Recent Developments in Integrated Fish Farming

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MESSAGE

National Institute of Agricultural Extension Management (MANAGE), Hyderabad is an autonomous organization under the Ministry of Agriculture & Farmers Welfare, Government of India. The policies of liberalization and globalization of the economy and the level of agricultural technology becoming more sophisticated and complex, calls for major initiatives towards reorientation and modernization of the agricultural extension system. Effective ways of managing the extension system needed to be evolved and extension organizations enabled to transform the existing set up through professional guidance and training of critical manpower. MANAGE is the response to this imperative need. Agricultural extension to be effective, demands sound technological knowledge to the extension functionaries and therefore MANAGE has focused on training program on technological aspect in collaboration with ICAR institutions and state agriculture/veterinary universities, having expertise and facilities to organize technical training program for extension functionaries of state department.

In India, integrated farming systems have emerged as a result of a rising demand for land and water. The foundation of integrated farming is the idea that by combining two or more production systems, farm profits can be maximised. The production of a greater variety of agricultural products, an increase in cash incomes, an improvement in the quality and quantity of agricultural products, a decrease in pollution, and a more effective exploitation of resources that would otherwise go unused are all benefits of this synergistic approach to agriculture that combines livestock and fish farming. Fish feed and pond fertilisers account for about 60% of the costs associated with fish cultivation. The carefully considered integration of fish production with other suitable farming methods can significantly lower these expenses.

It is a pleasure to note that, Fisheries Research and Information Center (FRIC), Vijayapur & National Institute of Agricultural Extension Management, Hyderabad, India is organizing a collaborative training program on “Recent Developments in Integrated Fish Farming” from 13-15 September, 2022 and coming up with a joint publication as e-book on “Processing and Quality Evaluation of Postharvest products of Sheep and Rabbits” as immediate outcome of the training program. I wish the program be very purposeful and meaningful to the participants and also the e-book will be useful for stakeholders across the country.

I extend my best wishes for success of the program and also I wish Fisheries Research and Information center, Bhutnal, Vijayapur a constituent of the Karnataka Veterinary Animal and Fisheries Sciences, University, Bidar, many more glorious years in service of Indian agriculture and allied sector ultimately benefitting the farmers. I would like to compliment the efforts of Dr. Sai Maheswari, Assistant Director, EAAS, MANAGE, Hyderabad and the Director Karnataka Veterinary Animal and Fisheries Sciences, University, Bidar for this valuable publication.

Dr. P. Chandra Shekara
Director General, MANAGE

FORWARD

India being an agrarian produces large quantity of animal and plant residues to the tune of 350 to 1000 million metric tons. Our country possesses large bovine population, sheep, goat, pig, poultry and other livestock which provide huge quantities of organic material for aquaculture. Different agro based industries also produce effluents which could be effectively used after proper recycling for fish culture.

Fisheries Research and Information center, Bhutnal, Vijayapur a constituent of the Karnataka Veterinary Animal and Fisheries Sciences, University, Bidar.

I am happy to note that the scientists of this center in collaboration with MANAGE, Hyderabad conducted Three days training Programme on " Recent Development in Integrated Fish Farming" and also publishing e – book on this topic.

I believe this book will be beneficial to the teachers, students and farming community.

Director of Extension

DIRECTOR OF EXTENSION

PREFACE

Fisheries Research and Information Center (FRIC), Vijayapur conducted a free online training program on "Recent Developments in Integrated Fish Farming" sponsored by the National Institute of Agricultural Extension Management (MANAGE), Hyderabad for the Extension officials of state/central fishery departments, faculty of SAUs/KVKs/ICAR institutes, etc. during 5-7th July 2022.

This e-book is a collaborative outcome of said online training program. The editors' main endeavor is to provide insights to all extension workers, faculties, researchers and students about Recent Developments in Integrated Fish Farming. The current information in these products development and value addition will help them to do well in the extension field and create entrepreneurship opportunities among various stakeholders.

The editors felt that all the experience of resource persons of this training should be clubbed together to form a Recent Developments in Integrated Fish Farming. The experts and resource persons in this collaborative training programme contributed enormously and tirelessly to develop various chapters of this e-book. The editors extend their sincere thanks to all the experts who have contributed valuable time. The editors also thank MANAGE, Hyderabad for the financial support to the training program. The editors express gratitude towards the Director Extension, for the constant encouragement for this training and e-book creation for the participants. The editors hope that this e-book will help participants as well as other extension people across the country to gain valuable information on integrated fish farming.

September, 2022

Vijaykumar.S
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Chapter-1

INTEGRATED FARMING OF FISH AND LIVESTOCK

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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, and provides additional income and food for small scale farming household.

The basic principle involved in integrated farming are the utilization of the synergetic effects of inter-related farm activities, and the conservation, including the full utilization, of farm wastes. It is based on the concept that there is no waste, and waste is only a misplaced material for another product (FAO, 1977).

The integrated fish farming is well recognized in Asian countries like China, Malayasia, 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 promoted as a strategy to improve nutritional standards. To meet the demand and supply the integration with fish and livestock is very encouraging and could bring a significant profitability from a unit area particularly for small holding farmers.

Most of the small holder farmers cannot afford the concentrate feed requirements of the fishes in intensive fish farming. Hence, the integrated fish farming with livestock and utilization of livestock excreta could meet demand by growing fish food organism i.e. plankton in the pond or water bodies along with direct feeding of animal waste. The common livestock- fish integrated farming systems are –

1. Duck cum fish integration system
2. Poultry cum fish integration system
3. Pig cum fish integration system
4. Sheep/Goat cum fish integration system
5. Cattle cum fish integration system
6. Buffalo cum fish integration system

Integrated livestock-fish farming: Basic principles

The basic principles for livestock-fish integrated farming system are full utilization of livestock farm wastes and conversion of waste in to valuable fish protein. The spilled over feed or feed derived from livestock manure may be utilized as direct feed or the manure from livestock helps in production of planktons which form the feed for fishes in the pond.

In this integrated farming system optimal stocking density with desired fish species, optimum utilization of manure and lime also play an important role for successful production of fish. Excess manuring with livestock excreta may cause poor water quality and may lead to depletion of dissolved oxygen in water causing mortality to fishes. The livestock-fish farming may be extensive, intensive or semi-intensive system depending upon the availability of resources and capital.

Selection of Fish species

The most suitable species of fishes for integrated livestock-fish farming are those fishes that can filter and feed on phytoplankton, zooplankton and bacteria from water. The objective of integrated livestock cum fish farming is to produce maximum plankton in water through manuring which is rich in protein and a natural feed for fishes. The species of fishes which are consumed by the people and are efficient utilizer of phyto and zooplankton and also with macrophytic feeding nature are excellent for integrated livestock fish culture. Depending on the feeding nature the fishes are divided into three categories viz. Surface feeder, Column feeder and Bottom feeder. In integrated system of fish farming both indigenous and exotic species are recommended. Indigenous species like Catla (Catla catla) which are zooplankton feeder and exotic species Silver carp (Hypophthalmichthys molitrix) which are phytoplankton consumer are best example of surface feeder, whereas Rohu (*Labio rohita*) an indigenous species is omnivorous in nature and column feeder. The indigenous species Mrigal (*Cirrhinus mrigala*), Kalabasu (*Labeo calbasu*) are detritivorous and common carp (*Cyprinus carpio*) an exotic species which are detritivorous/ omnivorous in nature are bottom feeder. Exotic species like Grass carp (*Ctenopharyngodon idella*) which are herbivorous cover surface, column and marginal area of feeding zone.

Model housing for livestock- fish integrated farming system

Considering the easy operation of day to day farm management and optimum production the livestock house is constructed above the water bodies especially for duck or poultry, nearby the pond or bank of pond for pig, poultry, cattle or buffaloes etc or partly in water and land. In duck cum fish farming the duck house may be constructed above the pond thus the excreta and feed waste directly goes to the pond and serve as a feed for fishes. When the house is constructed in bank of the water bodies, a channel is diverted from animal shed to the pond, so that the feed waste or excreta rinsed to the pond. In this case optimum livestock-fish ratio should be maintained to avoid excess manuring in water. In this type of housing duck, poultry, pig or cattle is recommended. In third type i.e. slatted floor is considered for both birds and animals like pigs. The animal excreta channelized in the pond directly. The slatted type floor may be constructed with wood, bamboo etc.

Pond Management:

The pond should be water retentive and not to be situated in flood prone area. There should be constant water supply or throughout the year there should be water in the pond. Seasonal ponds, which can retain 8 to 9 month water also, can be considered for integrated farming system. At least there should be 1.0 m of water and ideal is 1.5 to 3.0 m. Soil pH should be within the range of 6.5 to 7.5. If the soil pH is not up to the desired level, the pH may be corrected by application of lime and the quantity of lime is 2000 kg/ ha for 4.0 to 5.0 pH, 1200 kg for 5.1 to 6.0, 1000 kg for 6.1 to 6.5 (mild acidic), 400 kg for 6.6 to 7.0 (more or less neutral) and 200 kg/ ha for pH 7.1 to 7.5, which is mildly alkaline.

Lime helps in maintaining pH, kills and decomposes parasites. The lime should be applied in 3 to 4 split doses.The basal dose of lime and cow dung application in per hectare of water bodies is 1200 kg and 5000 kg, respectively. The pond should be regularly cleaned from aquatic plants which prevents sunlight penetration and oxygen circulation in water as well as shelter fish predators. The weeding can be done by manually, mechanically, biologically, chemically or by increasing the water depth in the pond. To kill predatory fishes Mahua (Bassicala tifolia) may be applied at the rate of 2500 kg/ ha of water bodies. By repeated netting unwanted fishes may also be removed. The ammonia, tea seed cake and bleaching powder also can be applied to remove enemy fishes.

Fish Stocking and harvesting:

The stocking time varies depending upon the climate in different regions of the country and also the availability of optimum water level in pond. Most suitable months for stocking of fingerlings is June and July. Water Temperature below 18 to 20ºC growth of the fishes restricted. During winter months growth is slow but in rainy season faster growth observed in fishes. Moreover, in winter months and in dry season water level comes down drastically in the water bodies. It is advisable to stocking fingerlings after winter months i.e. in rainy season and harvested before the water scarcity in pond. Generally, fishes are harvested after 12 months of stocking. But, where water bodies remain functional for 8 to 9 months fingerlings may be stocked in April and harvested in the month of November/ December. In composite fish culture 3 species, 4 species or 6 species may be stocked depending upon the availability of fingerlings in the market. In integrated livestock cum fish farming considering the surface, column and bottom feeder the ratio of fishes viz. Catla, Rohu and Mrigal should be 4: 3: 3 (3 species), in 4 species Catla, Rohu, Mrigal and Common carp ratio 3:3: 3:2 whereas, in 6 species Catla, Rohu, Mrigal, Silver carp, Grass carp and Common carp ratio should be 1.5: 2.0: 1.5: 1.5: 1.5: 2.0, respectively.

For example, as Catla and Silver carp are surface feeder, the combined stocking density should not be more than 30 to 35%, but for Rohu which is column feeder grows well in ponds with 3 to 4 m water depth should be stocked at the rate of 15 to 20%, whereas, bottom feeder like Mrigal and Common carp the ratio may be 40 to 45%.

Grass carp should not be more than 5 to 10%, which can be fed with land grasses, vegetable refuse, banana leaves (practiced at ICAR RC ER, Patna) or with aquatic plants. Central Inland Fisheries Research Institute and ICAR Research Complex for NEH Region, Barapani recommended 6000 fingerlings/ ha for duck-fish integrated system and 6000 to 7000 fingerlings for integrated and non-integrated pig-fish farming system, respectively.

Potentiality of livestock manure in integrated fish farming

Livestock excreta contain about 70 to 80% water and 20 to 25% dry matter. A cow produces 15 to 18 kg dung/ day. A poultry layer bird can produce 68 kg of excreta per year. A pig of 50 kg can produce 2.5 kg dung per day whereas; 90 kg pig produces 5 kg dung per day. Livestock excreta generally used as a potential manure in agricultural production system. It is rich in Nitrogen (N), Phosphorous (P) and Potassium (K) and also contains micronutrients. Thus, it makes the soil fertile. The average dung production in different animals varies according to their body size, body weight and feed and water consumption. In domestic animals like sheep, goat, cattle, buffalo, pig and poultry manure production is 0.15, 0.15, 1.10, 1.35, 0.25, and 0.014 tonnes/ animal/ year, respectively on dry weight basis. The N, P, K level in excreta varies in different species of animals. Like sheep/ goat 0.65, 0.50 and 0.03%, cattle 0.15, 0.01 and 0.05%, pig 0.60, 0.50 and 0.20%, poultry 0.76, 0.63 and 0.22%, duck 0.91, 0.38 and 0.36%, respectively.

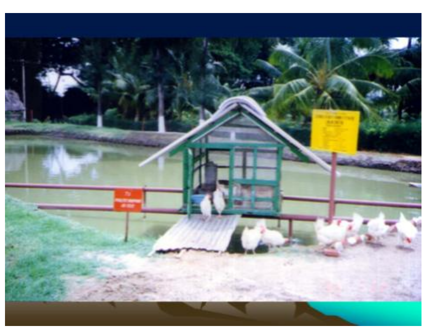
Types of Livestock- Fish integrated farming systems:

Duck cum fish farming:

This system is very popular and widely practiced in countries like China, Hungary, Germany, Poland, and Russia in our country particularly in Assam, West Bengal, Bihar, Orissa, Andhra Pradesh, Kerala, Tamil Nadu, and Karnataka and in North Eastern States. It is one of the best livestock – fish integration system. Duck droppings directly fall in water or collected and used for fertilization in pond. Fish gather duck droppings as direct food or consume spilled feed. Ducks consume mosquito larvae, tadpoles, dragon fly larvae and snails which also serve as vector for certain parasites. The dabbling habit of ducks increases the available oxygen in pond water. For commercial farming or for maximum profit high egg producing ducks like Khaki Campbell or Indian Runner is preferred instead of local ducks. About 200 to 240 eggs/ duck/ year is expected for commercial farming and on an average 250 ducks/ ha is recommended for duck cum fish farming. Multi-species culture of fishes with rearing period of one year yield fish ranging from 3000 – 4000kg/ha/year is expected.


Poultry cum fish farming:

Poultry excreta is an excellent feed for fish as it contains highly soluble organic salts, more N and P as compared to other livestock manure. Broiler or layer bird can be raised in the integrated system. It was found suitable even with dual purpose poultry birds like Vanaraja. For one hectre fish pond 1000 birds produce sufficient manure with 90,000-100,000 eggs and over 1500 kg of meat per year while broiler rearing provides over 1500kg meat/batch. At least 5-6 batches can be reared in a year. A production 3000 – 4000kg of multispecies fish could be harvested per ha per year.



Milkfish, Tilapia, Shrimp Plus Chickens:

In 1984-86, the Leganes Research Station of the SEAFDEC Aquaculture Department developed the polyculture of milkfish, tilapia, and shrimp with poultry. The fish swim in the water and the chickens grow to slaughter-size in poultry houses built above the water. The two forms of husbandry mesh well in the biological food chain. Chicken droppings that pass through a welded-wire floor in the poultry house into the water below become a fertilizer for plankton, the natural food organisms on which fish feed. The milkfish, tilapia, and shrimp then thrive on the plankton. Further research showed that a 4m x 8m poultry house was right for a 1000 m2 fish pond. A bamboo catwalk connected the poultry house to the dike. Stocking in the pond consisted of 200 milkfish fingerlings, 1 500 tilapia fingerlings, and 5000 shrimp juveniles - and above it, 90 3-wk old chicks were put in the poultry house. This mix was found to give the best productivity. The chickens were harvested after 45 days - half the period for the fish. Two chicken crops were harvested for one fish crop. At harvest time; farmers who go into polyculture have both fish and chickens for household food and for sale. For sanitation, it is suggested that chickens be harvested a week before the fish, and the pond water, immediately changed. When the fish are harvested after another week, the pond has the healthy smell of fresh fish.

Sheep/goat cum fish farming:

Fifty to fifty five goats are sufficient for one hectre water bodies for sheep/goat integrated farming system. Sheep/goat manure is also rich in N, P and K. Moreover, there is a great demand for mutton and chevron and no religious taboo is attached with these meats. A adult goat weighing about 20kg discharges 300-400g excreta on daily basis. For manuring 1h water body, 50-60 goats herd are needed. This integration could produce 3.5 – 4 tonnes fish /ha/year without supplementary feed or fertilizer in pond. These types of IFF produce fish and 750-900kg Sheep/goat meat.

Cattle/buffalo cum fish farming:

This system is very common in rural India. People generally mix cow dung with paddy husk or wheat bhusa and spread over water bodies as a ready source of fish food. A healthy cow weighing 400-450kg exretes over 400-500kg of dung and 3500 – 4000 litres of urine on annual basis. Sometimes cow dung and cattle/ buffalo shed waste channelized directly in to the pond which serve as excellent fish food directly or indirectly as a source of plankton growth in the pond. But, caution should be taken for number of animals per unit of water bodies; otherwise there may be fish mortality due to excess manure in water. A unit of 5-6 cows can provide adequate quantity of dung and urine to produce 3000 – 4000kg of fish per ha per year.

Pig cum fish farming:

Pig manure is very suitable for integrated fish farming system. Generally pig house is constructed in the bank of pond and wastes are directly channelized in to the water. A floor space of 3-4 m^2 is required for pig weighing 70-90kg. Sometimes pig manure is accumulated and fermented for some days and then applied in pond. If channelized system is practiced there is no need for supplementing feed for fish. The spillover feed and pig manure is sufficient for fish farming. Pig manure is rich in nitrogen and phosphorus and thus it helps in very fast growth of fingerlings. A full grown pig provides 500-600 kg of dung in a year and exreta of 40-45 pigs provides required quantity of manure to fertilize 1 ha pond. Pigs attain slaughter size of 60-70kg within 6 months. This type of integration is very profitable when good quality of pig variety like Large and Middle white Yorkshire, Barkshire, Duroc, Hereford, Landrace, Chesterwhite, Tamworth etc are introduced in integrated fish farming. Fish harvest of 3-4 tonnes/ha without any feed and fertilization in 12 months culture period at the stocking density of 8000 -8500 fingerlings/ha.


CONCLUSION:

Fish culture integrated with livestock provides a higher source of income to the farmer having a small land holding. These practices help in improving production with little additional expenditure. It is expected that IFF practices will increase in the near future in suitable agro-climatic regions of the country as they are dependent on eco-friendly measures and ensure higher returns as well as sustained production levels of fish and other bio-resources.

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Chapter-2

WATER QUALITY QUALITY MANAGEMENT IN AQUACULTURE

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Water quality is the first most important limiting factor in pond fish production. It is also the most difficult production factor to understand, predict and manage. Water is not just where the fish live. Its quality directly affects feed efficiency, growth rates, the fish's health and survival. Most fish kills, disease outbreaks, poor growth, poor feed conversion efficiency and similar management problems are directly related to poor water quality. Water quality refers to anything in the water, be it physical, chemical or biological that affects the production of fish. The objective of pond management, is to manage the water quality, so as to provide a relatively stress free environment that meets the physical, chemical and biological standards for the fishes normal health and production performance. Within a pond, water quality is a product of:

1. The quality of water at the water source,
2. The quality of the pond soils and immediate environment,
3. Production technology and management procedures employed, notably those associated with feeding, the maintenance of adequate dissolved oxygen as well as any other chemicals or inputs applied.

