Best Management Practices for **Freshwater Ornamental Fish Production**

Editors
Atul Kumar Jain, V P Saini & Vaneet Inder Kaur

National Fisheries Development Board, Hyderabad
Department of Animal Husbandry, Dairying & Fisheries
Ministry of Agriculture and Farmers Welfare, Government of India
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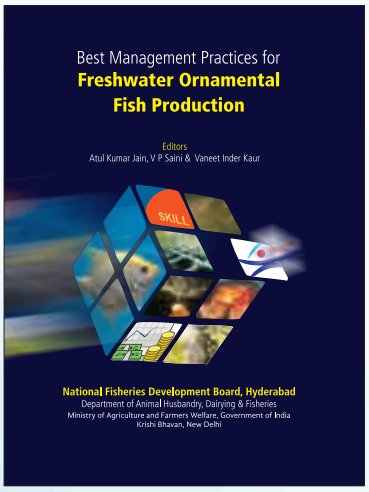

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Editorial Inputs from:
Dr. K. Ravindranath, Senior Consultant (Tech.) NFDB, Hyderabad

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Foreword

Ornamental fisheries is increasingly getting popular in the country as evidenced in the growth of demand for aquaria and accessories, ornamental fish, formulated and live feeds and aquarium service providers. While it is a fact that the contribution of the country to the World trade of ornamental fisheries is very insignificant, the potential of the domestic market is undeniably very large. It is estimated that the total value of domestic aquarium trade is about Rs.300 crore per year and is directly or indirectly supporting about 50,000 house-holds, mainly in rural India. The potential for domestic aquarium trade is estimated at about Rs.1200 crore and employment opportunities also can be created for 1.5 lakh house-holds. However, the availability of high quality brooders is still a major concern, the principal cause behind our insignificant presence in the global ornamental fish trade.

In view of the current status and potential of ornamental fish industry, need was felt for a very strong and continuous institutional support to the sector, to upgrade the knowledge-base and skills of existing ornamental fish producers, aquarium fabricators and aquarium service providers. It is also necessary simultaneously to develop a new cadre of youth who should be knowledgeable, skilled and willing to generate employment opportunities in ornamental fishery sector. Hence, the knowledge enhancement and skill development in ornamental fisheries remain the major focal activities of National Fisheries Development Board (NFDB) to enable the country to produce the best quality ornamental fish both for domestic and international trade. The environmental safeguards and protecting the interest of ornamental fish hobbyists will also be major concerns.

In order to achieve all these objectives and to develop a road map for future actions in the sector, NFDB consulted different stakeholders that included researchers, academicians, extension workers, ornamental fish producers, aquarium traders, exporters, hobbyists and institutional functionaries, over the last few months. The discussions revealed a definite lack of knowledge about the scientific management practices of ornamental fish production. Therefore, it was decided to develop a set of "Best Management Practices (BMPs)" for the different stakeholders engaged in Ornamental Fish Production (OFP) to widen and deepen their knowledge. The responsibility for developing the BMPs for OFP was given to a team comprising of scientists, entrepreneurs and other stakeholders and a writeshop was organized at NFDB, Hyderabad during 25-27 July, 2016. The first draft of the "BMP for OFP" was developed and it was subsequently reviewed and edited by an editorial team consisting of selected members from the group.

The document covers all the aspects relating to freshwater ornamental fish production and is written in a simple language, with a lot of illustrations, photographs and examples, making it easy for the users to understand. Authors have very selectively identified the BMPs relating to different activities and thereafter suggested the strategies or guidelines to implement the suggested BMPs. I appreciate the very hard work done by the team members and am grateful to them for their academic guidance and commendable effort in bringing out the very first publication of its kind. I hope this publication will be useful to the entrepreneurs, exporters, hobbyists, researchers, students, extension officers and institutional functionaries in different ways.

