for 20 hours. T-chest of 45.5 X 45.5X 45.5 CM (capacity 80 Kg Ice and Fish) and 58.5 X 58.5 X 58.5 cm (capacity 110 Kg fish and Ice).

**Disadvantages:**

1. Not cleaned or dried.
2. Loss insulation properties when wet and become heavy.
3. Prone to heavy bacterial load, causing problem for reuse.
4. Collection and repair of boxes involves additional cost.

To improve the property of boxes 25 mm thermacol slab is provided on all side of box in sealed polythene bags (of 200 gauges to prevent the wetting of thermacol). This insulated plywood box can be used for transportation of iced and frozen fish.

**CONTAINERS FOR LONG DISTANCE TRANSPORTATION:**

1. Used plywood boxes (used tea-chests) provided with 2.5 cm thick foamed polysterene (in polythene sleeves) on all sides ideal for transportation for 60 hours.
2. For areas not covered by direct rail/road, transported by air economical, if 50%concession in freight charges, as provided by railways, is extended.
3. Insulation corrugation polypropylene containers keep chilled fish in good condition for 60 hours. Can be used for minimum of 5 trips. Can be collapsed and light in weight.
4. Emptied containers can be returned without incurring much expanses.
5. Rigid high density polythene (4mm thick), containing 20mm thick polyurethane foam inside, keep chilled fish for 60 hours in good condition. Cost of container is comparatively high.

A number of factors associated with the system of transportation contribute to the deterioration of raw materials is as follows,

1. Non availability of ice
2. Insufficient supply of ice.
3. Lack of proper insulation material.
4. Inadequate packing.
5. Lack of sanitation.
6. Dependence on traditional transport systems.
7. Lake of mechanization of the system
8. Lake of quality consciousness.

Since fish is a highly perishable commodity, the care is must be taken during handling to reduces the spoilage of fish. The quantity and acceptability of the product very much depend up on the raw material. The qualities of the product reaching the ultimate user have relation that how it was handled, preserved, transported etc. So, primary responsibility to ensuring the quality of landed fish handling, transportation and aspects is very much essential for upgrading the quality of the end product.

| LIST OF RESOURCE PERSONS | |
|---|---|
| NAME & ADDRESS | NAME & ADDRESS |
| **Dr.Gaurav Rathore**<br>Principal Scientist<br>Central Institute of Fisheries Education<br>Off Yari Road, Versova, Mumbai<br>E-mail: rathodcifa@gmail.com | **Dr. S.D. Naik**<br>Professor & Head<br>Dept. of Fish Processing Technology and Microbiology<br>College of Fisheries, Shirgaon, Ratnagiri<br>E-mail: Sdn2003@yahoo.co.in |
| **Mr. B. R. Kharatmol**<br>Associate Dean<br>College of Fishery Science, Udgir<br>E-mail: brkharatmol@rediffmail.com | **Dr. A.S. Mohite**<br>Professor & Head,<br>Department of Fisheries Engineering,<br>College of Fisheries, Shirgaon, Ratnagiri.<br>E-mail: ashishmohite@yahoo.com |
| **Mr. V. B. Sutar**<br>Assistant Professor<br>Dept. of Fisheries Hydrography<br>College of Fishery Science, Udgir<br>E-mail: vijaysutar08@gmail.com | **Dr. B.R. Chavan**<br>Associate Research Officer<br>MBRS, Ratnagiri<br>Email; brc15672@gmail.com |
| **Mr. A. T. Markad**<br>Assistant Professor<br>Dept. of Fisheries Engineering<br>College of Fishery Science, Udgir<br>E-mail: kiran.markad@gmail.com | **Dr. A. S. Kulkarni**<br>Assistant Professor<br>Dept. of Fisheries Resources, Economics, Statistics and Extension Education.<br>College of Fishery Science, Udgir<br>E-mail: askulkarni12@yahoo.co.in |
| **Mr. S. R. Yadav**<br>Assistant Professor<br>Dept. of Aquaculture<br>College of Fishery Science, Udgir<br>E-mail: som_fish@rediffmail.com | **Mr. A. T. Tandale**<br>Assistant Professor<br>Dept. of Fish Processing Technology and Microbiology<br>College of Fishery Science, Udgir<br>E-mail:nilkranti@gmail.com |
| **Shri S.S. Gangan**<br>Asstt. Research Officer,<br>Taraporwala Marine Biological Research Station,<br>New Administrative Building, Bandra,<br>Mumbai - 400 051, Maharashtra.<br>E-mail: shardul76@rediffmail.com | **Mr. S. N. Kunjir**<br>Assistant Professor<br>Dept. of Fisheries Resources, Economics, Statistics and Extension Education.<br>College of Fishery Science, Udgir<br>E-mail:snkunjir@gmail.com |
| **Mr. U. A. Suryawanshi**<br>Assistant Professor<br>Dept. of Fisheries Biology<br>College of Fishery Science, Udgir<br>E-mail: u_suryawanshi@yahoo.com | **Mr. M. M. Girkar**<br>Assistant Professor<br>Dept. of Fisheries Hydrography<br>College of Fishery Science, Udgir<br>E-mail:milindgirkar@yahoo.com |

| LIST OF PARTICIPANTS | |
|---|---|
| NAME & ADDRESS | NAME & ADDRESS |
| Shri. R.S. Kamble<br>Assistant Fisheries Development Officer,<br>Aurangabad. | Shri. Suresh R. Bharati<br>Assistant Commissioner of Fisheries,<br>Nanded. |
| Shri. D. R. Dhope<br>Assistant Fisheries Development Officer,<br>Aurangabad. | Shri. B. N. Nade<br>Assistant Fisheries Development Officer,<br>Latur. |
| Shri. B. S. Tumbare<br>Assistant Fisheries Development Officer,<br>Aurangabad. | Shri. J. M. Shaikh<br>Assistant Fisheries Development Officer,<br>Latur. |
| Shri. S. P. Gotephode<br>Assistant Fisheries Development Officer,<br>Morshi, Dist. Amravati. | Shri. B. S. Kamble<br>Assistant Professor in Zoology,<br>Maharashtra Udayagiri Mahavidyalaya,<br>Udgir. |
| Shri. A. A. Khan<br>Assistant Fisheries Development Officer,<br>Fish Seed Production Unit, Katepurna- Mahan,<br>Tal. Barshitakli, Dist. Akola | Dr. P. S. Shete<br>Assistant Professor in Zoology,<br>Maharashtra Udayagiri Mahavidyalaya,<br>Udgir. |
| Shri. M. V. Jaiswal<br>Assistant Fisheries Development Officer,<br>Fish Production Unit,<br>Koradi. Tal. Mehkar, Dist. Buldhana. | Shri. A. N. Joshi<br>Fisheries Development Officer,<br>Latur. |
| Dr. S. T. Patil<br>Principal & H.O.D. of Zoology,<br>Shivaji Mahavidyalaya, Udgir. | Shri. H. R. Biradar<br>Assistant Fisheries Development Officer,<br>Osmanabad. |
| Dr. Sanjay D. Niture<br>Assistant Professor in Zoology,<br>Shivaji Mahavidyalaya, Udgir. | Shri. Balasheb V. Sagar<br>Assistant Professor<br>College of Food Technology, Udgir. |
| Dr. Usha Sitaram Dhaswadikar<br>Assistant Professor in Zoology,<br>Shri. Hawagiswami Mahavidyalaya, Udgir. | |