Aquaculture pond dynamics

Aquaculture ponds are a living dynamic systems they exhibits continuous and constant fluctuations. The pond undergoes a vast collection of both chemical reactions and physical changes. Exchange of atmospheric gases including Oxygen (O2), nitrogen (N2) and Carbon dioxide (CO2) with the pond water are vital to the process of fish metabolism and plant photosynthesis. Inorganic substances (minerals) dissolve from the pond walls and bottom while precipitation of dissolved minerals occurs. Physicals exchanges between the pond its surroundings include absorption of sunlight (radiant energy) to fuel photosynthesis and supply oxygen within the pond, heat exchange and volume changes caused by evaporation and precipitation (rain). Changes in the volume of a pond are very important as they affect the concentration of dissolved substances and correspondingly requirements for treatment.

Water chemistry

A guiding principle of aquaculture is that water quality and hence efficient production are a direct consequence of good water chemistry. Water may be considered as a 'binder' or 'matrix' in which the dissolved gases, inorganic substances (minerals), as well as organic matter prevails. In addition to dissolved substance, the water matrix gives support to microorganisms, plant and animal life forms and provides a medium for chemical exchange among these populations. However, water is itself relatively chemically inert, physically water has a high heat capacity (holds heat efficiently), is relatively 'polar' affording it the ability to act as an excellent solvent and is also quite dense. Its boiling point is quite high compared to similar molecules and its freezing point quite low. Therefore, water exists as a liquid over a rather broad range of temperature making it a most suitable medium for the support of life forms. The maintenance of good water quality is essential for both survival and optimum growth of culture organisms. The major source of nutrients in aquaculture is the feed. Because large quantities of feed are loaded in ponds, excess feed, fecal matter and other metabolites become available in large quantities for the growth of algae and microorganisms. By realizing the overriding significance of water chemistry, it is important to have a firm grasp of some basic concepts. Like:

- **Temperature**

Aquaculture organisms are cold-blooded animals. They can modify their body temperature to the environment in normal condition. If the temperature falls below 28°C, the metabolism reduces and so does the active behaviour and growth rate. During the rainy season, there is a greater possibility of occurrence of thermal stratification in pond water column, as well as the salinity (density) and dissolved oxygen stratification. It also influences the volume of the pond and therefore the ponds capacity to support the dissolved oxygen, influencing productivity, biomass and production yield.

Salinity

Salinity plays an important role in the growth of culture organisms through osmoregulations of body minerals from that of the surrounding water for e.g., the optimum range of salinity for black tiger shrimp is between 10 and 25 ppt, although the shrimp will accept salinity between 5 and 38 ppt. since its eurihaline character. However, for better survival and growth optimum range of salinity should be maintained in the aquaculture ponds.

Dissolved Oxygen

Dissolved oxygen with O ppm represents total oxygen depletion and 15 ppm represents the maximum or saturation concentration. The solubility of oxygen in water decreases as the water temperature increases. Decaying plant and animal matter consume substantial amounts of oxygen in the decaying process. It is important to realize that the oxygen cycle and hence dissolved oxygen levels can be affected by changes in the surroundings; unusually high temperatures will lower the solubility of oxygen in water and hence low dissolved oxygen. Lack of dissolved oxygen can be directly harmful to culture organisms or cause a substantial increase in the level of toxic metabolites.

- **PH (measure of acidity or alkalinity)**

PH or the concentrations of hydrogen ions (H^+) present in pond water is a measure of acidity or alkalinity. PH condition of routine aquaculture occurs in the range 7.0 to 9.0 (optimum is 7.5 to 8.5). Exceedingly alkaline water (greater than pH 9) is dangerous as ammonia toxicity increases rapidly. At higher temperatures fish are more sensitive to pH changes.

It is an important chemical parameter to consider because it affects the metabolism and other physiological processes of culture organisms. A certain range of pH (pH 6.8 – 8.7) should be maintained for acceptable growth and production. But in semi- intensive culture, re-optimum range is better maintained between pH 7.4 – 8.5. Control of pH is essential for minimizing ammonia and H2S toxicity.

- **Hardness**

Numerous inorganic (mineral) substances are dissolved in water. Among these, the metals calcium and magnesium, along with their counter ion carbonate (CO3 -2) comprise the basis for the measurement of 'hardness'. Optimum hardness for aquaculture is in the range of 40 to 400 ppm of hardness. Hard waters have the capability of buffering the effects of heavy metals such as copper or zinc which are in general toxic to fish. The hardness is a vital factor in maintaining good pond equilibrium.

- **Turbidity**

Water turbidity refers to the quantity of suspended material, which interferes with light penetration in the water column. In prawn ponds, water turbidity can result from planktonic organisms or from suspended clay particles. Turbidity limits light penetration, thereby limiting photosynthesis in the bottom layer. Planktonic organisms are desirable when not excessive, but suspended clay particles are undesirable. It can cause clogging of gills or direct injury to tissues of prawns. Erosion or the water itself can be the source of small (1-100 nm) colloidal particles responsible for the unwanted turbidity. The particles repel each other due to negative-charges: this can be neutralized by electrolytes resulting in coagulation. It is reported that alum and ferric sulfate are more effective than hydrated lime and gypsum in removing clay turbidity. Both alum and gypsum have acid reactions and can depress pH and total alkalinity, so the simultaneous application of lime is recommended to maintain the suitable range of pH. Treatment rates depend on the type of soil.

Toxic wastes:

- **Ammonia:**

  Ammonia is the second gas of importance in fish culture; its significance to good fish production is overwhelming. High ammonia levels can arise from overfeeding, protein rich, excess feed decays to liberate toxic ammonia gas, which in conjunction with the fishes, excreted ammonia may accumulate to dangerously high levels under certain conditions. Fortunately, ammonia concentrations are partially ‘curbed’ or ‘buffered’ by conversion to nontoxic nitrate (No3 -) ion by nitrifying bacteria. Additionally, ammonia is converted from toxic ammonia (NH3) to nontoxic ammonium ion (NH4 +) at pH below 8.0.

  When ammonia levels in blood considerably increase, it leads to Toxic Necrosis of the gills in carps. Ammonia is the final product of nitrogen metabolism in carp and most of it is excreted via gills into the water. If the diffusion rate is reduced, then the ammonia level in the blood will steadily rise, causing a condition known as Autointoxication, which may lead to toxic gill necrosis in carps.

- **Nitrite:** Nitrite enters fish culture system after feed is digested by fish and excess nitrogen is converted into ammonia, which is then excreted as waste into the water. Under normal conditions, ammonia is converted into nitrite which then converted to non-toxic nitrate by naturally occurring bacteria. High nitrite concentration in water causes “Brown Blood Disease” when nitrite enters the bloodstream through the gills and turns blood to a chocolatebrown colour. Under these circumstances, heamoglobin combines with nitrite to form methemoglobin, which is incapable of oxygen transport. Affected fish can suffocate despite adequate oxygen concentration in the water. Sodium chloride (common salt) at the rate of 15-25 ppm can be used to treat brown blood disease.

- **Nitrate:**

  Nitrate level at 2 –3 mg/l is required in pond water. Shortage of this nutrient is not common when compared with that of phosphate because the latter one is usually not present in available form. Therefore, it has to be supplied with nitrate @ 1:4 to 1:8 for good production.

- **Hydrogen sulphide:**

  Hydrogen sulphide at 0.01 to 0.05 ppm is harmful to fish life. Therefore, care should be taken prevent accumulation of hydrogen sulphide even below detection levels. This problem can be overcome by the application of lime to fish ponds.

Water quality management

Water quality parameters should be monitored to serve as guide for managing a pond so that conditions that can adversely affect the growth of prawns can be avoided. In cases where problems are encountered, these parameters can help in the diagnosis, so a remedy can be formulated. The population of phytoplankton and microorganisms are major determinants of the level of oxygen and metabolites in the pond. The diet fluctuation of DO (including its vertical profile), pH and CO2 serve as indicators of their population. Since CO2 is the major factor affecting the dial fluctuation of pH, monitoring pH fluctuation may be adequate. Also, CO2 is more difficult to measure. Daily measurements are conducted at early hours i.e. 5-6 am and after noon measurements in the i.e. 2-3 pm. This represents the period before the start of photosynthesis and the peak of photosynthesis, respectively. Thus the maximal and the minima of these parameters occur during this period. The other parameters do not have a distinct dial pattern and therefore can be monitored only once a day, preferable at a common time. Feed and growth data need to be presented with water quality parameters, side by side. This is because algal blooms are consequences of nutrients from feeds and excess feed can cause the rapid deterioration of water quality. Careful monitoring and data collection will remain useless unless it influences decisions regarding water management. This becomes more important as cost to implement various management schemes (aeration, water exchange, inputs) increase. Most of the water quality problems can be solved with adequate water exchange. Thus, if large quantities of water suitable for aquaculture were available, monitoring would not be as critical and high production levels can be targeted.

Water Exchange

When stocking density increases, it is of primary importance to have a dependable water supply and to maintain good water quality. So far, besides aeration, water exchange is still the most effective and widely employed method to maintain good water quality besides water quality enhancers like sanitizers, zeolite etc. Generally, water exchange is used to adjust salinity as desired, to remove excess metabolites, to keep algae healthy and producing ample oxygen and to regulate pond water temperature. The exchange rate varies with the production period, stocking density and total biomass, levels of natural productivity, turbidity and source and volume of water. The principle of water exchange is to change the water in a way such that the water quality changes gradually instead of abruptly. In semi-intensive systems, frequent and sometimes even continuous water exchange at a small flowing rate is employed. Abrupt addition of large quantities of water in small ponds may result in sudden environment change, which subsequently can stress in culture organism. Therefore, massive water replacement is not recommended unless there is sudden die-off of plankton, critical low oxygen or after the application of chemicals. Continuous water exchange should be accompanied with running of paddlewheels to have the pond water fully mixed. Otherwise, it will cause great differences of water quality within a pond and heterogeneous distribution of culture organisms on the pond bottom. Lowering the water level first and adding new water is not recommended, especially during daytime in summer. Increasing water temperature, while lowering water level, can reduce the capability of water to hold oxygen and hasten the degeneration of the pond bottom, leading to oxygen depletion. It is better to add new water first according to the predetermined exchange rate, have the paddlewheel running to homogenize water throughout the pond and then discharge water.

Water exchange is the first method to improve pond management, except when

- Good quality of water is not available.
- A drastic change to the pond environment should be avoided.
- Culture organisms have been greatly weakened as a result of nutrition depletion and diseases.
- Ponds are being treated with chemicals and medicine.

- Acceptable water quality can be achieved using the following pond management techniques:
- Controlled water exchange. Water exchange is done daily, as routine or extra exchange may be recommended to prevent onset of a problem or be recommended as integral to a crisis management.
- Co-ordinating water exchange and fertilization to maintain populations of algae.
- Avoid overfeeding through proper management of feeding trays.
- Aeration.
- Continual or periodic removal of accumulated organic material from the pond bottom.
- Maintenance of a high density bacterial flock i.e. probiotics combined with water circulation and aeration.

Phytoplankton management

Phytoplankton plays a significant role in stabilizing the whole pond ecosystem and in minimizing the fluctuations of water quality. A suitable phytoplankton population enriches the system with oxygen through photosynthesis during day light hours and lowers the levels of CO_2, NH_3, NO_2 and H_2S. A healthy phytoplankton bloom can reduce toxic substances since phytoplankton can consume NH4 and tie-up heavy metals. It can prevent the development of filamentous algae since phytoplankton can block light from reaching the bottom.

Pond bottom treatment

For farms adopting advanced technology, it is necessary that pond bottom should be completely dried and aerated to get rid of toxic gases. Many ponds in low-lying areas cannot be completely drained and dried. To overcome this, Aquafarmers apply waste digesters to the ponds. The digesters are harmless bacteria (probiotics) and enzymes that consume organic matter on the pond bottom. After the application of digesters farmers apply a disinfectant, either organic silver or organic iodine. Copper sulphate is not used as a disinfectant now a days as it is not biodegradable and accumulates in the pond upto levels that are toxic to aquatic life.

Organic silver is highly effective against bacteria and viruses and its toxicity to aquatic life is very low. Organic silver is applied at the rate of 18 litres (4 gallon) per hectare after lowering the water depth to 12 inches. Seven days after the application, this disinfectant disintegrates, so there is no need to flush the pond.

Nitrogen Metabolites

Large quantities of organic matter originating from the heavy feed load and feacal matter accumulate in aquaculture ponds. These undergo oxidation-reduction reactions leading to decomposition, mainly through the action of bacteria. Different forms of inorganic nitrogen like ammonia, nitrite and nitrate are produced during decomposition.

Table1. Water quality criteria for aquaculture

#	Parameter	Acceptable range	Desirable range	Stress
1	Temperature(^{O}C)	12-35	20-30	<12, >35
2	Turbidity (cm)		30-80	<12, >80
3	Water colour	Pale to light green	Light green to light brown	Clear, dark green & brown
4	Dissolved Oxygen (mg/l)	3-5	5	<5, >8
5	BOD (mg/l)	3-6	1-2	>10
6	CO_2(mg/l)	0-10	<5, 5-8	>12
7	pH	7.0-9.5	6.5-9.0	<4, >11
8	Alkalinity (mg/l)	50-200	25-100	<20, >300
9	Hardness (mg/l)	>20	75-150	<20, >300
10	Ammonia (mg/l)	0-0.05	0-<0.025	>0.3
11	Nitrite (mg/l)	0.02-2	<0.02	>0.2
12	Nitrate (mg/l)	0-100	0.1-4.5	>100, <0.01
13	Phosphate (mg/l)	0.03-2	0.01-3	>3
14	H2S (mg/l)	0-0.02	0.002	Any detectable level
15	Primary Productivity(C/l/day)	1-15	1.6-9.14	<1.6, >20.3
16	Plankton (no./l)	2000-6000	3000-4500	<3000, >7000

Chapter-3

INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA)

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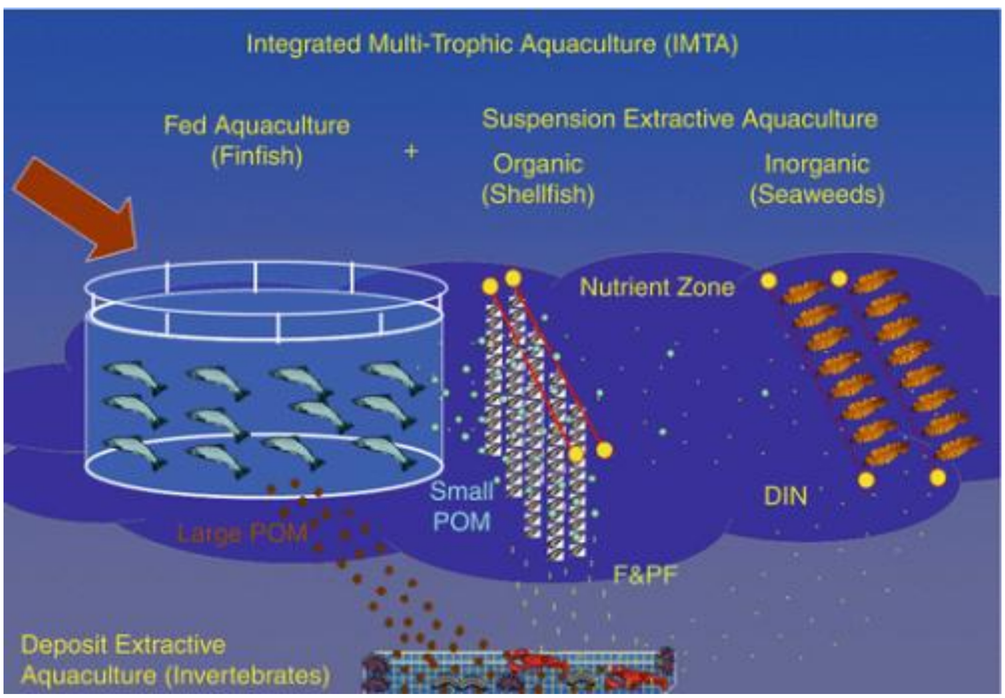
Fish production from capture fisheries is stagnant, at 90.8 million metric ton in 2007, and 90.3 million metric ton in 2020 (FAO, 2022). However, total demand for fish is rising, along with the growing human population. It is estimated that by 2030, there will be dearth of 50-80 million ton seafood. Therefore, to meet the growing global demand for aquatic foods from capture fisheries is not feasible. Hence, aquaculture is considered to be a promising sector to bridge the supply and demand gap for aquatic food in most regions of the world. Thus, it is obligatory to develop, expand and strengthen the aquaculture industry world over. However, the negative environmental impact of intensive aquaculture has to be taken in to consideration. In view of this, it is indispensable to design the ecosystem responsible aquaculture practices that maintain the integrity of ecosystems ensuring the feasibility of this segment by extending food provision, safety, and security.

Feed is the most important item in aquaculture operations, accounts for more than 70-80% of the total operating expenditure. Intensive feeding of cultured species results in a large amount of sedimentation, leading to high levels of nutrient accumulation (nitrogen, phosphorus, and organic carbon) in the culture environment, both in soil and water. Approximately more than 60-70% of the nitrogen and phosphorus from feeds and fertilizers accumulated in the pond sediment, and the rest is taken in terms of harvested fish. This accumulated nutrient causes stress and diseases in cultured fish, resulting in lesser production and monetary returns. In effect, intensive aquaculture is the transformation of dietary inputs into fish biomass, which inevitably produces waste in the enclosure.

The waste products released from aquaculture operations are organic (feed and fecal wastes), and inorganic (nitrogen and phosphorus containing compounds) and both result in the degradation of water bodies. Intensive finfish farming in cages also release considerable quantities of nutrients to the water body, from uneaten feed, faeces and excretory products. These metabolic wastes may contribute to increased nutrients and localised eutrophication. One of the major challenges for the sustainable growth of aquaculture is to reduce environmental degradation concomitantly with its expansion. The recent development in intensive farming of marine carnivorous fed-species is coupled with environmental concerns. Hence, integrating fed aquaculture (fish and prawn farming) with farming extractive organisms (Bivalves and Sea weeds) is a practical technology for sustainable mariculture. In a balanced integrated system, aquaculture effluents can be converted into viable produce by restoring water quality by a concept called Integrated Multi-Trophic Aquaculture (IMTA). IMTA is the farming of various aquaculture species of different trophic levels in the vicinity with compatible ecosystem functions, wherein unconsumed feed, waste, and by-products of one species to be utilized as fertilizers, feed, and energy for the other commodity, by taking the advantage of symbiotic interactions among the species. Integrated multi-trophic aquaculture, or IMTA, is similar to polyculture, where two or more organisms are farmed together.



Source: Aquaculture, Integrated Multi-trophic (IMTA) by Dr. Thierry Chopin

In IMTA, multiple aquatic species from different trophic levels are farmed in an integrated fashion to improve efficiency, reduce waste, and provide ecosystem services, such as bio-remediation. IMTA promotes bio-mitigation, and diversification of fed single species culture, by amalgamating with extractive aquaculture species, to comprehend benefits economically, environmentally and socially. Biomitigative services can also be provided by natural populations of similar organisms. Integrated multi-trophic aquaculture scrounged a concept from nature, as in the food chain, one species always finds a feeding niche in the waste produced by another species. Researchers accordingly checked the theory that nutrients fed to finfish would generate high-quality organic and inorganic waste that shellfish and marine plants dependent to grow.