Hyderabad
August 22nd, 2016

(K. N. Kumar)
Chief Executive
NFDB, Hyderabad

PREFACE

It was during "National Consultation" on "Ornamental fisheries development" at NFDB, Hyderabad on 27-28th April, 2016 where it was felt that in order to develop ornamental fish industry in the country, among many other requirements, there was need of a self imposed "Code of Conduct" (CoC) at all levels *i.e.* ornamental fish producers, aquarium traders & ornamental fish hobbyists and also of developing a set of "Best Management Practices" (BMPs) for all those different activities that are carried at an ornamental fish production farm. The CoC will be helpful to educate the producers, traders and hobbyists about their individual role on ethical progression of both the industry & the hobby while BMPs will enhance the knowledge of the producers to culture quality fish and improve productivity of the units in a sustainable manner. Hence, a list of CoCs was identified and all the participants were given the responsibility to share it with all the stakeholders. It was also agreed that the exercise of developing a set of BMPs shall be taken care by NFDB through a write-shop and responsibility of coordinating the same was entrusted to me.

Now, there were two tasks, the first was of constituting a team and the second was of organizing a writeshop. The team constitution was not easy as I neither wanted a very large team nor to miss any expert and also to have some ornamental fish producers. So, a team of nine members was constituted who had diversified experience of research, education, extension and business in the field of ornamental fisheries. It was decided to hold the write-shop at NFDB, Hyderabad during 25-27 July, 2016, but before that it was required to conceptualize the idea and sub-divide the major theme into sub-themes (later named as Chapters) and allot the sub-themes among the participants. A total of twelve sub-themes were framed and allotted to members either individually or in combination about fifteen days in advance of writeshop. Each member was asked to come prepared with all the information on their allotted sub-theme. It was probably the first exercise for any commercial aquaculture activity in the country where an effort was being made to develop a set of "Best Management Practices" that too through a write-shop. The outcome of the writeshop is time bound and group members are under immense pressure to complete their write-ups within a given period of time in a pre-defined format incorporating suggestions received from all the participating members.

The writeshop began on scheduled day & time and all the participants were very enthusiastic to undertake the pressure of writeshop. The first exercise was to define the BMP and develop a standard format so to have uniformity of presentation, continuity of subject and avoidance of any overlapping of information in the entire manual. It was agreed that in the present context, BMPs could be defined as a set of guidelines related to a specific problems/issues that intends to improve the knowledge and understanding of mainly the existing users so that they are enabled to enhance their production from existing levels, improve upon quality of produce and economize the cost of operations within the frame-work of existing rules and regulations including environmental safety. It was also decided that first section of each chapter would be titled as "An Overview" which will mainly include present national status of all activities to be covered in that specific chapter. The first paragraph could describe the strengths and opportunities while the second paragraph should mention all the weaknesses and threats. The Second section would be listing the BMPs where entire group shall try to identify and prioritize BMPs to address the problems listed in first section. Thereafter, each identified BMPs could be described in much detail including the importance of that specific BMP and guiding factors to implement the same. The guiding factors shall simultaneously describe a brief theory/concept and related details for clarity on the BMP.

Thereafter, the second exercise of listing the BMPs for each identified sub-theme was initiated. It was the most critical part of the entire writeshop. A sub-theme was selected and group members were asked to give their inputs to list & prioritize the BMPs and also to frame each BMP in a "message delivery" mode. The importance and requirement of

each BMP along with sentence structure was thoroughly discussed and a list of BMPs was finalized and handed over to concerned group member. Now, it was the responsibility of the group member to develop a full write-up on the sub-theme allotted to him/her covering all the listed BMPs. The group members were asked to make a presentation of their write-ups for the other members of the group on the second day. Group members were also advised to use simple language with photographs, illustrations and examples so to make it more user-friendly.

The second day began with the presentations of write-ups by individual group members and other group members were asked to critically review the same. Each write-up was thoroughly discussed mainly based on the suggested "Guiding factors" and finalized among the group members . All the twelve presentations were discussed on the second day. The group members were asked to incorporate the suggested corrections in their write-ups and again present the same to the house on the third day. It was by the evening of the third day that the write-ups on all the twelve sub-themes were ready as first draft of "Best management practices for ornamental fish production". The first draft was subsequently edited by an editorial team and was available in its present form by the mid of August, 2016.

The entire process from the day of conceptualizing the idea of organizing a writeshop to final printing was very speedy and moved very fast from one stage to other without any hurdles. It was because of quick decisions and timely support of Sh. K.N. Kumar, Chief Executive, NFDB, Hyderabad who himself was very keen to develop ornamental fisheries in the country. All the group members are sincerely grateful to him. I personally owe a special "Vote of Thanks" to the Chief Executive for entrusting me the responsibility of coordinating the same and giving the freedom of decisions.

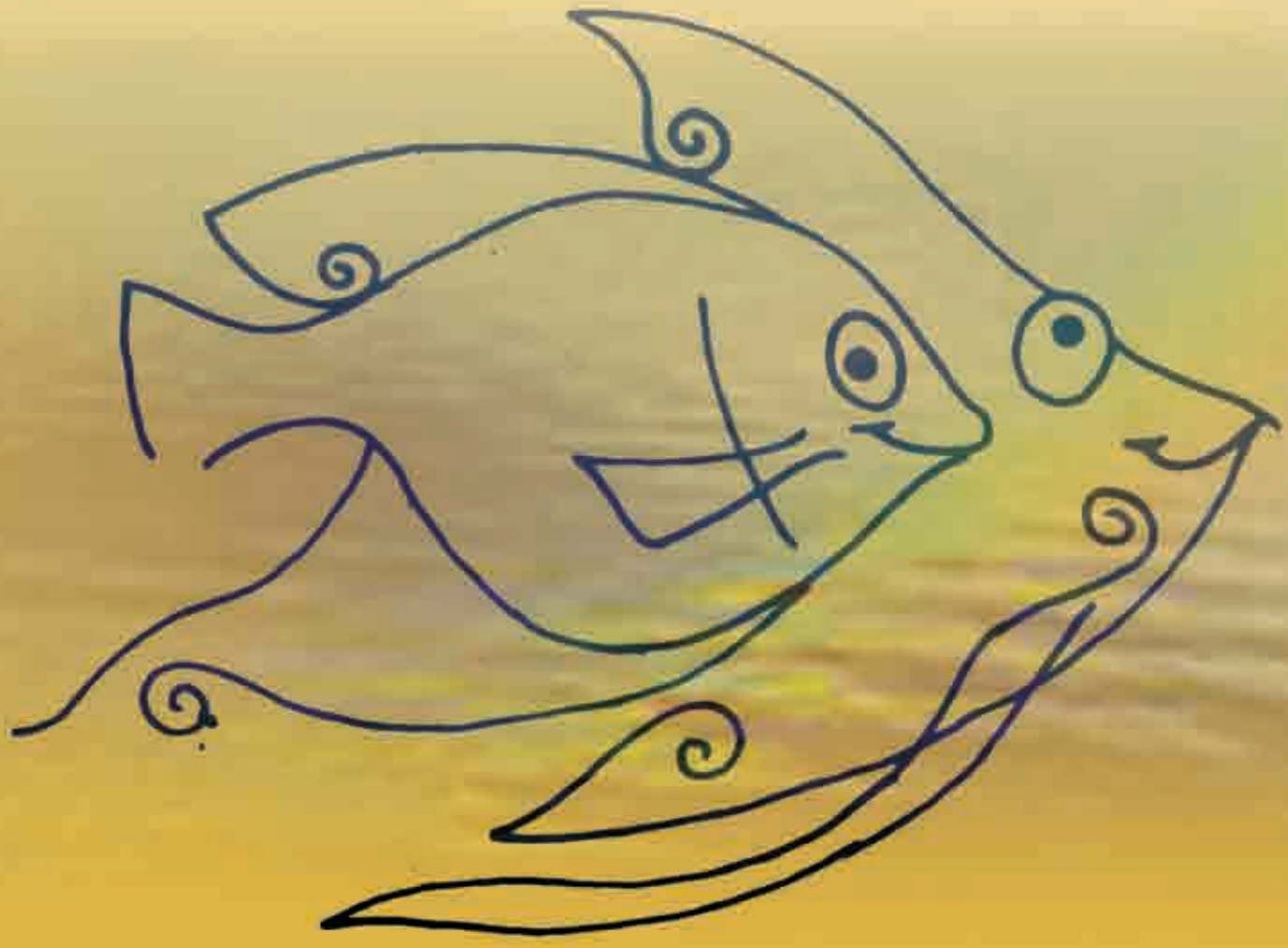
A writeshop is a very fast process of completing a given assignment. However, it requires that all the team members are seriously devoted to the cause and able to complete the assigned activity within the scheduled time. I am thankful to all the members of my team