Case studies

As IMTA is a recently developed technology world over, it is still in its infancy. The concept of IMTA is in near commercial scale in some temperate countries like Canada, Chile, Ireland, South Africa, the United Kingdom of Great Britain and Northern Ireland (mostly Scotland) and the United States of America. While in France, Portugal and Spain have ongoing research projects related to the development of IMTA. The countries of Scandinavia, especially Norway, despite possessing a large finfish aquaculture network, have made some individual groundwork towards the development of IMTA. Majority of the studies have focused on the integration of seaweeds with marine fish culturing for the past twenty years in Canada, Japan, Chile, New Zealand, Scotland and the USA. Australia, USA, Canada, France, Chile, and Spain have conducted numerous studies with the integration of mussels and oysters as bio-filters in fish farming. Off late IMTA research includes a focus on seaweeds, bivalves, fish and crustaceans. Studies conducted in an IMTA system indicate that Sea weeds can efficiently absorb the ammonium and phosphorus from nutrient rich fish farmed areas. Further, IMTA system has generated an additional income through the production of Sea weed. In another study on IMTA where Atlantic salmon (*Salmo salar*), kelp (*Saccharina latissima* and *Alaria esculenta*) and blue mussel (*Mytilus edulis*) were reared together at several IMTA sites in the Bay of Fundy, East coast of Canada. The growth rates of kelp and mussels cultured in proximity to fish farms have been 46 and 50% higher, respectively, than at control sites. Numerous other investigations too have demonstrated the faster growth of mussels and oysters grown adjacent to fish cages.

Outcome of the several economic models have also revealed overall increase in net productivity of a given IMTA site which lead to the increased profitability of the farm compared with monoculture. Experimental data and mass balance estimation signified that seaweed cultivation, up to one ha for each ton of fish standing stock, would be required for the removal of the excess nitrogen associated with a commercial fish farm.

The open-sea IMTA investigations in India are very recent; however, various studies have been carried out on the beneficial composite culture of various mariculture species. Combined culture of compatible species of fishes and prawns is of considerable importance in the context of enhancing yield from the field and effective utilization of the available ecological niches of the pond system. Finfish culture of *Etroplus suratensis,* in cages erected in combination of bivalve farms (racks) resulted in high survival rates and growth of fish in the cages. Cultivation of a Sea weed, *Gracilaria* sp. at different stocking densities with the shrimp, *Feneropenaeus indicus* showed nutrient removal from shrimp culture waste by the seaweed. The seaweed (600 g) was able to reduce 25% of ammonia, 22% of nitrate and 14% of phosphate from the shrimp waste. Polyculture of shrimp with molluscs facilitate in breaking down organic matter efficiently and provides as an important food source for a range of organisms. The culture of mussels could be used in the effective removal of phytoplankton and detritus to reduce the eutrophication caused by aquaculture. Individual mussel can filter between 2-5 l/h and a rope of mussel more than 90000 l/day. as well as.

The introduction of IMTA in open sea cage farming yielded 50% higher production of seaweed, *Kappaphycus alvarezii*, when integrated with finfish farming of *Rachycentron canadum* along east coast of India. Open-sea mariculture of finfishes integrated with raft culture of green mussels, *P. viridis* resulted in slight, but not significant reduction in nutrients along Karnataka. The beneficial effect of combining bivalves such as mussels, oyster and clams as bio-filters in utilizing such nutrient rich aquaculture effluents has been documented in estuaries. In a tropical integrated aquaculture system, the farming of bivalves along with finfish (*Etroplus suratensis*) resulted in controlling eutrophication effectively and improved the clarity of water in one of the studies conducted along Indian coast.

IMTA has been the focal point of global research because it is observed as a way to make aquaculture more sustainable and profitable on land or at sea. An often perceived criticism of finfish net pen and cage aquaculture is that wastes and uneaten feed pollute the bottom under the pens and cages, release nutrients such as nitrogen into the water, which in turn can fertilize algal blooms. In IMTA, other organisms that can use these wastes as nutrients are grown by the fish farmer in proximity to the net pens. Integration should be understood as cultivation in proximity, not considering absolute distances but connectivity in terms of ecosystem functionalities. Long-term planning/zoning promoting biomitigative solutions, such as IMTA, must become an integral part of coastal regulatory and management frameworks. IMTA is one of the promising options, but, certainly, it needs to be customized to the location where it is implemented.

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Chapter- 4

FISH DISEASES AND MANAGEMENT

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Introduction

Fisheries and aquaculture have made contribution of about 0.91% to the National Gross Domestic Production (GDP) and 5.23% to the agricultural GDP (2014-2015), which is very significant. At present India contributes about 6.30% to the global fish basket and 5% of global fish trade. India is the second largest fish producing country and hold second largest aqua- culture producing nation in the world. While, Asia contributes more than 90% to the world's aquaculture production, India now takes the second position with regard to annual fisheries and aqua- culture production, only after China. As per FAO data, aquaculture has been the fastest growing food producing sector in the world, with an average annual growth rate of 8.9% since 1970, compared to only 1.2% for capture fisheries and 2.8% for terrestrial farmed meat production systems over the same period. During the year 2015- 2016, the country has produced about Indian Rupees 1.0 lakh crore value fish for local consumption and export. This resulted in an unparalleled average annual growth rate of over 4.5 percent over the years which has placed the country on the forefront of global fish production. The country has plans to increase the fish production and productivity by 8 per cent annual growth rate and to reach 15 million tonnes mark by 2022FF. This sector is also a principal source of livelihood for a large section of economically underprivileged population of the country and more than 14.5 million people depend on fisheries activities. However, progress of aquaculture has caused some unwarranted activities both for the species and environment. At the same time, over-exploitation of fisheries and anthropogenic stress on aquatic ecosystems has placed pressure on wild fish populations. The consequence has been the emergence and spread of an increasing array of new diseases change. As has been noticed in other food producing sector, aquaculture has been adversely affected due to frequent occurrence of disease outbreaks mostly due to intensive culture practices for higher economic gain. This review examines the development and characteristics of freshwater aquaculture practices in India, major fish diseases, principle of dis- ease diagnosis and control programme and future scope of develop- ment of freshwater aquaculture in India. It also considers the potential challenges for heath management issues in aquaculture for sustain- able development.

Aquaculture Production Status in India

By virtue of its geographical situation in the monsoon belt, India is endowed with good rainfall. As a consequence, it has extensive potential aquaculture area in the form of ponds and tanks. These water bodies are distributed throughout almost all the states of India. In India the aquatic resources are vast and diversified. As per the re- cord of Department of Animal Husbandry, Dairying and Fisheries, Government of India records, the country has varied potential aquatic which includes 1.95 km of rivers and canals, 7.95 lakh hectare (ha) of floodplain wetlands, 24.33 lakh ha of freshwater ponds and tanks, 29.26 lakh ha of reservoirs and 11.55 lakh ha of brackish water ponds. Besides, the country has 19134 small reservoirs, 180 medium and 56 large reservoirs, with a total water surface area of 1485557 ha, 527541 and 1140268 ha, respectively Cage culture is practiced in open water resources especially in reservoirs and lakes. The major aquatic resources, aquaculture practices being followed in India and their management modes are given in table 1. Fresh- water aquaculture contributes to over 95 percent of the total aqua- culture production. It accounts for nearly 55% of the total fish production in India. The sector has benchmarked from a domestic activity in Eastern Indian states of West Bengal and Odisha to an enterprise in the states like Andhra Pradesh, Punjab, Haryana, Maharashtra, etc. taking up fish culture as a trade and enterprise. The largest area under aquaculture being in the state of Andhra Pradesh (0.52 mha), followed by Karnataka (0.41mha) and West Bengal (0.276 mha). These three states account for about 50.5% of India’s aquaculture areas. The fish production status during 2012-2013 in different states table as below indicates that out of total 90,19,148 tonnes total fish production, inland fisheries contributed to 57,44,057 tonnes with maximum contribution by Andhra Pradesh (13,93728 tonnes), followed by West Bengal (13,37,664 tonnes). Besides these other states like Karnataka, Maharashtra, Odisha, Chhattisgarh, Jharkhand and Gujarat also contributed significantly to freshwater fish basket in India. The freshwater aquaculture comprises of the culture of mainly three species of Indian Major Carps (IMC) viz. Catla catla (Catla), Labeo rohita (Rohu), and Cirrhinus mrigala (Mrigal) with three exotic species Hypophthalmichthys molitrix (Silver carp), Ctenopharyngodon idella (Grass carp), and Cyprinus carpio (Common carp) through polyculture of either only Indian Major Carps (IMC) or combination of Indian and exotic carps Kathia et al., Culture of catfishes (air breathing and non-air breathing), Giant fresh- water prawn Macrobrachium rosenbergii (Scampi), pangasius (Pangasiandon hypophthalamus) and culture of tilapia (Oreochromis niloticus; Oreochromis mossambicus) are also practiced in freshwater aquaculture. Production of IMCs contribute between 70% and 75% of the total freshwater fish production, while silver carp, grass carp, common carp and catfish make up 25% to 30% of the production.

However, currently, only an estimated 40% of the available re- sources in India, is in use for aquaculture because of technical and market access issues and there is lot of scope of development of aqua- culture. With technological inputs, productivity has gone up from 500-600 kg/ha to 3000 kg/ha, with several farmers and entrepreneurs achieving higher production levels of 6-8 t/ha/yr. The national aver- age productivity has increased from 50 kg/hectare/year increased about 2,135 kg/hectare/year in 1994-1995 and 2,270 kg/hectare/ year in 2020.

However, as indicated by the most common constraints of aquaculture production in India include, i) Lack of perennial rivers, tanks and ponds with year the round availability of water ii) Frequent erratic and inadequate rain fall
iii) Mismatch of monsoon rain and breeding season (May-August) of IMC iv) Lack of awareness among the farmers on improved methods of fish cultivation and better Management Practices (BMPs) in aqua- culture, v) Improper coordination with production, demand and sup- ply of fish and fish-seed vi) Non availability of quality fish-seed for stocking vii)Under-utilization and poor management of water bodies by

local authority or cooperatives and viii) Lack of suitable public policies on long-term lease of water bodies or giving ownership, in some states.

Water potential in India:

Sl.No	Resource	Size	Management
1	Rivers	54,000 Km	Capture Fisheries
2	Medium and Large Reservoirs	16.86 lakh ha	Capture Fisheries
3	Small Reservoirs	14.86 lakh ha	Culture based Fisheries
4	Fresh Ponds/Tanks	23.80 lakh ha	Culture based Fisheries

Disease Problems in Indian Aquaculture:

Disease is one of the major constrains to aquaculture and limiting factor for economic and socio-economic development in India and as in many other countries of the world. Some diseases have caused serious damage, not only the livelihood of fish farmers, but also, to the future development of the industry. Many diseases affecting present day aquaculture is resultant of intensification of culture practices without the basic perception of intricate balance between host, pathogen and environment. In India, the increase in aquaculture production particularly in expansion into intensive and semi-intensive methods of production has been coupled by increase in fish and shellfish resulting from high stocking densities and stress conditions that favors the occurrence and spread of infectious dis- eases. A total loss of one billion US $ was reported due to dis- eases in shrimp culture. The vertical expansion of fish culture with diversified species and higher stocking density has resulted more frequent occurrence of bacterial, parasitic and viral pathogens, often leading to higher morbidity or mass mortalities and lowered production. Rural resource poor farmers with little or no knowledge of fish health management and skill to prevent and control disease outbreaks are the most sufferers, incurring huge economic loss. It is understood that occurrence of disease is a result of the complex interaction between the host, the pathogen and the environment. In aquatic systems, disease management is a difficult proposition due to the unique ecosystem, where the pathogen is always looking for an opportunity when the health status of the host is compromised. In many cases, disease outbreaks are closely related to environmental deterioration, leading to stress to the cultured animals. Different stress factors such as non-optimal water quality, higher microbial load, poor nutritional status, high stocking density can trigger the chances of infection by opportunistic pathogens in aquatic environment. Most bacterial, parasitic and fungal pathogens are not strictly parasitic micro-organisms. These pathogens have a high adaptability to environmental changes. If the conditions for parasitism are unsuitable, saprophytic relationship will develop. Environmental stress factors can result in increased occurrence of fungal infections. High organic loadings were also identified as a cause of increased infection of Saprolegnia parasitic

State wise Fish Production in India:

S. No.	State	Inland
1	Andhra Pradesh	1393728
2	Bihar	400140
3	Gujarat	92586
4	Karnataka	202216
5	Kerala	149098
6	Madhya Pradesh	85165
7	Maharashtra	145110
8	Odisha	291832
9	Tamilnadu	191956
10	Uttar Pradesh	449750
11	West Bengal	1337664
12	Chhattisgarh	255611
13	Jharkhand	96600
14	All States together in India, total	5744057

Common diseases reported in freshwater aquaculture:

India is basically a carp country and indigenous Indian Major Caps (IMC) which include rohu (Labeo rohita), Catla (Catla catla), mrigal (Cirrhinus mrigal), exotic carps like common carp (Cypri- nus carpio), grass carp (Ctenopharyngodon idella) silver carp (Hypophthalmicthys molitrix) along with catfishes (Clarius batrachus, Heteropneuestes fossilis, Pangassius spp.) and freshwater prawn Macrobrachium rosenbergii also being widely cultured account for bulk of aquaculture production.

In last few years, the exotic catfish Pangasiandon hypophthalamus, and pacu, Piaractus brachypomus, culture are also increasing. Also Tilapia and Pangasius offer oppor- tunities, for cage culture freshwater lakes and reservoirs. Instead of 10 ton per ha, in pond culture system, now a fish production of 3.0 ton in a cage of 6ft × 4ft × 4ft can be achieved. The focus has been on the production of genetically improved tilapia for market of cheap source of proteins.However, carp production contributes to bulk of the fish production in Indian freshwater aquaculture, with produc- tion over 3.25 million tonnes. As there is limited scope for horizontal expansion, the current trend in aquaculture development is towards.

Bacterial diseases

Bacterial fish diseases are very common and are one of the most difficult health problems to deal with. These bacteria are generally saprophytic in nature and only become pathogenic when fishes are physiologically unbalanced, nutritionally deficient, or there are other stressors, i.e., poor water quality, overstocking, which allow opportunistic bacterial infections to proceed. Bacterial diseases have been frequently encountered in eggs, fry, fingerlings of fish, causing heavy mortality. These microorganisms are essentially opportunistic pathogens which invade the tissues of a fish host rendered susceptible to infection by stress factors . Occurrence of bacterial diseases was not considered to be a serious problem in our country, as economic losses in fish culture was not known. The incidences of Ulcerative disease (EUS) in various Southeast Asian countries as well as in India, focused tremendous attention on the threat the disease epidemics hold for the farmers. Economic losses of the order of US $ 10 million in Thailand and over 3 $ million in Bangladesh were lessons enough to realize their importance. Some of the important bacterial diseases like motile aeromonads septicaemia caused by Aeromonas hydrophila, edwardsiellosis caused by Edwardsiella tarda, Pseudo- monas septicaemia by Pseudomonas fluorescens and Pseudomonas putrefaciens, flexibacteriosis by Flexibacter columnar, Vibriosis by Vibrio alginolyticus and V. parahaemolyticus bacterial gill disease, streptococcal septicaemia, mycobacteriosis, disease, and enteric septicaemia, are often being reported in carp culture in India. In general there are four types of bacterial infections i) Fin rot - usually resulting from environmental stress, ii) Bacterial body ulcers-open, shallow to deep, lesions on the fish's body iii) Bacterial gill disease - in which the gills are the primary target iv) Systemic bacterial disease, in which bacteria invade and cause damage to internal organs.

Another bacterial disease commonly reported in fish culture is bacterial skin disease or red disease. It is a systematic bacterial infec- tion. There are red areas on body, depression with swollen eyes and abdomen. A wide variety of bacteria mainly belonging to Gram-neg- ative rods are involved. Many pathogens are present only at skin le- sions, especially Flexibacteria, Aeromonads, Vibrios etc. There may be necrotic lesions on fins (fin rot). The disease may become system- atic, more severe form causing mortality. Another important bacterial disease often confused with red disease in carp culture in Motile Aeromonas Septicaemia (MAS). This is probably the most common bacterial disease causing severe production loss to freshwater fish culture. This disease has been associated with several members of the genus Aeromonas, including A. hydrophila, A. sobria, A. caviae, A. schuberti, and A.veronii. The clinical signs of motile Aeromonas septicaemia include high morbidity often with superficial to deep skin lesions and sometimes sudden death with or without any clinical symptoms. Skin lesions are often noticed at base of the fins, with variously sized areas of haemorrhage and necrosis. There are red areas on body, skin ulcers, swollen body, abdomen and eyes and musculature, hence often called as "red-disease". These lesions may progress to reddish to grey ulcerations with necrosis of the underlying. Unless immediate action not taken, the mortality rate often reached to 100%. Other bacterial diseases of less importance are Edwardsiellosis, caused by Edwardsiella tarda and Enteric Red mouth Disease, caused by the pathogen Yersinia ruckeri. There are some reports of occurrence of Columnaris bacterial disease that affects the skin or gills of freshwater fish and is caused most commonly by Flexibacter columnaris. This is primarily an epithelial disease and necrosis and erosions of the skin and gills are often observed which may become systemic. Whitish plaques with reddish peripheral zone are observed mostly on the head or back, hence the disease also called saddleback disease. Lesions on fins arte also often observed, hence, it is also called as fin rot disease.

Parasitic diseases of fish:

The production from culture system is hampered by the infestation of various fish parasites. Compared to other diseases, occurrence of parasitic disease has been the major cause of concern and caused significant setback to freshwater aquaculture in India. Fish parasites multiply rapidly under favorable conditions, there by affecting the health of fishes, often leading to high mortality. Parasites interfere with nutrition of hosts, disrupts metabolism and secretary functions of alimentary canal and damage nervous system. During survey of different carp and Pangasius farms in Andhra Pradesh, Odisha, Karnataka and Gujarat, fish were observed to be affected by fish par- asites, mostly, the protozoan ciliates (Ichthyophthirius sp., Trichodina sp.), monogenetic trematodes (Dactylogyrus spp., Gyrodactylus sp.) and larger crustacean ectoparasites viz. Lernae spp., Argulus spp., (the freshwater louse,) Ergasilus, which cause substantial economic loss in fish culture system in India. Disease and mortality due to monogenian trematodes Gyrodactylus spp., (commonly known as skin flukes), and Dactylogyrus spp., (known as gill flukes) have also been commonly reported in carp culture and cage culture. These monogenetic trematodes are considered as one of the most prevalent parasitic agents affecting skin and gills, causing irritation and destruction of gill tissues leading to impairment of breathing. The Ichthy- opthirius, cause “white spot” or “Ich” in most freshwater fishes. An- other fish parasite, Trichodina browse over gills and skin, damaging the host tissue and consuming the resulting dead tissues. Repeated chemical treatments are necessary to eliminate the parasites. An- other important and most prevalent parasitic disease causing severe economic loss in carp culture is “Argulosis” caused by crustacean ectoparasites of the genus Argulus also called “freshwater fish lice” . Acute infestation of Argulus infestations often cause dermal ulceration, osmotic imbalance, physiological stress and immunosuppression, leading to high morbidity and lowered growth rate of carps .but the incidence of mass mortality due to this disease has been very low. Reported that Indian major carps are more susceptible to Argulus parasites, in comparison to Chinese and European carps. The intensity of infestation is greatly influenced by seasonality, which affects host physiology and ecology .Intense parasite infestation can cause ulceration and upset the normal course of repro- duction. Besides, indirect effects of infestation such as reduced fish growth, reduced feed conversion ratio, secondary infections with other bacterial and parasitic infestations and fish mortality as well as farmers perception about safe aquaculture, too contribute substantially to the loss incurred.