which consisted of Dr. T.V. Anna Mercy, Dr. G. Gopakumar, Dr. V.P. Saini, Dr. B.K. Mahapatra, Dr. Vaneet Inder Kaur, Dr. Shivkumar Magada, Mr. Joy Joseh and Mr. Hanson K. Mathew who worked very seriously to achieve our objective and freely exchanged information among each other so that each chapter is complete in itself. However, I would like to specially appreciate the cooperation of Dr. Saini and Dr. Vaneet who were very helpful as editorial team members. I am also indebted to Mr. Dasari Bhoomaiah, Mr. Yasesh Shah and Prof. Hemendra Chandalia for their timely support for graphics designing, illustrations and language editing respectively. The suggestions of Dr. K.N. Mohanta, Principal Scientist, CIFA, Kausalyaganga on the presentations during write-shop were also very helpful. I would also like to thank "Team NFDB" which visibly consisted of Dr. V.V. Sugnan, Senior Consultant (Tech), Dr. K. Ravindranath, Senior Consultant (Tech), Dr. B.K. Chand, Executive Director (Tech), Dr. Sanjay Sharma, Senior Executive (Tech.), Dr. M. Vishwas Rao, Junior Consultant and Dr. K. Pau Biak Lun, Junior Consultant and all other invisible officers of NFDB who extended all the needed support to our team as and when required. My entire team is highly grateful to Dr. V.V. Sugnan, Dr. K. Ravindranath, Dr. Utpal Kumar Sar and Dr. B.K. Chand for critically reviewing the manuscript. Finally, I would like all the readers to know that a number of persons have put very serious efforts to bring this publication in its present form and I am sure you will find it very useful and informative for field application which shall ultimately result in production of quality ornamental fish.

Atul Kumar Jain
(Team Leader)

Chapter 1

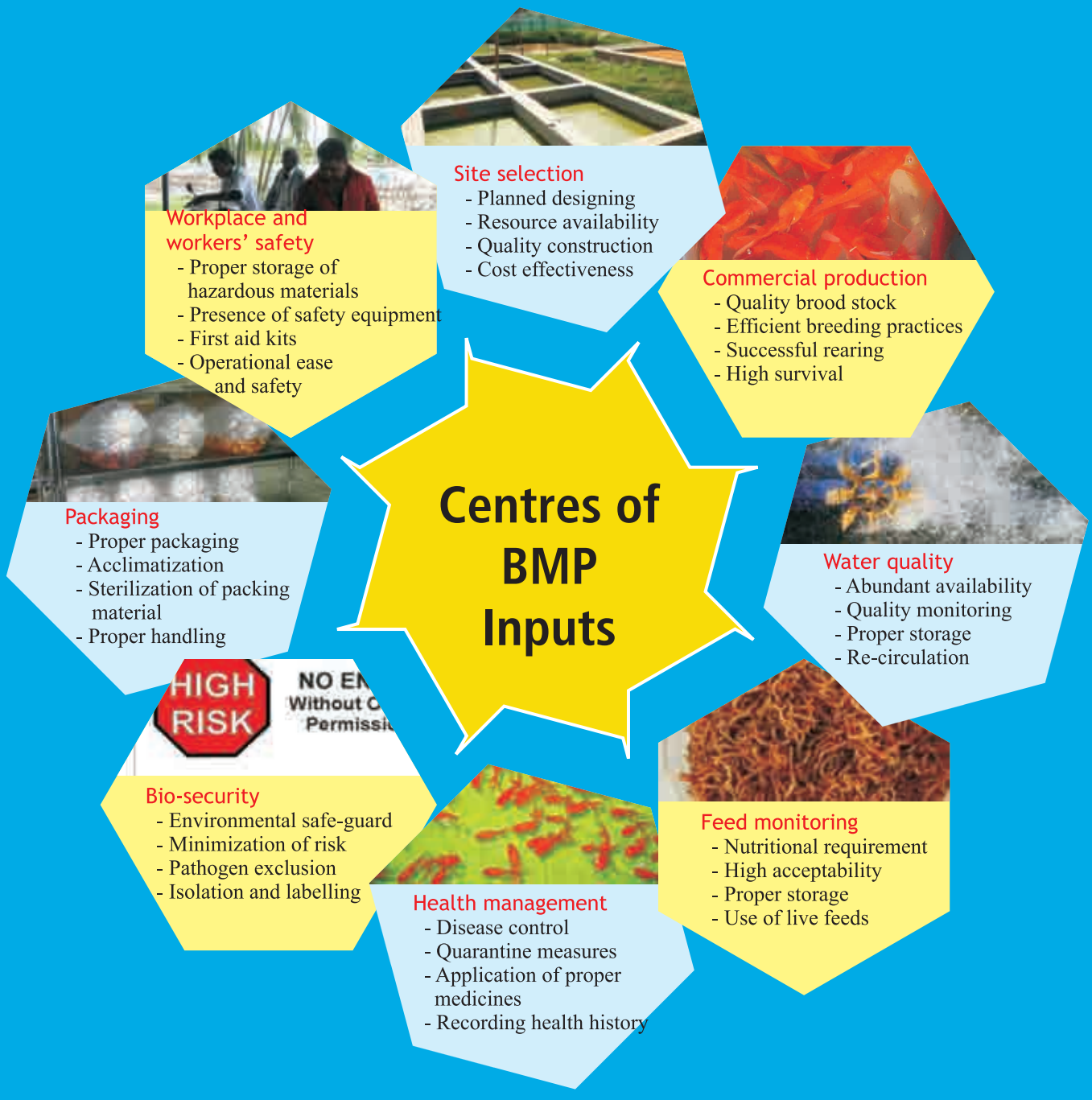
Need for best management practices for freshwater ornamental fish production

Atul Kumar Jain



Best Management Practices

A set of guidelines to be followed by freshwater ornamental fish producers



The ornamental fish industry is considered as a sleeping giant in India. It is stated so because of the reasons that we are blessed with a huge biodiversity of freshwater ornamental fish, large availability of natural freshwater resources distributed throughout the country and suitability of agro-climatic conditions for captive breeding of many varieties of ornamental fish all round the year not only along 8129 km long coast-line but also in semi-arid environment of inland states. India has been exporting some unique varieties of wild caught ornamental fish to many developed countries of the world since 1969. But, our contribution to global export of ornamental fish remains only 0.32% of a total of US$ 362 million (FAO,2012). It is insignificant compared to other Asian countries that entered in the trade only recently. They command a sizable share of global market through export of captive bred fish few of which are of Indian origin e.g. *Sahyadria denisonii*, an important fish of Western Ghats.