Among all fish parasitic infestations, disease with Argulous is most common (29%), followed by infestation with Dactylogyrous (25%) and Myxobolous (9%) (Figure 2). However, in some cases infestation with multiple parasites have also been reported in fish culture. It has been observed that incidence of Argulosis in the wild fish populations is of very low in intensity compared to that reported in pond culture conditions . Loss due to parasitic disease Argulosis was been estimated to be to the tune of Rupees 30,000 (US$ 615) per hectare per year in carp culture in India. However, estimated loss of BDT 35,552.50 ha-1 yr-1 due to parasitic diseases in carp cultures in Bangladesh. Overall loss due to parasitic diseases was found 11% for mortality, 11% for chemicals cost and 65% for reduction of growth of carps in the study areas.

Fungal diseases of fish

Contrary to bacterial and parasitic diseases, only a few numbers of fungal species are known to be pathogenic to fish. Mostly these are present in water and under unfavorable conditions; they attack the fish causing skin lesions. Most fungal infections recorded in carp culture are those caused by species belonging to the oomycete fungi, Saprolegnia, Achlya and Aphanomyces. Diseases caused by these fungi are collectively called “saprolegniasis”. These oomycete fungi, are commonly present in aquatic environments, are rarely considered to be primary pathogens. These are often recognized as saprophytic, opportunistic secondary pathogens that readily colonise the damaged tissues infected by bacteria or parasites. Fungal growths on skin or fins look like patches of white to whitish-grey cotton-wool like growths. These are mostly composed of numerous fungal hyphae, which can be visualized under microscopic observation Saprolegniasis is particularly prevalent in over-wintering ponds with a high stocking density, like in cage culture or intensive aqua- culture. Although there are several reports of saprolegniasis mostly is cage culture systems, the incidences are normally less in pond culture system, unless there is gross mismanagement. Besides Saprolegnia, Branciomyces and Aphanomyces causes disease in pond aquaculture.

Another important fungal induced disease in fish culture of high economic importance is Epizootic Ulcerative Syndrome (EUS). It is widely occurred in freshwater aquaculture causing a great loss in South East Asia including India. It is a severe and economically important disease affecting farmed freshwater fish and listed as a noticeable disease. Haemorrhages and ulcers are the clinical manifestation of the disease symptoms on the body surfaces. It is an important bacterial-fungal mixed infection responsible for high mortality in fresh- water fishes. Fish species commonly affected are Catla catla, L. rohita, C.mrigala, C. carpio, Channa sp., Puntus sp., and G. chapra. Affected fishes become weak, off-fed and float on the surface of the water. Initially, red colored lesions often with haemorrhages are seen on skin, which gradually becoming deeper and assuming the form of ulcers. In some cases tissues patches fall off, causing secondary infection and high mortality [36]. Although a wide variety of organisms have been isolated from the body surfaces and internal organs of the fish, Aphanomyces invadrans is believed to be the primary causative organism. A range of both biotic and abiotic factors may pre- dispose fish to infection by EUS, reported EUS to be the most common disease in Bangladesh that has a significant impact on carp culture they indicated that ponds receiving water from rice field and river/ditch had high relative risk of EUS.

Farmers in the region are in practice of using various probiotic formulations, aqua drugs and chemicals, various antimicrobials, sanitizers, anti-parasitic drugs and even antibiotics in fish culture system, as preventive and control measures to protect the crops. Some drugs and preparations, which are used in animal medicine and agriculture practices, are also being used in fish culture [37]. CIFAX, a chemical formulation developed by the scientists of ICAR-CIFA, has been found quite useful in controlling EUS and other bacterial infections, besides have some other useful actions in pond culture.

Viral diseases for fish:

There are more than 125 different viruses have been identified in fish around the globe and new viruses are being discovered every new date. However, there are only few reports of viral diseases affecting finfish in India. Viral diseases like Cyprinid Herpesvius-2 (CyHV-2), Koi Rana Virus (KIRV), Carp Edema Virus (CEV), Megalocytiviris and Goldfish haematopoietic virus necrosis herpes have been reported in ornamental fish culture. KIRV causing huge mortality of koi Cyprinus carpio was reported in ornamental fishery. In addition, koi sleepy disease caused by CEV was reported in Cyprinus carpio. Report of Viral Encephalopathy and Retinopathy (VER) or Betanoda virus was also reported for a period in seabass farming, although there were no subsequent reports of such disease occurrence in India. There are some reports of occurrence of Tilapia Lake Virus (TILV) in some pockets of tilapia culture in cages and tanks. However, Indian Native Species of Carps (IMC), which is the predominant species is not affected by any of above describes viruses, which is a good sign for Indian aquaculture sector. Overall the freshwater aquaculture sec- tor is free from adverse impact of fish viral epidemics as has been reported in marine or brackish water shrimp culture and in other parts of the world. White spot disease has caused havoc in shrimp aquaculture, viral disease outbreaks has not been the cause of concern in fish culture. The significant observation is that so far not a single case of viral disease outbreak has been reported in freshwater aquaculture in India, causing huge mortality. May be that India is blessed with Indigenous Variety of Indian Major Carps (IMCS) which are not susceptible to fish viral pathogens as prevalent in other Asian countries or the culture environment is not conducive for the viral pathogens to multiply and cause disease. However, frequent occurrence of parasitic infestations in fish culture has been an area of concern, which is responsible for high morbidity and production loss, compared to other pathogens. As has been presented in figure 3, incidences of occurrence of parasitic infestations in freshwater aquaculture are maximum (46%), followed by loss due to alternation in water quality parameters (24%) leading to production loss. Infection of fish with bacterial pathogens are in the range of 22% and in only 8% cases the mortality are due to other factors Another significant observation in Indian aquaculture has been seasonal variation in occurrence and severity of fish diseases in freshwater aquaculture. Whereas incidences of red disease or Aeromoniasis are common during all seasons, the incidences of Black-gill disease are more during winter periods. Among parasitic diseases, occurrence of Argulousis and gill fluke disease are comparatively more during winter and post-rainy season. Hence, the farmers are advised to take due preventive and control measures during post- rain and winter seasons in grow-out culture system.

Disease diagnosis and control:

The impacts of emerging diseases of aquatic animals have been substantial, adversely affecting livelihood security of millions and have impacted regional or national economies. The most devastating production loss with socioeconomic impacts was that observed in in shrimp aquaculture in India during 1995-1998, which almost led to collapse of shrimp aquaculture industry in India. Development and application of suitable diagnostic and control measures to combat disease occurrence in fish and shellfish culture to control production loss, thus have assumed significance in many aquaculture-producing countries. The most important approach to disease control programme is managing the culture unit to reduce disease predisposing conditions. This is best achieved through the use of realistic stocking densities, preventing the introduction of pathogens into culture systems or hatcheries, maintenance of good water quality parameters, avoiding stress and through the provision of adequate nutrition to cultured animals. Until few years from now, diseases in aquatic organisms were not considered to be a serious problem in our country, as economic losses in fish culture were not known. Recent incidences of various emerging diseases have focused attention in these aspects. However consolidate affords are necessary to tackle this problems for sustainable aqua farming and to prevent production losses. the essential principles of disease treatment and control are to i) establish an accurate diagnosis; ii) select an appropriate and environmentally responsible treatment and iii) evaluate management practices within the farm and determine if future outbreaks could be prevented by changes in procedure or design. At National level, the laboratory facilities, diagnostic expertise, control protocols and therapeutic strategies are becoming better day by day to handle such disease out- breaks. In addition, many farmers, especially in developed countries, have improved their capacity to respond quickly and effectively to emergent disease situations. It has been emphasized to establish such composite "Water quality testing- disease diagnosis Laboratory" required to be set up at every district level, specifically in aquaculture zones to tackle the problem. Considering the present condition, it is presumed unless there intra-state and inter-state cooperation and co- ordination, it would be difficult to implement it. If implemented, this would greatly Enhanced their disease prevention awareness.

Future scope of development of aquaculture in India:

Data indicate currently, only an estimated 40% of the available resources in India are in use for aquaculture because of technical and market access issues and there is lot of scope of development of aquaculture. Realizing the immense scope for development of fisheries and aquaculture, the Government of India has restructured the Central Plan Scheme under an umbrella of "Blue Revolution". The restructured Central Sector Scheme on Blue Revolution called Integrated Development and Management of Fisheries (CSS) approved by the Government provides for a focused development and management of the fisheries sector to increase both fish production and fish productivity from aquaculture and fisheries resources of the inland and marine fisheries. Including deep national Fisheries Development Board, Hyderabad in collaboration with state agricultural universities (SAUs) has already implemented national program "All Indian network project on fish health" through ICAR-Research institutes and SAUs. The project aims to understand the disease prevalence status, economical losses cussed due to diseases, cataloging of various drugs and chemicals used in aquaculture and conducting fish health camp and awareness programs for the benefit of farmers. Efforts are being made to bring a “National Inland Fisheries Policy” along with “New Marine Fisheries Policy, with will decide an overall and integrated growth framework in the area of inland fisheries throughout the country, which would lead sustainable development of aquaculture in India.

Chapter-5

CONCEPT OF ORGANIC AQUACULTURE AND ITS CHALLENGES

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INTRODUCTION

A practice of aquaculture that includes various elements which ensure the farming activity is in harmony with nature. The methods and materials used have low impact towards the environment. It promotes environmentally, socially and economically sound production. Organic fish farming is a method of sustainable aquaculture based on long term ecologically and environmentally sound practices (Diwan and Ayyappan, 2004). Its principles are based on protecting the environment, in minimizing soil and water degradation, and in decreasing pollution and optimizing biological diversity and productivity. Generally the concept of organic fish farming is to optimize the health and productivity of the interdependent communities of water, soil, plant and animal life. Management practices are carefully selected with intent to restore and then maintain ecological harmony on the farm and the environment.

Over the years, environmental awareness has grown all over the world. Consumers, and also business professionals, have come to be increasingly interested in environmentally sound fish and fish products produced in a polluted environment has a marginal avenues. More and more consumers want to know what they are eating and whether the products are produced without harming the environment. For these reasons, the demand for organic products is now growing worldwide and has tremendous market prospects for growth and development.

In recent years the market for organic products has expanded considerably farmed aquatic products earning premium prices over conventional products. A number of species are now being farmed by organic methods as consumers in major export markets, as well as in domestic markets, are becoming more and more conscious of environmental and health issues especially pertaining to the production of food that they consume. Organic farming has become a special form of value addition as consumers of organic products are prepared to pay a substantial premium for them compared to conventional products.

Over the last decade, the organic food sector is being seen as one of the most dynamic in the international food market. Many countries have shown remarkable growth rates for organic foods. Denmark and Sweden for example, have exhibited growth rates ranging from 30-40% and Switzerland and United Kingdom, 20-30%. The international market for organic food was worth approximately US$20 billion in 2000. The largest single market was the USA with sales of around US$10 billion followed by Europe with US$9 billion and Japan with US4 1.5 billion (Diwan and Ayyappan, 2004).

CONCEPT OF ORGANIC AQUACULTURE

The concept of organic aquaculture is being developed for

1) Maintenance of sustainability of the system by restricting the introduction of harmful substance and practices that adversely alter the ecosystem.
2) It would help in raising aquatic products in a human manner that is sustainable and pollution free.
3) Appropriate living condition with adequate space for free movement and minimize stress by optimum stocking density as per carrying capacity of the system much be in the practice of the farming.
4) The input materials such as seed, feed and fertilizers much be raised under the organic management.
5) Cultivable species much be fed on organic feed to optimize good health condition in case fish meal is taken as component in organic feed, the fish meal much be from certified sustainable sources. Thereby, harvesting of the products would be pollution free and also sustainable.

CHALLENGES IN ORGANIC AQUACULTURE

The challenge in organic aquaculture is to follow the same principles as terrestrial organic agriculture. It is a significant challenge, given the basic difference in providing treatment to the sick aquatic animals. While the terrestrial animal can be treated individually, but the aquatic animals would have to be generally treated in group. Within the aquaculture there are also huge differences between the species themselves. For instance, rearing of mussel is vastly different from rearing fish and crustaceans. Hence, there are more specific standards under each norm that organic farmers must follow to raise the yield.

Organic aquaculture helps in:

- Increasing soil fertility
- Minimizing input cost
- Eco-friendly
- Safe

Chemical Fertilizers/Pesticides gradually discarded due to:

- Chemicals leave harmful residues on main crops
- Long term use of such food materials leads to serious diseases
- Chemicals mix up with earth and contaminate soil and water layer

STANDARDS FOR ORGANIC AQUACUTURE:-

These standards are classified into two categories viz. miscellaneous and general principle of farm management.

I. Miscellaneous:-

a. **Prerequisites for granting the producer contract: -** the entrepreneurs who produce the fish are obliged to provide information on the method of farming that is being practiced, the economic situation of the farm and the prevailing environmental conditions and if possible causes of contamination with comprehensive description of all the water bodies and of the production and storage sites.

b. **Producer contract: -** on signing the contract the entrepreneur commits himself adhering to the standards set by Naturland for fish farming.

c. **Standards: -** the standards set by Naturland are obligatory for the entrepreneurs.

d. **Conversion:-** during conversion of land to organic aquaculture, management practices in accordance with principles of organic aquaculture set by Naturland need to be followed throughout the entire operation.

e. **Operational changes:-** if new areas are introduced into the farming operation either by way of purchase or lease, then the animal kept on that area have to be comply with usual conversion period which is specified in standards.

f. **Documentation and inspection: -** the association must be provided with the latest data on farming viz. the product flow (feed and fertilizers), about the cultivable stocks, use of drugs and chemicals, incidences of diseases, mortality rates and negative impact on the quality of the products. Adherence to the standards shall be monitored by the authorized by Naturland.

g. **Certification: -** the association at the end will certify the entrepreneurs' adherence to the standards to the farming methods and quality of the produce.

h. **Labeling and marketing:** - the products thus produced can be labeled with Naturland trademark, as originating from certified organic aquaculture.

II. GENERAL PRINCIPLES OF ORGANIC AQUACULTURE:-

1) Bio fertilizers can be used for increasing the natural productivity of the system and plant extract or medicinal herbs can be used to control pest and diseases management of plant communities in farm management.
2) Used of hormones for seed production genetically modified organism (GMO) and used of organic fertilizers are strictly restricted, no used of synthetic pesticides and herbicides.
3) Organic standards are strictly followed in the practices material used to produce products. Feed and fertilizers from certified organic aquaculture. Although the process is organic this doesn't make any claim about the end products such as quality and food safety.
4) Limitation of stocking density.
5) Preference of natural medicines.
6) Processing according to organic farming.
7) Intensive monitoring of environment inputs.

STATUS IN WORLD:

Farmland lender Organic farming: 32 million. ha.

Continent wise area under organic farming:

CONTINENT	AREA	% OF LAND
Australia	**12.2 million ha**	**39**
Europe	**6.5 ,,**	**21**
Latin America	**6.4 ,,**	**20**
Asia	**4.1 ,,**	**13**
North America	**1.4 ,,**	**4**
Africa	**1.2 ,,**	**3**

Source: Souresh, 2008 Fishing Chimes

Top Ten Countries With Largest Area In Organic Farming:

1. AUSTRALIA	6. BRAZIL
2. CHINA	7. GERMANY
3. ARGENTINA	8. URUGUAY
4. ITALY	9. SPAIN
5. USA	10. UK

Market value of worldwide organic products: $27.8 billion.

Largest Market: Europe & North America (2004)

(***Source: Souresh, Fishing Chimes***)

BENEFITS OF SOIL ORGANIC MATTER

- Buffer against change in soil pH.
- As cement for holding clay and silt particles increasing water holding capacity.
- Resistance against soil erosion.
- Plant & Plankton at the bottom.
- Binding of micronutrients & metal ions in the soil.
- Releasing of nutrients N, P & S slowly for growth of plankton and beneficial microbes.

NUTRIENT CONTENT OF ANIMAL MANURES (FRESH):

MANURE	**N%**	**P%**	**K%**
Cattle Dung	0.3-0.4	0.1-0.2	0.1-0.3
Horse Dung	0.4-0.5	0.3-0.4	0.3-0.4
Pig Dung	0.59	0.46	0.43
Poultry Manure	**1.0-1.8**	**1.4-1.8**	**0.8-0.9**
Duck Droppings	1.0	1.4	0.62
Sheep Dung	0.5-0.7	0.4-0.6	0.3-1.0
Night Soil	1.0-1.6	0.8-1.2	0.2-0.6

(***Source: Souresh, 2008 Fishing Chimes***)

UTILITY OF DIFFERENT ORGANIC MATERIALS IN FISH FARMING:

A) CATTLE DUNG:

- Highest availability.
- Widely used for pond fertilization in raw condition

- Enhances zooplankton preferred by Carps.
- Directly consumed by some fishes.
- Mixed with water and broad cast over water.
- Requirement: 2.5-5.0 mt/ha.

B) BIOGAS SLURRY:

- More preferable than cattle dung.
- Decomposition of organic matter is outside pond.
- Semi liquid form.
- Requirement: 2.5-3.5 mt/ha.

C) COMPOST MANURE:

- Mixture of cattle dung, aquatic weeds, green matters, oil seed cakes etc at the ratio 50:25:20:5
- Ancient and wide practice in Pisciculture.
- Enhances usefulness and acceptability of organic materials.
- Organic matters are decomposed, pathogens are destroyed and nutrients are easily available.
- CN ratio is increased from 40:1 to 20:1

D) VERMI COMPOST:

- Green matters and cattle dung are spread in layers in a cistern with side open.
- Open side is covered with bamboo gratings.
- Water sprinkled over cistern.
- Exuded manure water collected at open side is used for manuring.
- 1800 nos of earthworms are released for $1m^2$ of compost after 2-3 weeks when temperature of material comes down to normal (30˚C).
- Earthworms burrow and feed on decomposed organic matter and leave stool on compost.
- Decomposition is completed in next 4-6 months.
- Compost is dried under sun, crushed into granules & packed.
- Dose not standardized for aquaculture, but applied @ 1500-2000 kgs/ha for agriculture.
- Very good for fruits, vegetables and crops.

E) POULTRY DROPPINGS:

- Both solid & liquid form.
- 50% of Nitrogen content is lost, when exposed to Sun.
- Dried in shade, stored in bags till application.

- N:1.5%, P: 1.2%, K: 0.5%
- 4-5 times more nutritive than cattle dung.
- Decomposition is quick.
- Application at low dose to avoid Oxygen depletion.
- Preference for shrimp/prawn farming.

F) OIL CAKES:

- Used in nursery management and shrimp farming.
- Good and long lasting manure.
- Neem, mohua and karang as prophylactic measures.
- MOC kills unwanted biota & turns to mohua in 3 weeks.
- Clean & Conc. Organic manures.
- High quantity of nitrogen & small quantity of P & K.
- Low CN ratio, helping in quick release of nutrients.
- MOC and GNOC are directly fed.