India is known in international ornamental fish trade for its wild caught fish

The captive bred freshwater exotic ornamental fish from India are not preferred in the global market because these are considered to be of inferior grade in terms of quality. Due to the lack of standard quarantine facilities and protocols, we are not able to develop brand image in the international market. A captive bred fish from India when imported by a Singapore buyer and re-exported to developed countries is accepted but not if exported directly.This is because of the lack of brand image.

The hobby of ornamental fish keeping is gaining popularity in the country and it is estimated that about 1.25% of the urban house-holds are keeping an aquarium. The total value of domestic aquarium trade has reached about Rs.300 crore with a potential to grow to Rs.1200 crore. The aquarium shops which were earlier limited to metro cities are now seen even in big towns with approximately 5000 outlets. The ornamental fish production which was earlier limited to Kolkata, Chennai and Mumbai is now extended to other parts of the country with more than 5000 units. However, the demand pattern of domestic trade is different from that of international trade. It is mainly (90%) the captive bred freshwater fish which is in large demand in the domestic market. The Indian ornamental fish industry is passing through a transitional phase presently and is slowly becoming vibrant that needs institutional support for further growth.

The Indian ornamental fish industry is becoming vibrant and needs institutional support for further growth

The National Fisheries Development Board (Ministry of Agriculture & Farmers Welfare, Government of India), Hyderabad organized a one-day brain-storming session on "Ornamental Fisheries Development in India" on 29th February, 2016 with the objective of identifying the priority areas for the proposed institutional initiatives at NFDB on ornamental fish and to set an agenda and ensuring participation for the proposed national consultation. It was attended by fourteen invited participants who included subject matter experts, scientists, academicians, entrepreneurs, exporters and administrators. The participants were engaged in group discussions in four technical sessions viz:

I. Ornamental fish breeding and culture for income generation and livelihood for the poor and women,

ii. Opportunities in growth of export trade,

iii. Protection of wild stock and biodiversity conservation,

iv. Role of cooperative societies, SHGs and NGOs.

The group members identified the priority areas, major challenges and role of NFDB to support the priorities identified in each technical session. Subsequently, a "National Consultation" on Ornamental Fish was conducted at NFDB, Hyderabad on 27th and 28th April, 2016. The agenda, format and participants for the National Consultation were based on the findings of the earlier one-day brainstorming session. The two-days "National Consultation" was aimed at identifying the priorities for the NFDB and setting a road map of activities for it. The participants included a much larger representation from all the sectors of ornamental fisheries. A total of eight consultation themes were identified and participants were distributed and re-distributed into eight groups. One of the identified themes was "Best Management Practices and code of conduct in ornamental fish industry". The group participants discussed at large the various issues related to the theme for half a day and presented the outcome of the discussion to all the participants of national consultation incorporating all the useful suggestions.

The overall conclusion of the National Consultation related to this specific theme was that there was near lack of regulatory processes/regimes in the country to ensure quality of products and services in ornamental fish culture and trade. This lacuna not only hits the consumers and farmers, but also tarnishes the image and credibility of the country in the overseas market. There is an urgent need to put in place regulatory regimes to ensure quality control and sustainability in all operations. A Code of Conduct (CoC) needs to be in place to be followed by all players: the producers, traders and hobbyists voluntarily. Equally important is development of a set of Best Management Practices (BMPs) for the sector.