NUTRIENT CONTENT:

OILCAKES	N%	P%	K%
Mustard	**4.65**	**1.65**	**1.56**
Ground nut	**7.29**	**1.53**	**1.33**
Mohua	**2.5**	**0.8**	**1.8**
Neem	**5.2**	**1.0**	**1.4**
Karang	**4.0**	**1.0**	**1.3**

(***Source: Souresh, 2008 Fishing Chimes***)

G) GREEN MANURE:

- Legume bearing plants which fix atmospheric nitrogen.
- Cultivated at the margin or basin of ponds.
- Ploughed down and mixed with soil which gives fertility (Nitrogen).
- Common practice in India.
- Cowpea, dhanicha, cluster bean, horse gram, sun hemp are green manures

Nutrient Content:

Plants	N%	P%	K%
Cowpea	0.71	0.15	0.58

Dhanicha	0.62	-	-
Cluster bean	0.34	-	-
Horse Gram	**0.84**	-	-
Sun hemp	0.75	0.12	0.51

(***Source: Souresh,2008 Fishing Chimes***)

POPULARITY OF ORGANIC PRODUCTS DUE TO:

- Rise in health and environmental awareness.
- Concern over food security.
- Assurance that food produced without adverse effects on nature or environment.
- Food scares-mad cow diseases; pesticide, antibiotic and other residues; GMOs.

CRITERIA FOR ORGANIC AQUACULTURE:

A) BREEDING:

- Natural method
- Organism from natural sources.
- 2/3 of life span in organic system.
- Triploid and genetically engineered fish not allowed.

B) NUTRITION:

- Fish should have 100% certified organic components.
- Minimum 50% protein in a diet from byproducts.
- Feed or fertilization should be animal or plant based.
- Mineral supplements are allowed.
- Synthetic growth promoters, apettizers, anti-oxidants, preservatives, colouring agents not allowed.
- Vitamins, supplements & trace elements from natural origins.

C) HARVESTING:

- Minimum handling of organisms.
- Harvesting not to exceed MSY of ecosystem.

D) TRANSPORT:

- Avoid physical stress/injury.
- Transportation equipments should not have toxic effects.

- Importance on water quality, quantity, SD, distance and time, precaution against escape during transportation.
- No use of chemical tranquilizers/stimulants.

E) HEALTH CARE:

- Only vaccination may be allowed, no prophylaxis treatment.
- Records of disease management.
- No mutilation of animals.

Other recommended criteria

The National Organic Standards Board (NOSB), an elected body that guides USDA's policy decisions regarding the National Organic Program (NOP), on the topic of certified organic aquaculture, recommended the following criteria for calling fish organic:

- Fish to be fed non-organic feed. Currently, certified organic livestock have to be fed 100% organic feed.
- Farmed fish to be fed fishmeal made from wild fish, which can carry mercury and other toxins.
- Fish to be raised in open net pens. These cages lead to pollution from concentrated waste and can spread disease and parasites to wild fish populations.

SPECIES FARMED ORGANICALLY:

FRESH WATER	SALINE WATER
• **Trout**	**Salmon**
• **Carp**	**Sea bass**
• **Eel**	**Sea bream**
• **Tench**	**Turbot**
• **Catfish**	**Mussel**
• **Tilapia**	**Shrimp**
• **Arctic charr**	**Milkfish**

SPECIES WISE ORGANIC AQUACULTURE IN COUNTRIES:

COUNTRIES	SPECIES
Ireland	**Salmon, mussel**
Uk	**Salmon, trout, carp**

France	**Seabass, Sea bream**
Chile	**Salmon**
Taiwan	**Microalgae**
Austrilia	**Trout, carp**
Switzerland	**Trout, carp**
Germany	**Trout, carp**
Spain	**Sturgeon, trout**
France	**Trout, oyster**
Israel	**Tilapia**
China	**White shrimp, Oriental shrimp, Tuna, Seaweeds, Carp, Trout**
USA	**Microalgae**
New Zealand	**Mussels**
Hungary	**Carp**
Vietnam	**Tiger shrimp**
Thailand	**Tiger shrimp**
Indonesia	**Tiger shrimp**
Colombia	**White shrimp**
Peru	**White shrimp**
Ecuador	**White shrimp**

(*Source: Tarlochan, 2005, Aqua International*)

Farmed Organic Fishery Products

Black tiger shrimp: Vietnam, Bangladesh and India.

White vannamei shrimp: Ecuador, Peru

Freshwater shrimp: USA, Bangladesh

Tilapia: China, Israel, Brazil, Honduras

Pangasius catfish (basa basa): Vietnam

Carp: Israel (domestic market) East and Southern Europe

Trout and sea bream: Eastern, Western and Southern Europe

Cod: Norway

Atlantic salmon Atlantic salmon: U.K., Ireland, Chile

Mussels: New Zealand

SUSTAINABILITY OF AQUATIC MEDIUM AND SUSTAINABLE MANAGEMENT PLAN

More than 20 ton/year by the production unit and the operator needs to provide an environmental assessment (Council Directive 85/337/EEC).

Production unit must have settlement ponds, biological filters or mechanical filters to collect waste nutrients to improve the effluent treatment.

MARKET PERSPECTIVES FOR ORGANIC FISH AND FISHERY PRODUCTS:

During the past decades all over the world, the steady increase in demand for organic food has stimulated a growing interest in organic farming. Organically produced foods offers an alternative source of hygienic food to consumers with food safety and environmental quality. However, in comparison to the global conventional food market, the organic food is still a niche market (0.3 market share). As far as the organic fish is concerned, there is a good market for organic salmon in Europe which increases from 12c mt in 1997 to 2000 mt in 2000.

Organic seafood products are niche market and users currently expect to pay premiums of 30-40%. Organic salmon is the top species and retails at 50%. Market demand is driving Danish rainbow trout farmers to switch to organic farming.

Known data on organic aquaculture by country:

ASIA

Country	Organically managed area (ha)
Bangladesh	2000
China	415000
Ecuador	6382
Indonesia	1317
Thailand	33
Total	424732

*Indonesian shrimp farms are locally certified as organic but recent study found them to be highly environmentally damaging.

CONCLUSION

Organic aquaculture is sustainable and eco-friendly. Application of manure (both) creates pollution load and imbalances natural ecosystem. For increasing production, it is better to add organic materials which are less reactive and leave no harmful residues on crops or on pond bottoms which makes it unproductive. Environment pollution, a serious concern at present can be reduced by recycling the available organic wastes. Indian farmers are conversant with organic manures and so promotion of organic fish farming will be easier. Suitability of different organic manures at different places and in different farming systems should be judged properly.

Many organic aquaculture issues still need to be resolved. Steps should be taken to encourage and enhance the biological cycles with respect to nutrient management and to retain the integrity of the organic product from farmer to consumer and conversion requirements for moving the conventional aquaculture system into organic systems. For the answers to these questions NGOs, academia, government and organic sectors have to work closely following the necessary guidelines. With continued emphasis worldwide, aquaculture will emerge as the most environmentally friendly and efficient form of agriculture and as an ally partner in sustainable development.

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Chapter-6

Fish Health Management

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

Classification of Fish Diseases

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

Parasitic disease in fishes

Parasitic disease is also called as pathogenic disease or infectious dis-ease of communicable disease. The important parasitic disease is vital, bacterial, fungal, protozoan, helminthic, annelid and crustacean.

The parasitic are mainly are two types

Exoparasite: These are found on the body surface, fins and gills, e.g., Argulus, Lernaea, Ergasilus, and Leaches

Endoparasites: These are found inside the body. These are further divided into 3 types

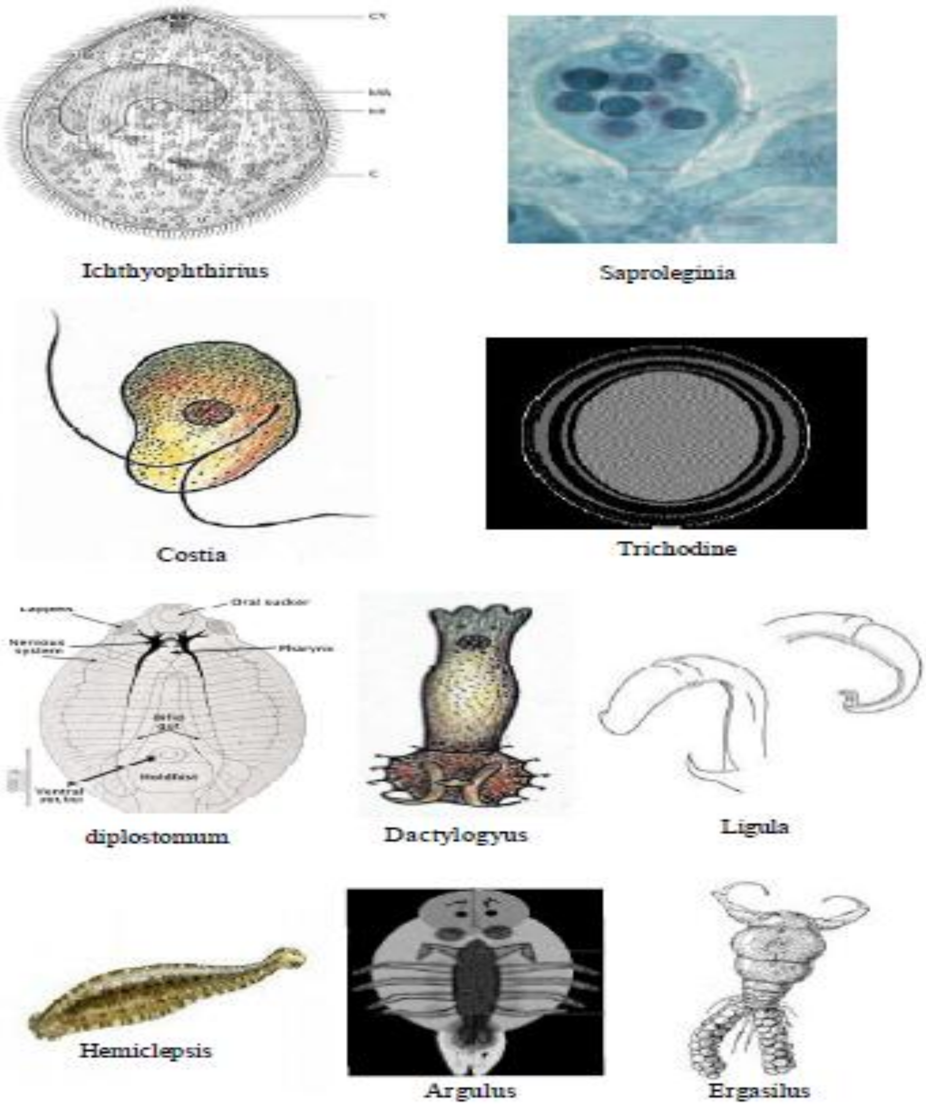
Cytozoic parasites: These are found in the cells, e.g., Microsporadia, Glugia

Histozoic parasites: These are found in the tissues

Coennozoic parasites: These are found in the body cavity or inside the alimentary canal e.g., Diphyllobothrium, nematodes

Non parasitic disease

These diseases also occur in fishes mainly due to environmental and nutritional problems. These are further divided into environmental fish disease and nutritional fish disease.



Common fish Parasite

COMMON FISH DISEASE

VIRAL DISEASES IN FISHES

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

a. Lymphocystis:

Woodcock (1904) identified this disease in fishes. Marine, freshwater and aquarium fishes are susceptible to this disease. Tumor formation is the important character of this viral disease. The external lesions are raised, and made up of the growing of granular, nodular tissue which is composed of many greatly enlarged host cells. Matured lesions may become slightly hemorrhagic. Within 6-15 days of infection the tumors grow to 50 thousand times. The only control measure is prevention

b. Viral Hemorrhagic Septicemia (VHS):

This disease is caused by an unequal shaped fish virus with RNA. This disease occurs in salmon fishes. Transmission of the disease occurs through the water by a flagellate. The symptoms are kidney swelling, reduced appetite, obvious distress, erratic spiral swimming, multiple haemorrhages in skeletal muscles, change in body colour, reddish fins. The only control measure is prevention.

c. Infectious Pancreatic Necrosis (IPN):

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

d. Infective Haemopoitic Necrosis (IHN):

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

e**. Chinook disease:**

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

f. Channel cat fish virus disease:

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

Bacterial diseases in fishes:

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

a. Furunculosis:

Furuculosis disease is caused by *Aeromona salmonicida* in salmon fishes. It is a non-motile, gram-negative bacterium. This disease frequently appears to infect fishes living in the dirty waters containing a large amount of decaying matter. The first symptoms of this disease are appearance of boil like lesions. Others symptoms are blood-shot fins, blood discharge from the vent, haemorrhages in muscles and other tissues and necrosis of the kidney. Bursting of boils allow the spread of this disease among other fishes and also offer suitable areas for fungus growth. Fishes severely infected with the bacteria die in good number. Remove the severely infected fishes from the pond and supply food containing antibiotics like sulphonamides or nitrofurans. Sulfonamides like sulfadiozine or sulfaguanidine are given orally with food at the rate of 22gms/100kg of fish/day. Other antibiotics like chloromycetin and tetramycin are most effective at a dose of 5-7.5gm/ 100kg of fish/day. Disinfect the eggs with 0.015% solution of methiolate or 0.185% acriflavin.

b. Columnaris disease:

Columnaris disease is caused by *Chondroccus columnaris* and *Cytophaga columnaris* in many freshwater aquarium fish. It is a long, thin, flexible, gram-negative slime bacterium (myxobacteriales). This disease is often associated with low oxygen level. Initially it is marked by appearance of grayish-white or yellowish-white patches on the body. The skin lesions change to ulcerations and fins may become frayed. Gill filaments are destroyed and eventually lead to the death of the fish. Addition of 1 ppm copper sulphate in the pond to control this disease is effective. Tetramycin administered orally with food at a rate of 3 gm/100 pounds of fish/day for 10 days is very effective. Dip treatment in malachite green (1:15000) for 10-30 seconds and one hour bath in 1 ppm furanase is very effective to control this disease.

c. Fin or tail rot:

Tail or fin rot disease is caused by *Aeromonas salmonicid* and *A. liquefaciens.* However, protozoans and fungi may also be involved. It is characterized by appearance of white lines along the margins of fins, the opacity usually progresses towards the base eroding them, and causing hemorrhage. The fin rays become brittle first and later break, leading to the complete destruction of the fins. The infection may also spread on the body surface. Fin and tail rot are associated with poor sanitary conditions in fish ponds and with water pollution in nature. The fin or tail rot may be checked at an early stage by keeping fishes in 0.5% copper sulphate solution for 2 minutes. Control may be achieved with 10-50 ppm tetramycin and 1-2 ppm of benzalkonium chloride. In severe infections the affected parts are surgically removed and the fishes are then kept in 0.04% potassium dichromate.

d. Vibriosis

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

e. Dropsy

Pseudomonas punctata is the causative agent of this disease. It is charecterised by accumulation of yellow coloured fluid inside the body cavity, protruding scales and pronounced exopthalmic conditions. This is known as intestinal dropsy. In case of ulcerative dropsy, ulcers appear on the skin, deformation of back bone takes place and show abnormal jumping. This is a fatal disease in culture systems. Removal and destruction of fishes, followed by draining, drying and disinfecting the pond with lime are preventive measures to control the disease. The infected fishes may be cured with 5 ppm potassium permanganate for 2 minutes dip bath. Streptomycin and oxytetracyclin give good results.

f. Cotton mouth disease:

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

g. Tuberculosis:

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

h. Bacterial gill disease:

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

PROTOZOAN DISEASES

a. Whirling disease:

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

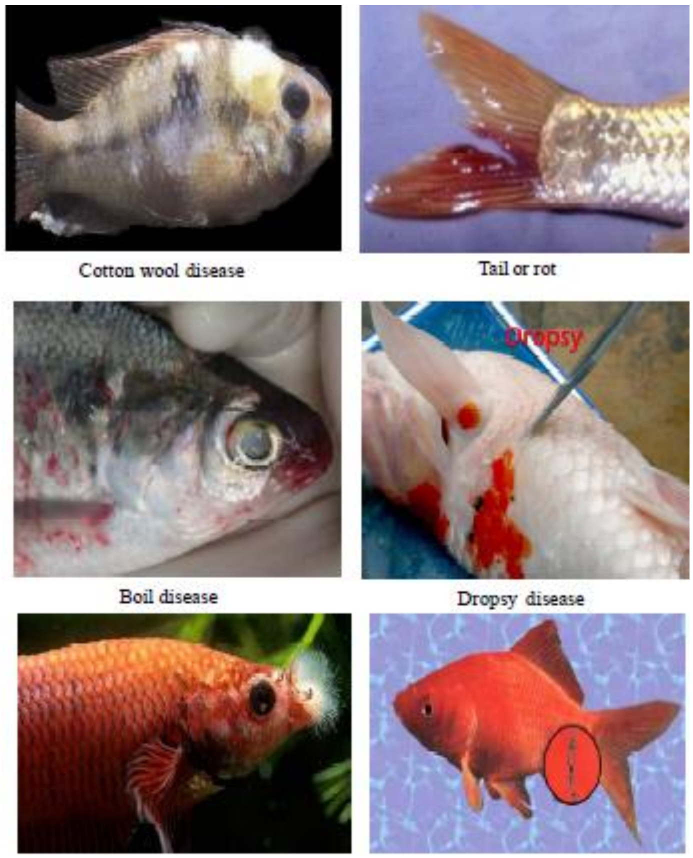
b. Costiasis:

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

c. Ichthyophthiriasis:

This caused by a ciliate, *Ichthyophthirius multifilis*. This disease is also called as ich or white spot disease. The young parasites moving in water get attached to the skin of the fish. They grow between the epidermis and dermis and after becoming large in size fall to the bottom of the pond. Infected fish develop small white spots on the skin and the fins. These parasites attack the gills also. Fish respond by jumping in the water and rubbing their body against the water objects. Respiration gets affected and they finally die. Dip treatment in 1.5 ppm of malachite green or in

10 ppm of acriflavin gives good results. 3% salt solution, 1:4000 formalin, 1:100000 quinine hydrochloride, 1:500000 methyl blue are also useful to treat the fish.



Common disease of fish

FUNGAL DISEASES

a. Saproligniasis:

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

b. Branchiomycosis:

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

c. Ichthyophonosis:

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

CRUSTACEAN DISEASES IN FISHES

a. Argulosis:

Argulus or fish lice are a common copepode parasite in fishes. It is a large ectoparasite and can move over the body surface of the fish. Argulus puncture the skin and inject cytolytic toxin through the oral sting to feed on the blood. The feeding site becomes a wound and hemorrhagic, providing ready access to secondary infection of other parasites, bacteria, virus and fungi. Argulus transmits dropsy in fishes. In advanced stages, fish swim erratically, show growth loss and loss of equilibrium. To control Argulus, remove the submerged vegetation, wooden lattices placed in the pond will serve as artificial substrate to deposit its eggs, which can be removed at intervals to kill the eggs. 500 ppm of ammonium chloride, 410 ppm of balsam, 10 ppm of DDT for 25 seconds dip, 0.25 ppm of dylox and 2000 ppm of Lysol for 15 second dip are effective to kill Argulus.

b. Lernaeasis:

It is caused by a copepode parasite, Lernaea or anchor worm. This disease is mostly caused by *L.cyprinacea*. The larval stages are temporary parasites that feed on mucous and blood of fish. The adult female is a specialized fish parasite, worm like, which burrows into the fish flesh, keeping its eggs cases protruding out of the fish body. Male Lernaea do not attack the fish and are not specialized for parasitic life. Early infected fish swim erratically, flashing against the sides and bottom of ponds. Heavily infected fish swim upside down or hang vertically in the water. Only partial control of Lernaea is possible with chemicals, because the head is buried in the fish tissues and there are no exposed respiratory organs. Hence, prevention is more effective than control. 1% common salt eliminates larvae in 3 days, 250 ppm formalin for 30 to 60 minutes. 0.2 ppm gammexane for 72 hours, 2 ppm of lexone, 0.1 ppm lindane for 72 hours and 1 ppm chlorine for 3 days may give good results.

c. Ergasillus and salmincola:

These two parasites are responsible for huge mortality of fishes in the culture systems. These two parasites are found attached to the gill filaments and feed on blood and epithelium. Later they may also be found on the fins and body. The infection results in impaired respiration, epithelial hyperatrophy, anaemia, retarded growth, restlessness and finally death. The fish becomes susceptible to secondary infection, especially fungus. Ergasilus can be treated successfully with a combination of 0.5 ppm copper sulphate and 0.2 ppm ferric sulphate for 6 to 9 days. Salmonicola can be controlled with 0.85% calcium chloride, 0.2% copper sulphate, 1.7% magnesium sulphate, 0.2% potassium chloride and 1.2% sodium chloride for 3-4 days. Achtheres is a common parasite attached to the gill rakers of fishes, but does not damage gill filaments. It can also be controlled by the above chemicals.

d. EPIZOIC ULCERATIVE SYNDROME (EUS):

Epizoic Ulcerative Syndrome, popularly known as EUS, has caused severe damage to India’s aquaculture. it appeared for the first time in India in 1988 and has now covered almost the entire length and breadth of the country and the disease has been reported from every state by now. One common feature of the disease is that it initially affects the bottom-dwelling species like murrels, followed by catfishes and weedfishes. Subsequently, the Indian major carps also get affected. Unlike other diseases, this syndrome has been disturbingly found to affect a variety of fish species, both wild and culturable, resulting in large scale mortalities. The most severely affected ones are *Channa sp., Puntius sp., Clarias batrachus, Heteropneusters fossilis and Mastacembelus sp.,* Other species which are affected are *Glossogobius sp., Trichogaster sp., Gadusia sp., Amphpipnous cuchia, Wallago attu, Anaba testudineus, Salmostoma bacaila,* etc. Among the major carps, it has been recorded in catla, mrigal, rohu and kalbasu. Common carp, grass carp and silver carp are also affected. Fishes of all sizes are affected. However, the incidence of infection is more in the younger ones. Clinical signs and gross pathology in the affected fishes are similar in almost all the species with moderate to severe ulcerative skin lesions. The lesions start as small grain to pea-sized hermorrhagic spots over the body which ultimately turns into big ulcers of the size of a coin, with grayish, slimy central necrotic area surrounded by a zone of hyperemia. The disease affects the fish to such an extent that they start rotating while still alive, and eventually die. Affected fishes with mild lesion may not show any clinical sign, whereas those with marked ulcerative lesions exhibit distinct abnormal swimming behaviour with frequent surfacing. In severe cases, hemorrhages have been noticed over the surface of the liver and kidney.

Clinical symptoms can be categorized in three stages:

1) Initial stage characterized by localized hemorrhages on scale pockets,
2) Advanced stage showing sloughing off of scales with degeneration of epidermal tissue and the ulceration, and
3) Final stage characterized by deep and large ulcers on various parts of the body.

Many antibiotics, sulfonamides, herbal preparations and chemicals have been advocated as preventive and curative measures. Yet, lime is the most accepted therapeutic agent. The chemical mixture has been named Cifax is used for treatment of EUS. The yellowish brown liquid is advised to be diluted in a sufficient quantity of water before being sprayed over the water body evenly for a thorough mixing. Appreciable changes are noticed in the affected fish within 3-4 days and marked improvement of the ulcerative condition is noticed within 7 days.

HELMINTHIC DISEASES IN FISHES

a. Dactylogyrosis:

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

b. Gyrodactylosis

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

c. Other helminthes

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

ENVIRONMENTAL DISEASES

a. Acidosis and alkalosis:

A great majority of fish live in P^H 7-8. If the P^H of water goes down drastically owing to reduction of calcium salts or release of humic acids from the soil, this phenomenon known as acidosis. In acidosis condition, fish may show very rapid swimming movements and a tendency to jump out of water. Acidosis causes dark greyish deposits in the gills of carps, darkening of the edges and mucous secretion. In the event of mortalities in ponds due to acidosis. The P^H must be normalized with powdered calcium carbonate and not with quicklime. Aquatic plants present in high densities liberate enormous quantities of oxygen during photosynthesis which is responsible for the formation of insoluble calcium carbonate from calcium bicarbonate followed by the formation of calcium oxide with the elimination of carbon dioxide. This phenomenon is known as alkalosis. Excessive alkaline condition leads to the corrosion of branchial epithelium and fins. Alkalosis can be prevented by buffering the medium by means of suitable calcification. Excessive plant growth in ponds should also be avoided. The lethal acid and alkaline ranges are <4.8 and >9.2 in trout, <5.0 and >10.8 in carps and <4.0 and >9.2 in perches respectively.

b. Gas bubble disease

When nitrogen of the water is higher than 125 percent saturation due to rapid temperature change, gas bubble disease may result and fish fry particularly, die in large numbers. Fish affected by this disease often swim at an angle of 45^0 with their head pointing down. Presence of bubbles beneath the skin, on fins, around the eyes, in the stomach and intestine or in blood capillaries are the major symptoms. In such conditions, water should be well agitated to bring down the nitrogen saturation below 110 percent or affected fish should be transferred to other ponds. Besides nitrogen, supersaturated levels of oxygen (>350 percent air saturation) have also been reported to cause gas bubble disease in fishes.

Prevention against environmental diseases:

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

NUTRITIONAL DISEASE IN FISHES

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

Nutritional components	**Symptoms**
Protein	Reduce growth rate and body deformities
Carbohydrate	Depress the digestion, symptoms are similar to that of *diabetes millitis* in warm blooded animals. Enlarge livers. Sikoki disease in carp similar to diabetic symptoms
Lipids	W3 deficiency (linolenic series) causes discoloration, hypersensitivity to shock and large liver. Fat oxidised diet causes muscular destrophy, poor growth. Lipoid liver degeneration is characterised when liver glycogen is replaced by lipoid and ceroid produced from liver lipid through fat metabolism. Visceral granuloma is due to auto xidation of lipid in diet. Enteritis and hepatoma are due to aflatoxin in diet.
Minerals	Thyroid hyperlasia or goiter caused by iodine deficiency. Dicalcium phosphate deficiency cause scoliosis in carps.
Vitamins (water	1. Thiamine (vit-B1) deficiency resulted in poor appetite, muscle

soluble)	atrophy, loss of equilibrium similar to that of whirling disease symptoms in trout, odema and poor growth. 2. Riboflavin (vit-B2) corneal vascularisation, cloudylens, hemorrhagic eye, photophobia, dim vision, incoordination, discoloration, poor growth and anemia. 3. Pyridoxine ((vit-B6) Nervous disorders hyper irritability, aemia serous fluid, rapid gasping and breathing. 4. Panthothenic acid. Loss of appetite, necrosis and scarring, cellular atrophy, exudates on gills, sluggishness, cubbed gills, poor growth 5. Inositol. Fin necrosis anaemia, distended stomach, skin lesions and poor growth. 6. Biotin. Blue slime patch on body, loss of appetite, muscle atrophy, fragmentation of erythrocytes, skin lesion and poor growth. 7. Folic acid. Poor growth, lethargy, fragility of caudal fin, Dark colouration, macrocytic anaemia, decreased appetite. 8. Choline. Anaemia, hemorrhagic kidney and intestine, poor growth. 9. Nicotinic acid. Loss of appetite, photophobia, swollen gills, reduced cooridation, lethargy 10. Vitamin (B12) cobalamin derivative. Erratic haemoglobin level, erythrocyte counts and cell fragmentation. 11. Ascorbic acid. Lordosis and scoliosis eroded caudal fin, deformed gill operculum, impaired collagen formation.
Fat soluble vitamins	Vit-A - Causes expthalmos, ascite, odema, hemmorhagic kidney. Hypervitaminosis (A) cause necrotic caudal fin Vit-D - Necrotic appearance in the kidney Vit-K - Mild cutaneous hemorrhages due to ineffectiveness of blood clotting Vit-E - Exophthalmia, distended abdomen, anemia with reduced RBC numbers and haemoglobin content. Accumulation of ceroid in

	fish liver.

Prevention of fish disease

1. General preventive measures:
    1. Increasing the internal resistance of fish is important in the prevention of diseases.
    2. Selection of healthy fish seed.
    3. Proper density and rational culture.
    4. Careful management
    5. Qualitatively uniform ration and fresh food.
    6. Good water quality.
    7. Prevention of fish body from injury.

2. Abolishing pathogens and controlling its spreading:

- Existence of pathogen is one among three factors (host, causative agent and environment) in outbreak of fish disease.

To abolish the pathogen and control its spreading the following measures can be taken.

1**. Thorough pond cleaning and disinfection**

Bleaching powder (chlorinated lime) should be applied at the rate of 50 ppm in the pond. It readily kills all the wild fish species, molluscs, tadpoles, crabs and disinfects pond soil and water. In nursery and rearing ponds it is desirable to use malathion at the rate of 0.25 ppm 4-5 days prior to stocking of fish seeds.

2. Disinfection of appliances

Nets, gears, plastic wares and hapas should be sun-dried or immersed in a disinfected solution.

3. Disinfection of fingerlings and feeding platform

Disinfection with mild concentration of potassium permanganate solution is helpful during the transfer of the fingerling to stocking tanks. The feeding platform can be disinfected by hanging bleaching powder cloth bags with mixture of copper sulphate and ferrous sulphate (ratio 5:2) near the feeding place. When fish come to the feeding place for feeding purpose, their skin will be automatically disinfected.

4. Proper feeding

Fixed quality, quantity, time and place have to be followed for proper feeding. Any reduction in quality and quantity and variations in feed application and place may cause not only deficiency disease but also will increase the susceptibility to many infectious diseases.

5. Segregation of year class fish population

Brood and older fish may serve as carriers of disease causing organisms without exhibiting any clinical symptoms. To avoid such risk, young fish should be segregated from the brood and older fish.

6. Spot removal of dead fish from the pond

Dead and sick fish should be removed as soon as it is located. The daily loss of fish should be recorded to provide valuable insight to the intensity of disease problem.

7. Chemoprophylaxis

Effective and inexpensive prophylactic measures against wide range of parasitic and microbial diseases are advisable as chemoprophylaxis. Occasional pond treatment with potassium permanganate at the rate of 2-3 ppm and dip treatments with potassium permanganate at the rate of 500- 1000 ppm for 1-2 minutes or short bath in 2-3% common salt solution is safe.

8. Immunoprophylaxis

Immunisation programme is gradually emerging as one of the most important measures for preventing infectious disease. Vaccine against *Aeromonas hydrophila, Plexibacter columnaris, Edwardsiella tarda, E.ictaluri, Aerononas salmonicida, Yoreinia ruckeri, Vibrio angullaram* and several viral pathogens such as IPNV (infectious pancreatic necrosis virus). CCVD (channel catfish virus disease), VHSV (viral hemorrhagic septicemia virus), IHNV (infectious haemopoitic necrosis virus), etc. are being tried on large scale. Serodiagnostic methods that included Fluorescent antibody test (FAT), Enzyme immuno assay (EIA) and passive haemagglutination (PHA) are employed.

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Chapter-7

BREEDING OF FISH

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Availability of required quantity of fish seed of desired species is one of the most important pre-requisite for successful fish farming. The widely cultured Indian major carps in inland waters like catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*) and and Chinese carps, silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*), normally do not breed in confined waters. They do mature there, but only breed in the flooded shallow areas along the course of the rivers during monsoon months which are their natural habitat. The Indian major carps do spawn in the specialised environments of bundhs, both wet and dry where lot of rain water is accumulated during monsoon period. Under such circumstances the fish culturists had to depend for the fish seed on collection from river systems and the collected fish seed consisted of not only of desired species, but also of uneconomic species including predators. The inability of Asiatic carps to breed in confined stagnant waters is owing to the lack of needed ecological stimuli to effect secretion of required quantity of gonadotrophic hormones and so extraneous hormones such as pituitary extract or synthetic hormones are injected to brood fish to induce them to breed.

Induced Breeding with Pituitary Gland Extraction

The fish production from inland water which are essentially culture fisheries and are less capital intensive have growth rate at present when compared to marine fisheries which are essentially capture and are capital intensive have relatively slow growth rate. Also increased population has resulted in shortage of foodstuff from land resources and even from the capture fisheries. Fish thus can be supplied with fewer man-hours and lesser capital investment. Thus, an emphasis has been given to culture fisheries.

The major problem in cultivating the major carps and Chinese carps is the non-availability of seeds for ready stocking in fish ponds. Because, they do not breed in confined waters even though they mature in these water bodies. They breed in flooded rivers during monsoon when temperature is low. Though riverine seed fish resources meats nearly 90 % of the demand, but they are mixed and found not suitable for profitable fish culture. Further, the seed fish may not be available at the time of requirements and seeds are available only at some selected collection centres which are often not easily accessible and their transportation from place of collection to the culture site may also pose mortality problems. In order to overcome these problems, the induced breeding by “Hypophysation Technique " has been development. Usually pituitary glands are used to induce the fish for spawn. The hormone secreted by pituitary gland stimulates growth, development, maturity and ovulation of eggs. These hormone secreted from pituitary are protein or peptide.

Collection of Pituitary Gland

The gland should preferably be collected from fully ripe gravid fishes, as the gland is most potent at the time of breeding or just before spawning. Glands collected from immature or spent fishes usually do not give satisfactory results. Glands in induced-bred fishes collected immediately after spawning have also been found to be effective. Most suitable time in India for collection of pituitary glands of major carps is during May to July months, as the majority of carps attain advanced stages of their maturity during this period. Common carp, *Cyprinus carpio* is a perennial breeder, its mature individuals can be obtained almost all the year round for the collection of glands. The glands are usually collected from freshly killed fishes

Collection technique

Glands are collected by chopping off the scalp of the fish skull by an oblique stroke of a butcher’s knife. After the scalp is removed, the grey matter and fatty substances lying over the brain are gently cleaned with a piece of cotton. The brain thus exposed is carefully lifted out by detaching it from the nerves. In majority of the cyprinids, when the brain is lifted, the gland is left behind on the floor of the brain box. The matter covering the gland is then cautiously removed using a fine needle and forceps. The exposed gland is then picked up intact without causing any damage to it because damaged and broken glands result in loss of potency. Glands are also collected through foramen magnum. In this method of gland collection, the fish is required to be completely beheaded.

Pituitary gland

Preservation of Pituitary Glands

The collected glands must be preserved immediately because glycol- or muco- protein contained in them are degraded by the enzymatic action.

The pituitary glands can be preserved by three methods

1. Absolute alcohol
2. Acetone and
3. Freezing

Preservation of fish pituitary gland in absolute alcohol is preferred in India.

Brood stock maintenance

A proper selection of brood fish is one of the most important aspects to obtain greater results in breeding and grow out. In general, farmers select the fast growing and largest fish on the assumption that these characteristics will be inherited by the progeny. However, it is not recommended to choose their offspring or same stock, as this results in inbreeding and poor growth rate and a significant number of deformed fry. To the extent possible, the brood fish should be selected from the different sources.

A minimum of three months before the breeding season the male and female fish has to be separated from the regular culture tank to avoid the unwanted breeding. During segregation, it is important to avoid stress while netting. Male and females can be identified through secondary sexual morphological characteristics, which develop during the season of reproduction. In males, the milt runs freely when abdomen is gently pressed and the females have a swollen abdomen due to the development of ovaries. The fishes have to be maintained with sufficient space and need to be fed with a protein-rich feed which improves the gonadal development and also produces high quality eggs.

Characteristics of Matured male and female fish

Sl. No	Characteristics	Male	Female
1	Scale, Operculum, and pectoral fins	Rough to touch, particularly the dorsal surface of pectoral	Pectoral smooth to slippery
2	Abdomen	Round and firm	Swollen and soft
3	Genital opening swollen	Elongated slit, white in colour, not swollen	Round and pink
4	When pressure applied on abdomen opening	Milky white fluid oozes through genital opening	A few ova may ooze through genital
5	Shape of body and size	Body linear, swollen	stouter, slightly large

Male (Top) and Female (bottom) Catla brooders

Dosage of pituitary extract:

The dose of the pituitary gland is calculated in relation to the weight of the breeders to be injected. A single high dose has been found useful when the breeders are in ideal condition and the weather is favourable. Rohu seed production technologies responds well to two injections while catla and mrigal to both one and two injections. An initial dose at the rate of 2-3 mg. of pituitary gland per kg body weight of fish is administered to the female breeder only. Male breeders do not require any initial dose, if they ooze milt on slight pressure on their abdomen. Two males against each female make a breeding set. To make a good matching set, the weight of the males together should be equal to or more than the female. In case the condition of any one of the two males is not found in the freely oozing stage, an initial injection may be administered to the male at the rate of 2-3 mg/ kg body weight. After 6 hours, a second dose of 5-8 mg/kg body weight is given to the female, while both the males receive the first or second dose at the rate of 2-3 mg/kg body weight. Slight alterations in doses may be made depending upon the condition of maturity of the breeders and the prevailing environmental factors. 1-3 pituitary glands are effective for a pair of fish.

Method of injection:

Intra-muscular injection is the most common practice in India and it is less risky in comparison with the other mehtods. Intra-peritonial injections are usually given through the soft regions of the body, generally at the base of the pelvic fin or sometimes at the base of the pectoral fin. Intra-peritonial injection may cause damage to the internal organs, specially the distended gonads in fully mature fishes. Injections are usually given at the caudal peduncle or shoulder regions near the base of the dorsal fin. While giving injections to the carps, the needle is inserted under a scale keeping it parallel to the body of the fish at first and then pierced into the muscle at an angle. Injections can be given at any time of the day and night. But since low temperature is helpful and the night time remains comparatively quieter, the injections are generally given in the late afternoon or evening hours with timings so adjusted that the fish is able to use the quietude of the night for undisturbed spawning. The most convenient hypodermic syringe used for the purpose is a 2 cc syringe having graduations of 0.1 cc division. The size of the needle for the syringe depends upon the size of the breeders to be injected. No. 22 needle is conveniently used for 1-3 kg carps, No. 19 for larger carps and No. 24 can be used for smaller carps. Use of anesthetics during injection would significantly increase the survival of brood fish. Commonly used anesthetics are MS 222 and Quinaldine. MS 222 may be added to water in doses of 50-100 mg/ litre. Quinaldine is used at the rate of 50-100 mg/ litre.

Intra muscular injection

Breeding hapa and spawning:

After the injection, the breeders are released immediately inside the breeding hapa. A breeding hapa is generally made of fine cloth in the size of 3.5 x 1.5 x 1.0 m for larger breeders and 2.5 x 1.2 x 1.0 m for breeders weighing less than 3 kg. All the sides of the breeding hapa are stitched and closed excepting a portion at the top for introducing the breeders inside. Generally, one set of breeders is released inside each breeding hapa. After the release of the fish, the opening of the hapa is securely closed so that breeders may not jump out and escape. Instead of hapas, cement cisterns or plastic pools as big as hapas can also be used for breeding. Spawning normally occurs within 3-6 hours after the second injection. Soon after fertilisation, the eggs swell up considerably owing to absorption of water. Fertilised eggs of major carps appear like shining glass beads of crystal clear transparency while the unfertilised ones look opaque and whitish. The size of eggs from the same species of different breeders varies considerably. Fully swollen eggs of the Indian major carps measure 2.5 mm in diameter, the largest being that of catla and the smallest of rohu. The carp eggs are non-floating and non-adhesive type. The yolk possesses no oil globule. The Indian major carps have a profuse egg laying capacity. Their fecundity, on an average, is 3.1 lakh in rohu, 1-3 lakh in catla and 1.5 lakh in mrigal.

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

Estimation of Eggs:

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

Quantitative assessment of eggs

Stripping:

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

Stripping of fish

Technique of hatching the eggs:

The eggs collected from breeding hapas are transferred into the hatching hapas. A hatching hapa consists of two separate pieces, the outer hapa and the inner hapa. The inner hapa is smaller in size and is fitted inside the outer hapa. The outer hapa is made up of a thin cloth in the standard size of 2 x 1 x 1 m while the inner hapa is made of round meshed mosquito net cloth in the dimension of 1.75 x 0.75 x 0.5 m. All the corners of the outer and inner hapas are provided with loops and ropes to facilitate installation. About 75,000 to 1,00,000 eggs are uniformly spread inside each inner hapa. The eggs hatch out in 14-20 hours at a temperature range of 24-31^{0} C. The period of incubation, in fact, is inversely proportional to the temperature. After hatching, the hatchlings escape into the outer hapa through the meshes of the inner hapa. The inner hapa containing the egg shells and the dead eggs which are removed when the hatching is complete. The hatchlings remain in outer hapa undisturbed till the third day after hatching. During this period, they subsist on the food stored up in their yolk sac. By the third day the mouth is formed and the hatchlings begin directive movement and feeding. At this stage they are carefully collected from the outer hatching hapa and stocked into prepared nurseries. It has been found that Indian major carps could be induced to spawn twice in the same season with an interval of two months. The breeders after the first spawning are fed with groundnut oilcake and rice-bran in the ratio 1:1 at 2.5 percent of the body weight. When favourable climatic conditions occur, they mature and are ready for spawning.

Fecundity of Major and Chinese carps

Species	Fecundity
Catla	2,50,000 eggs / kg of fish
Rohu	3,00,000 eggs / kg of fish
Mrigal	2,80,000 eggs / kg of fish
Grass carp	80,000 eggs / kg of fish
Silver carp	2,00,000 eggs / kg of fish
Common carp	1,20,000 eggs / kg of fish

Method of calculating the eggs: Both Weight and Volumetric Method can be adopted for the measuring the eggs.

In Weight Method: weigh the eggs before absorption of water, multiply the weight of the egg number per unit weight, and then total eggs can be calculated.

In Volumetric Method: Measure the volume of eggs before absorbing the water, multiply it by egg number per unit volume and then the total quantity of eggs can be calculated.

$$1.\ \text{Fertilization Rate (\%)} = \frac{\text{No. of fertilized eggs}}{} \times 100$$

Total No. of eggs

No. of individuals harvested

2. Survival Rate (%) = ------------------------------------ X 100

No. of fertilized eggs

No. of hatched fry

3. Hatching Rate (%) = ---------------------------- X 100

No. of fertilized eggs

INDUCED BREEDING WITH OVATIDE

Ovatide is an indigenous, cost-effective and new hormonal formulation for induced breeding of fishes. It is also effective in breeding major carps. The doses for females are 0.20-0.40 ml/kg for rohu and mrigal, 0.40-0.50 ml/kg for catla, silver carp and grass carp. The dosages for males are 0.10-0.20 ml/kg for rohu, mrigal, 0.20-0.30 ml/ kg for catla and 0.20-0.25 ml/kg for silver carp and grass carp.

Ovatide

The advantages of ovatide are:

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

INDUCED BREEDING WITH OVAPRIM

Ovaprim is a ready to use product and the solution is stable at ambient temperature. It contains an analogue of 20 µg of Salmon gonadotropin releasing hormone (sGnPHa) and a dopamine antagonsist, domperidone at 10 mg/ml. The potency of ovaprim is uniform and contains sGnRHa which is known to be 17 times more potent than LHRH (Peter, 1987). Ovaprim being a ready to use product and one which does not require refrigerated storage, appears to be the most convenient and effective ovulating agent. This drug is administered to both female and male brood fish simultaneously in a single dose, unlike pituitary extract which is given in two split doses.

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

Ovaprim has unique advantages over pituitary hormone – ready to use liquid form in 10 ml vial, consistent potency and reliable results, long shelf life, and can be stored at room temperature, formulated to prevent over dosing, male and female can be injected only once simultaneously, reduces handling and post breeding mortality, repeated spawning possible later in the season and high percentage of eggs, fertilization and hatching. This reduces the handling of brood fish but also helps in saving considerable amount of time and labour which will add on to the cost of seed production.

Breeding of Common Carp

Common carp (*Cyprinus carpio*) generally breeds in confined water. Spawning takes place in shallow marginal, weed infected areas from January to March and from July to August.

Common Carp is also observed to breed round the year. Controlled breeding of common carp is conducted to achieve better spawning and hatching. A set of selected brooders one female and two males are put together in breeding hapa.

Brood fishes in hapa

In order to ensure successful spawning sometimes the female fish is injected with pituitary gland extract at a low dose 2 to 3 mg per kg body weight. Freshly washed aquatic weeds (Hydrilla, Najas, Eichhornia etc) are uniformly distributed inside the hapa. These aquatic weeds act as egg collections.

Eggs attached to the hydrilla

The quantity of weed used is roughly double the weight of the female introduced. Each weed attached with 40,000 to 1,00,000 eggs are distributed into a single hatching hapa. After 4 or 5 days the weeds are taken out carefully.

Common carp in breeding hapa with hydrilla

Factors affecting induced breeding

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

Temperature:

There is an optimal temperature range for induced breeding of culturable fishes. Critical temperature limits exist, above and below which fish will not reproduce. Warm temperature plays a primary role in stimulating the maturation of gonads in many fishes. Temperature has a direct effect on gonads regulating their ability to respond to pituitary stimulation and effects on primary synthesis and release of gonadotropins. Major carps breed within a range of temperature varying from 24-31°C.

Light

Light is another important factor controlling the reproduction in fishes. Enhanced photoperiodic regimes result in early maturation and spawning of fishes like Fundulus, Oryzias, etc. *Cirrhinus reba* attains early maturation when subjected to artificial day lengths longer than natural day even at low temperature.

Water currents and rain

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

Hormonal influence

Gonadotropins have been found to increase during spawning and decrease afterwards. Due to the presence of females, there is an increase in gonadotropin level in males.FSH and LH have been reported to influence gonadal maturity in carps.

Chapter-8

INTEGRATED FISH FARMING – FOR BETTER FEATURE

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Introduction

Nowadays, the economy is mainly based on the field of agriculture and software development in the area of Information Technology. For achieving rapid progress in rural area, our strategy must focus on; conserving natural resources, enhancing efficient use of resources, increasing productivity and profitability and improving quality and competitiveness through reduced unit cost of production. Water is emerging as international challenge and its most efficient management as well as recycling has been given high priority in the plan of formulation. Recycling of crop residue as well as agricultural by products inclusion of nitrogen fixing legumes in rotation, bio fertilizers, vermicultres, agro forestry, nutrient solubilising micro-organisms, efficient nutrient up taking plant varieties etc. are being strategies in the research mandate. Improved efficiency of farm machinery, agro- input and resource conservation technologies of minimum tillage are being researched to minimize the cost of production.

Integrated Fish Farming is one of the best examples of mixed farming. This type of farming practices in different forms mostly in the East and South East Asian countries is one of the important ecological balanced sustainable technologies. The technology involves a combination of fish polyculture integrated with crop or livestock production. On farm waste recycling, an important component of integrated fish farming is highly advantageous to the farmers as it improves the economy of production and decrease the adverse environmental impact of farming.

Integrated fish farming refers to the simultaneous culture of fish or shell fish along with other culture systems. It may also be defined as the sequential linkage between two or more culture practices. Generally integrated farming means the production or culture of two or more farming practices but when fish becomes its major component it is called as integrated fish farming. Fish culture can be integrated with several systems for efficient resource utilisation.

The integration of aquaculture with livestock or crop farming provides quality protein food, resource utilisation, recycling of farm waste, employment generation and economic development. Integrated fish farming is well developed culture practice in China followed by Hungary, Germany and Malaysia. Our country, India, is organic-based and derives inputs from agriculture and animal husbandry. The integrated fish farming is accepted as a sustainable form of aquaculture. For integration we can use recycled effluents from agro-based industries as well as food processing plants.

Integrated fish farming serves as a model of sustainable food production by following certain principles:

- The waste products of one biological system serve as nutrients for a second biological system.
- The integration of fish and plants results in a polyculture that increases diversity and yields multiple products.
- Water is re-used through biological filtration and recirculation.
- Local food production provides access to healthy foods and enhances the local economy.

ECOSYSTEM OF INTEGRATED AQUACULTURE

The integrated fish farming includes the

1. process of trapping solar energy,
2. production of organic material by primary producers(autotrophs),
3. its utilisation by phagotrophs,
4. decomposition of autotrophs & phagotrophs by saprotrophs,
5. release of nutrients for autotrophs.

ADVANTAGES OF INTEGRATED FISH FARMING

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

TYPES OF INTEGRATED FISH FARMING

Basically the integrated fish farming is of two types

a) Agri-based fish farming

b) Live-stock based fish farming

The fish-cum live-stock farming is realised as innovation for recycling of organic wastes as well as production of high class protein at low cost.

I. PADDY CUM FISH CULTURE

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.

Site selection:

About 80 cm rainfall is optimum for this integrated system. Fields having an almost uniform contour and high water retention capacity are preferred. Groundwater table and drainage system are important factors to be taken into consideration for selection of site.

Types of paddy fields for integrated system:

Preparation of the paddy plot can vary according to the land contours and topography.

1. **Perimeter type:** The paddy growing area may be placed at the middle with moderate elevation and ground sloping on all sides into perimeter trenches to facilitate easy drainage.
2. **Central pond type:** Paddy growing area is on the fringe with slopes towards the middle.
3. **Lateral trench type:** Trenches are prepared on one or both lateral sides of the moderately sloping paddy filed.

Suppose the area of the integrated system is 100 m X 100 m i. e., 1 ha. The area to be utilized for paddy should be 82 m X 82 m -i.e., 0.67 ha. The area to be utilized for fish culture should be 6m X 352 m -i.e., 0.21 ha (4 sides). The embankment area should measure 3m X 388 m i.e 0.12 ha. and the area for fruit plants should be 1m X 388 m i.e., 0.04 ha. This is an ideal ratio for preparation of an integrated system.

Paddy cultivation

Rice varieties used for integrated system:

The most promising deep water varieties chosen for different states are PLA-2 (Andhra Pradesh) , IB-1, IB-2 , AR-1, 353-146 (Assam) , BR-14, Jisurya (Punjab), AR 61-25B, PTB-16 (Kerala) , TNR-1, TNR (Tamil nadu), Jalamagan (Uttar Pradesh), Jaladhi-1, Jaladhi-2 (West

Bengal) and Thoddabi (Manipur). Manoharsali rice variety seeds are used in rice fields where the fishes are reared. The paddy plot should be made ready by April - May. Having prepared the plot, deep water variety of paddy is selected for direct sowing in low lying areas after the first shower of monsoon rain.

Fertilization schedule:

The paddy plots are enriched with farm yard manure or compost at 30 t / ha on a basal dose. The nutrient uptake of deep water paddy being very high, the rate of inorganic fertilizer recommended are nitrogen and potassium at 60 kg/ha. Nitrogen and posphorus are to be applied in three phases viz., at planting, tilling and flowering initiation.

Pesticide use:

Paddy cum fish culture is not developed much due to the use of pesticides in rice fields for the eradication of different pest and these are toxic to fish. To overcome the pesticide problem, the integrated pest control system may be introduced and pesticides less toxic to fish may be used in low doses, if absolutely necessary. Pesticides like carbomates and selective organophosptes only should be used. Furadon when used 7 days prior to fish stocking proved to be safe. During the Kharif crop period, pesticides should be avoided. Harvesting of Kharif crop takes place in November - December. The yield in this crop is 800 - 1200 kg/ha. During the Rabi crop, the pesticides can be used according to the necessity. Before adding pesticides to paddy, the dyke of the trench should be increased so that the pesticide may not enter into the trenches. The yield in this rice crop is 4000 - 5000 kg/ha.

Culturable species of fish in rice fields

The fish species which could be cultured in rice fields must be capable of tolerating shallow water (>15 cm depth), high temperature (up to 35^0 C), low dissolved oxygen and high turbidity. Species such as *Labeo rohita, Catla catla, Oreochromis mossambicus, Anabas testudineus, Clarias batrachus, Clarias macrocephalus, Channa striatus, Channa punctatus, Channa marulius, Heteropneustes fossilis, Chanos chanos, Lates calcarifer and Mugil sp* have been widely cultured in rice fields. The minor carps such as *Labeo bata, Labeo calbasu, Puntius japanicus, P.sarana,* etc. can also be cultured in paddy fields. Culture of freshwater prawn *Macrobrachium rosenbergii* could be undertaken in the rice fields. The selection of species depends mainly on the depth and duration of water in the paddy field and also the nature of paddy varieties used.

Major systems of paddy cum fish culture

Two major systems of paddy-cum-fish culture may be undertaken in the freshwater areas:

1. Paddy-cum-carp culture
2. Paddy-cum-air breathing fish culture

1. Paddy-cum-carp culture:

Major or minor carps are cultured in paddy fields. In the month of July when rain water starts accumulating in the paddy plot and the depth of water in the water way becomes sufficient, the fishes are stocked at the rate of 4000 - 6000 / ha . Species ratio may be 25% surface feeders, preferably catla, 30% column feeding, rohu and 45% bottom feeders mrigal or common carp.

2. Paddy-cum-air breathing fish culture:

Air breathing cat fish like singhi and magur are cultured in paddy fields in most rice grown areas. The water logged condition in paddy fields is very conducive for this fast growing air breathing cat fish. Equal numbers of magur and singhi fingerlings are to be stocked at one fish/m^2. Channa species are also good for this integrated system.

Fish culture in rice fields

Fish culture in rice fields may be attempted in two ways, viz. simultaneous culture and rotation culture.

1. Simultaneous culture:

Rice and fish are cultivated together in rice plots, and this is known as simultaneous culture. Rice fields of 0.1ha area may be economical. Normally four rice plots of 250 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 dykes enclosing rice plots may be 0.3 m high and 0.3 m wide and strengthened by embedding straw. The water depth of the rice plot may vary from 5 - 25 cm depending on the type of rice and size and species of fish to be cultured. Five days after transplantation of rice, fish fry are stocked at the rate of 5000/ha or fingerlings at the rate of 2000/ha. The stocking density can be doubled if supplemental feed is given daily.

Releasing of fish seeds in paddy cum fish farm

The simultaneous fish – rice culture may have few limitations

Use of agrochemicals is often not feasible. Maintaining high water level may not be always possible, considering the size and growth of fish. Fish like grass carp may feed on rice seedling, and Fish like common carp and tilapia may uproot the rice seedlings. However, these constraints may be overcome through judicious management.

Simultaneous culture of paddy and fish

2. Rotational culture of rice and fish:

In this system fish and rice are cultivated alternately. The rice field is converted into a temporary fish pond after the harvest. This practice is favoured over the simultaneous culture practice as it permits the use of insecticides and herbicides for rice production. A greater water depth up to 60 cm can be maintained throughout the fish culture period. One or two weeks after rice harvest, the field is prepared for fish culture. The stocking densities of fry or fingerlings for this practice could be 20,000/ha and 6,000/ha respectively.

Fish culture:

The weeds are removed manually in trenches or paddy fields. Predatory and weed fishes have to be removed either by netting or by dewatering. Mohua oil cake may be applied at 250 ppm to eradicate the predatory and weed fishes. After clearing the weeds and predators the fertilizers are to be applied. Cow dung at the rate of 5000 kg/ha, ammonium sulphate at 70kg/ha and single super phosphate at 50 kg/ha are applied in equal instalments during the rearing period. Stocking density is different in simultaneous and rotational culture practices. The fishes are provided with supplementary food consisting of rice bran and groundnut oil cake in the ratio 1:1 at 5% body weight of fishes in paddy cum carp culture. In paddy cum air breathing culture, a mixture of fish meal and rice bran in the ratio 1:2 is provided at the rate of 5% body weight of fishes. After harvesting paddy when plots get dried up gradually, the fishes take shelter in the water way. Partial harvesting by drag netting starts soon after the Kharif season and fishes that attain maximum size are taken out at fortnightly intervals. At the end of preparation when the water in the waterway is used up for irrigation of the Rabi paddy, the remaining fishes are hand picked. The fish yield varies from 700 - 1000 kg/ha in this integrated system. Survival rate of fish is less than 60 %. Survival rate is maximum in renovated paddy plots when compared to fish culture in ordinary paddy plots. The dykes constructed for this system may be used for growing vegetables and other fruit bearing plants like papaya and banana to generate high returns from this system.

II. Fish cum poultry farming

Much attention is being given for the development of poultry farming in India and with improved scientific management practices, poultry has now become a popular rural enterprise in different states of the country. Apart from eggs and chicken, poultry also yields manure, which has high fertilizer value. The production of poultry dropping in India is estimated to be about 1,300 thousand tons, which is about 390 metric tones of protein.Utilization of this huge resource as manure in aquaculture will definitely afford better conversion than agriculture.

STOCKING DENSITY OF FISH

The application of poultry manuring in the pond provides a nutrient base for dense bloom of phytoplankton, particularly nano plankton which helps in intense zooplankton development. The zooplankton has an additional food source in the form of bacteria which thrive on the organic fraction of the added poultry dung. Thus, indicates the need for stocking phytoplanktophagous and zoo planktophagous fishes in the pond. In addition to phytoplankton and zooplankton, there is a high production of detritus at the pond bottom, which provides the substrate for colonization of micro-organisms and other benthic fauna especially the chironomid larvae. Another addition will be macro-vegetation feeder grass carp, which, in the absence of macrophytes, can be fed on green cattle fodder grown on the pond embankments. The semi digested excreta of this fish forms the food of bottom feeders. For exploitation of the above food resources, polyculture of three Indian major carps and three exotic carps is taken up in fish cum poultry ponds. The pond is stocked after the pond water gets properly detoxified. The stocking rates vary from 8000 - 8500 fingerlings/ha and a species ratio of 40 % surface feeders, 20 % of column feeders, 30 % bottom feeders and 10-20 % weedy feeders are preferred for high fish yields. Mixed culture of only Indian major carps can be taken up with a species ratio of 40 % surface, 30 % column and 30 % bottom feeders. In the northern and north - western states of India, the ponds should be stocked in the month of March and harvested in the month of October - November, due to severe winter, which affect the growth of fishes. In the south, coastal and north - eastern states of India, where the winter season is mild, the ponds should be stocked in June - September months and harvested after rearing the fish for 12 months.

Use of poultry litter as manure

- The fully built up deep litter removed from the poultry farm is added to fish pond as manure.

Two methods are adopted in recycling the poultry manure for fish farming.

1.**The poultry droppings from the poultry farms is collected, stored it in suitable places and is applied in the ponds at regular installments.**

Applied to the pond at the rate of 50 Kg/ha/ day every morning after sunrise. The application of litter is differed on the days when algal bloom appears in the pond. This method of manurial application is controlled.

2. **Constructing the poultry housing structure partially covering the fish tank and directly recycling the dropping for fish culture.**

Direct recycling and excess manure however, cause decomposition and depletion of oxygen leading to fish mortality. It has been estimated that one ton of deep litter fertilizer is produced by 30-40 birds in a year. As such 500 birds with 450 kg as total live weight may produce wet manure of about 25 Kg/day, which is adequate for a hectare of water area under polyculture. The fully built up deep litter contain 3% nitrogen, 2% phosphate and 2% potash. The built up deep litter is also available in large poultry farms. The farmers who do not have the facilities for keeping poultry birds can purchase poultry litter and apply it in their farms. Aquatic weeds are provided for the grass carp. Periodical netting is done to check the growth of fish. If the algal blooms are found, those should be controlled in the ponds. Fish health should be checked and treat the diseased fishes.

Poultry husbandry practices:

The egg and chicken production in poultry rising depends upon multifarious factors such as breed, variety and strain of birds, good housing arrangement, blanched feeding, proper health care

a. Housing of birds

In integrated fish-cum-poultry farming the birds are kept under intensive system. The birds are confined to the house entirely. The intensive system is further of two types - cage and deep litter system. The deep litter system is preferred over the cage system due to higher manurial values of the built up deep litter. In deep litter system 250 birds are kept and the floor is covered with litter. Dry organic material like chopped straw, dry leaves, hay, groundnut shells, broken maize stalk, saw dust, etc. is used to cover the floor up to a depth of about 6 inches. The birds are then kept over this litter and a space of about 0.3 - 0.4 square meters per bird is provided. The litter is regularly stirred for aeration and lime used to keep it dry and hygienic. In about 2 month's time it becomes deep litter, and in about 10 months time it becomes fully built up litter. This can be used as fertilizer in the fish pond. The fowls which are proven for their ability to produce more and large eggs as in the case of layers, or rapid body weight gains is in the case of broilers are selected along with fish. The poultry birds under deep litter system should be fed regularly with balanced feed according to their age. Grower mash is provided to the birds during the age of 9-20 weeks at a rate of 50-70 gm/bird/day, whereas layer mash is provided to the birds above 20 weeks at a rate of 80-120 gm/bird/day. The feed is provided to the birds in feed hoppers to avoid wastage and keeping the house in proper hygienic conditions.

b. Egg laying

Each pen of laying birds is provided with nest boxes for laying eggs. Empty kerosene tins make excellent nest boxes. One nest should be provided for 5-6 birds. Egg production commences at the age of weeks and then gradually decline. The birds are usually kept as layers up to the age of 18 months. Each bird lays about 200 eggs/yr.

c. Harvesting:

Some fish attain marketable size within a few months. Keeping in view the size of the fish, prevailing rate and demand of the fish in the local markets, partial harvesting of table size fish is done. After harvesting partially, the pond should be restocked with the same species and the same number of fingerlings depending upon the availability of the fish seed. Final harvesting is done after 12 months of rearing. Fish yield ranging from 3500-4000 Kg/ha/yr and 2000-2600 Kg/ha/yr are generally obtained with 6 species and 3 species stocking respectively. Eggs are collected daily in the morning and evening. Every bird lays about 200 eggs/year. The birds are sold after 18 months of rearing as the egg laying capacity of these birds decreases after that period. Pigs can be used along with fish and poultry in integrated culture in a two-tier system. Chick droppings form direct food source for the pigs, which finally fertilise the fish pond. Depending on the size of the fish ponds and their manure requirements, such a system can either be built on the bund dividing two fish ponds or on the dry-side of the bund. The upper panel is occupied by chicks and the lower by pigs.

III. FISH CUM DUCK FARMING

Benefits of fish cum duck farming

Water surface of ponds can be put into full utilization by duck raising. Fish ponds provide an excellent environment to ducks which prevent them from infection of parasites. Ducks feed on predators and help the fingerlings to grow. Duck raising in fish ponds reduces the demand for protein to 2 – 3 % in duck feeds. Duck droppings go directly into water providing essential nutrients to increase the biomass of natural food organisms. The daily waste of duck feed (about 20 - 30 gm/duck) serves as fish feed in ponds or as manure, resulting in higher fish yield. Manuring is conducted by ducks and homogeneously distributed without any heaping of duck droppings. By virtue of the digging action of ducks in search of benthos, the nutritional elements of soil get diffused in water and promote plankton production. Ducks serve as bio aerators as they swim, play and chase in the pond. This disturbance to the surface of the pond facilitates aeration. The feed efficiency and body weight of ducks increase and the spilt feeds could be utilised by fish. Survival of ducks raised in fish ponds increases by 3.5 % due to the clean environment of fish ponds. Duck droppings and the left over feed of each duck can increase the output of fish to 37.5 Kg/ha. Ducks keep aquatic plants in check. No additional land is required for duckery activities. It results in high production of fish, duck eggs and duck meat in unit time and water area. It ensures high profit through less investment.

Stocking density of fish

The pond is stocked after the pond water gets properly detoxified. The stocking rates vary from 6000 fingerlings/ha and a species ratio of 40 % surface feeders, 20 % of column feeders, 30 % bottom feeders and 10-20 % weedy feeders are preferred for high fish yields. Mixed culture of only Indian major carps can be taken up with a species ratio of 40 % surface, 30 % column and 30 % bottom feeders. In the northern and north - western states of India, the ponds should be stocked in the month of March and harvested in the month of October - November, due to severe winter, which affect the growth of fishes. In the south, coastal and north - eastern states of India, where the winter season is mild, the ponds should be stocked in June - September months and harvested after rearing the fish for 12 months.

Use of duck dropping as manure:

The ducks are given a free range over the pond surface from 9 to 5 PM, when they distribute their droppings in the whole pond, automatically manuring the pond. The droppings voided at night are collected from the duck house and applied to the pond every morning. Each duck voids between 125 - 150 gm of dropping per day. The stocking density of 200-300 ducks/ha gives 10,000 - 15,000 kg of droppings and are recycled in one hectare ponds every year. The droppings contain 81% moisture, 0.91% nitrogen and 0.38% phosphate on dry matter basis.

Duck husbandry practices*:*

The following three types of farming practice are adopted.

1. Raising large group of ducks in open water

This is the grazing type of duck raising. The average number of a group of ducks in the grazing method is about 1000 ducks. The ducks are allowed to graze in large bodies of water like lakes and reservoirs during the day time, but are kept in pens at night. This method is advantageous in large water bodies for promoting fish production.

2. Raising ducks in centralized enclosures near the fish pond

A centralized duck shed is constructed in the vicinity of fish ponds with a cemented area of dry and wet runs out side. The average stocking density of duck is about 4 - 6 ducks/sq.m. area. The dry and wet runs are cleaned once a day. After cleaning the duck shed, the waste water is allowed to enter in to the pond.

3. Raising ducks in fish pond

This is the common method of practice. The embankments of the ponds are partly fenced with net to form a wet run. The fenced net is installed 40-50 cm above and below the water surface, so as to enable the fish to enter into the wet run while ducks cannot escape under the net.

Selection of ducks and stocking

The kind of duck to be raised must be chosen with care since all the domesticated races are not productive. The important breeds of Indian ducks are Sylhet Mete and Nageswari. The improved breed, Indian runner, being hardy has been found to be most suitable for this purpose, although they are not as good layers as exotic Khaki Campbell. The number of ducks required for proper manuring of one hectare fish pond is also a matter of consideration. It has been found that 200 – 300 ducks are sufficient to produce manure adequate enough to fertilize a hectare of water area under fish culture. 2 - 4 months old ducklings are kept on the pond after providing them necessary prophylactic medicines as a safeguard against epidemics.

Feeding

Ducks in the open water are able to find natural food from the pond but that is not sufficient for their proper growth. A mixture of any standard balanced poultry feed and rice bran in the ratio of 1:2 by weight can be fed to the ducks as supplementary feed at the rate of 100 gm/ bird/day. The feed is given twice in a day, first in the morning and second in the evening. The feed is given either on the pond embankment or in the duck house and the spilled feed is then drained into the pond. Water must be provided in the containers deep enough for the ducks to submerge their bills, along with feed. The ducks are not able to eat without water. Ducks are quite susceptible to afflatoxin contamination, there fore, mouldy feeds kept for a long time should be avoided. The ground nut oil cake and maize are more susceptible to *Aspergilus flavus* which causes aflotoxin contamination and may be eliminated from the feed.

Egg laying

The ducks start laying the eggs after attaining the age of 24 weeks and continue to lay eggs for two years. The ducks lay eggs only at night. It is always better to keep some straw or hay in the corners of the duck house for egg laying. The eggs are collected every morning after the ducks are let out of the duck house.

Health care

Ducks are subjected to relatively few diseases when compared to poultry. The local variety of ducks is more resistant to diseases than other varieties. Proper sanitation and health care are as important for ducks as for poultry. The transmissible diseases of ducks are duck virus, hepatitis, duck cholera, keel disease, etc. Ducks should be vaccinated for diseases like duck plague. Sick birds can be isolated by listening to the sounds of the birds and by observing any reduction in the daily feed consumption, watery discharges from the eyes and nostrils, sneezing and coughing. The sick birds should be immediately isolated, not allowed to go to the pond and treated with medicines.

Harvesting

Keeping in view the demand of the fish in the local market, partial harvesting of the table size fish is done. After harvesting partially, the pond should be restocked with the same species and the same number of fingerlings. Final harvesting is done after 12 months of rearing. Fish yield ranging from 3500 - 4000 Kg/ha/yr and 2000 - 3000 Kg/ha/yr are generally obtained with 6 - species and 3 - species stocking respectively. The eggs are collected every morning. After two years, ducks can be sold out for flesh in the market. About 18,000 - 18,500 eggs and 500 - 600 Kg duck meat are obtained.

Duck cum fish farming

IV. FISH CUM PIG FARMING

Benefits of fish cum pig farming

The fish utilize the food spilled by pigs and their excreta which is very rich in nutrients. The pig dung acts, as a substitute for pond fertilizer and supplementary fish feed, hence, the cost of fish production is greatly reduced. No additional land is required for piggery operations. Cattle fodder required for pigs and grass are grown on the pond embankments. Pond provides water for washing the pig - sties and pigs. It results in high production of animal protein per unit area. It ensures high profit through less investment. The pond muck which gets accumulated at the pond bottom due to constant application of pig dung, can be used as fertilizer for growing vegetables and other crops and cattle fodder.

Stocking of Fish

The stocking rates vary from 8000 - 8500 fingerlings/ha and a species ratio of 40 % surface feeders, 20 % of column feeders, 30 % bottom feeders and 10-20 % weedy feeders are preferred for high fish yields. Mixed culture of only Indian major carps can be taken up with a species ratio of 40 % surface, 30 % column and 30 % bottom feeders. In the northern and north - western states of India, the ponds should be stocked in the month of March and harvested in the month of October - November, due to severe winter, which affect the growth of fishes. In the south, coastal and north - eastern states of India, where the winter season is mild, the ponds should be stocked in June - September months and harvested after rearing the fish for 12 months.

Use of pig waste as manure:

Pig - sty washings including pig dung, urine and spilled feed are channelled into the pond. Pig dung is applied to the pond every morning. Each pig voids between 500-600 Kg dung/year, which is equivalent to 250-300 Kg/pig/6 months. The excreta voided by 30 – 40 pigs is adequate to fertilize one hectare pond. When the first lot of pigs is disposed off after 6 months, the quantity of excreta going to the pond decreases. This does not affect the fish growth as the organic load in the pond is sufficient to tide over for next 2 months when new piglets grow to give more excreta. If the pig dung is not sufficient, pig dung, can be collected from other sources and applied to the pond. Pig dung consists 69 - 71 % moisture, 1.3 - 2 % nitrogen and 0.36 - 0.39 phosphate. The quality and quantity of excreta depends upon the feed provided and the age of the pigs. The application of pig dung is deferred on the days when algal blooms appear.

Pig husbandry practices:

The factors like breed, strain, and management influence the growth of pigs.

Construction of pig house:

Pig houses with adequate accommodation and all the requirements are essential for the rearing of pigs. The pigs are raised under two systems the open air and indoor systems. A combination of the two is followed in fish cum pig farming system. A single row of pig pens facing the pond is constructed on the pond embankment. An enclosed run is attached to the pen towards the pond so that the pigs get enough air, sunlight, exercise and dunging space. The feeding and drinking troughs are also built in the run to keep the pens dry and clean. The gates are provided to the open run only. The floor of the run is cemented and connected via the drainage canal to the pond. A shutter is provided in the drainage canal to stop the flow of wastes to the pond. The drainage canal is provided with a diversion channel to a pit, where, the wastes are stored when the pond is filled with algal bloom. The stored wastes are applied according to necessity. The height of the pig house should not exceed 1.5 m. The floor of the house must be cemented. The pig house can be constructed with locally available materials. It is advisable to provide 1 - 1.5 square meter space for each pig.

Selection of pigs:

Four types of pigs are available in our country - wild pigs, domesticated pigs or indigenous pigs, exotic pigs and upgraded stock of exotic pigs. The Indian varieties are small sized with a slow growth rate and produce small litters. Its meat is of inferior quality. Two exotic upgraded stock of pigs such as large - White Yorkshire, Middle - White Yorkshire, Berkshire, Hampshire and Hand Race are most suitable for raising with fish culture. These are well known for their quick growth and prolific breeding. They attain slaughter maturity size of 60 - 70 Kg within six months. They give 6 - 12 piglets in every litter. The age at first maturity ranges from 6 - 8 months. Thus, two crops of exotic and upgraded pigs of six months each are raised along with one crop of fish which are cultured for one year. 30 - 40 pigs are raised per hectare of water area. About two months old weaned piglets are brought to the pig-sties and fattened for 6 months, when they attain slaughter maturity, are harvested.

Feeding*:*

The dietary requirements are similar to the ruminants. The pigs are not allowed to go out of the pig house where they are fed on balanced pig mash of 1.4 Kg/pig/day. Grasses and green cattle fodder are also provided as food to pigs. To minimize food spoilage and to facilitate proper feeding without scrambling and fighting, it is better to provide feeding troughs. Similar separate troughs are also provided for drinking water. The composition of pig mash is a mixture of 30 Kg rice bran, 15 Kg polished rice, 27 Kg wheat bran, 10 Kg broken rice, 10 Kg groundnut cake, 4 Kg fish meal, 3 Kg mineral mixture and 1 Kg common salt. To reduce quantity of ration and also to reduce the cost, spoiled vegetables, especially the rotten potatoes can be mixed with pig mash and fed to pigs after boiling. The pigs are hardy animals. They may suffer from diseases like swine fever, swine plague, swine pox and also infected with round worms, tapeworms, liver flukes, etc. Pig - sties should be washed daily and all the excreta drained and offal into the pond. The pigs are also washed. Disinfectants must be used every week while washing the pig - sites. Piglets and pigs should be vaccinated.

Harvesting:

Fish attain marketable size within a few months due to the availability of natural food in this integrated pond. According to the demand of fish in the local market, partial harvesting is done. After the partial harvest, same numbers of fingerlings are introduced into the pond as the fish harvested. Final harvesting is done after 12 months of rearing. Fish yield ranging from 6000-7000 Kg/ha/yr is obtained. The pigs are sold out after rearing for six months when they attain slaughter maturity and get 4200 - 4500 Kg pig meat.

Pig cum fish farming

V. FISH CUM HORTICULTURE

Considerable area of an aquaculture farm is available in the form of dykes some of which is used for normal farm activities, the rest remaining fallow round the year infested with deep-rooted terrestrial weeds. The menacing growth of these weeds causes inconvenience in routine farm activities besides necessitating recurring expenditure on weed control. This adversely affects the economy of aqua-farming which could be considerably improved through judicious use of dykes for production of vegetables and fish feed. An integrated horti-agri-aquaculture farming approach leads to better management of resources with higher returns. Several varieties of winter vegetables (cabbage, cauliflower, tomato, brinjal, coriander, turnip, radish, beans, spinach, fenugreek, bottle gourd, potato and onion) and summer vegetables (amaranth, water bind weed, papaya, okra, bitter gourd, sponge gourd, sweet gourd, ridge gourd, chilly, ginger and turmeric) can be cultivated depending upon the size, shape and condition of the dykes.

Suitable farming practices on pond dykes:

Intensive vegetable cultivation may be carried out on broad dykes (4m and above) on which frequent ploughing and irrigation can be done without damaging the dykes. Ideal dyke management involves utilisation of the middle portion of the dyke covering about $2/3^{rd}$ of the total area for intensive vegetable cultivation and the rest $1/3^{rd}$ area along the length of the periphery through papaya cultivation keeping sufficient space on either side for netting operations. Intensive cultivation of water bind weed, Indian spinach, radish, amaranth, okra, sweet gourd, cauliflower, cabbage, spinach, potato, coriander and papaya on pond dyke adopting the practice of multiple cropping with single or mixed crops round the year can yield 65 to 75 that year. Semi-intensive farming can be done on pond dykes (2 to 4 m wide) where frequent ploughing, regular irrigation and deweeding are not possible. Crops of longer duration like beans, ridge gourd, okra, papaya, tomato, brinjal, mustard and chilli are found suitable for such dykes. Extensive cultivation may be practised on pond dykes (up to 2 m wide) where ploughing and irrigation by mechanical means are not at all possible. Such dykes can be used for cultivation of sponge gourd, sweet gourd, bottle gourd, citrus and papaya after initial cleaning, deweeding and digging small pits along the length of the dykes. Extensive cultivation of ginger and turmeric is suitable for shaded dykes.

Carp production using leafy vegetables and vegetables wastes:

A huge quantity of cabbage, cauliflower, turnip and radish leaves are thrown away during harvest. These can be profitably utilised as supplementary feed for grass carp. During winter, grass carp can be fed with turnip, cabbage and cauliflower leaves, while in summer, amaranth and water-bind weed through fortnightly clipping may be fed as supplementary feed for rearing of grass carp. Monoculture of grass carp, at stocking density of 1000 fish/ha, fed on vegetable leaves alone fetches an average production of about 2 t/ha/yr. While mixed culture of grass carp along with rohu, catla and mrigal (50:15:20:15) at a density 5000 fish/ha yields an average production of 3 t/ha/yr.

Fish cum horticulture cum paddy culture

VI. FISH CUM CATTLE FARMING

Fish farming by using cattle manure has long been practiced in our country. This promotes the fish-cum-cattle integration and is a common model of integration. Cattle farming can save more fertilizers, cut down fish feeds and increase the income from milk. The fish farmer not only earns money but also can supply fish, milk and beef to the market.

Pond management practices:

Cow dung is used as manure for fish rearing. About 5,000 - 10,000 Kg/ha can be applied in fish pond in installments. After cleaning cow sheds, the waste water with cow dung, urine and unused feed, can be drained to the pond. The cow dung promotes the growth of plankton, which is used as food for fish.

Cattle husbandry practices:

The cow sheds can be constructed on the embankments of the fish farm or near the fish farm. The locally available material can be used to construct the cow shed. The floor should be cemented. The outlet of the shed is connected to the pond so that the wastes can be drained into the pond. Cultivable varieties of cows are black and white (milk), Shorthorn (beef), Simmental (milk and beef), Hereford (beef), Charolai (beef), Jersey (milk and beef) and Qincuan draft (beef).

Cattle cum fish farming

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