There is need for BMPs for improving quality and quantity of ornamental fish

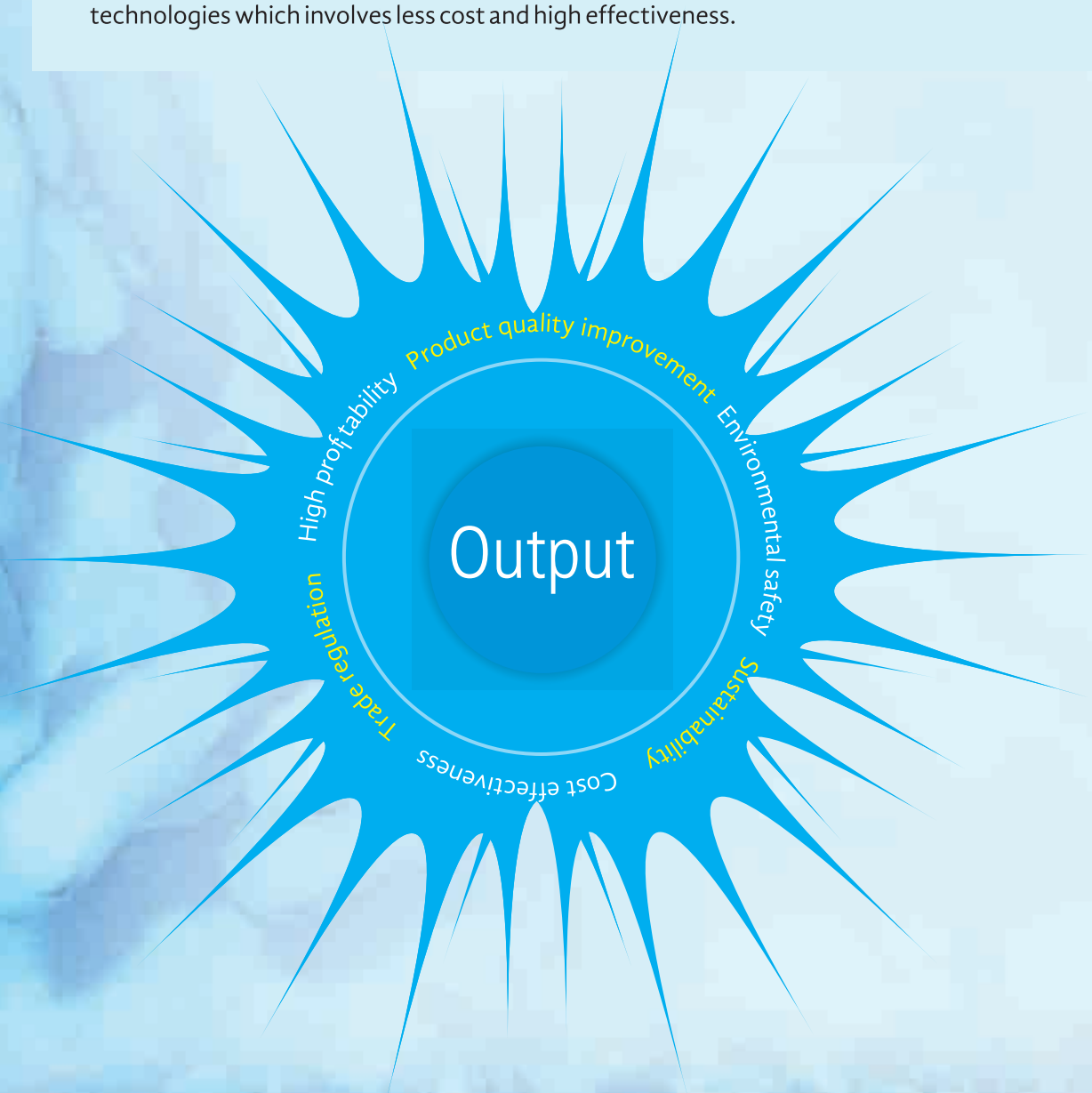
The purpose of BMP will be to ensure (a) environmental safeguards, (b) quality of products, (c) high profitability, (d) sustainability of stock and trade, (e) meeting the requirement of certifying agencies, (f) workers' health and safeguards, (g) meeting product certification standards, (g) bio-security, (h) cost effectiveness and cost reduction. BMPs should be met at different critical points such as design of hatchery & production units, water management practices, culture units, quarantine units, therapeutics, feed and feeding management, harvesting, packaging & transportation, and marketing. Whereas the Research Institutes should give the inputs for developing BMP and Code of Conduct, NFDB will facilitate creation of a platform that encourages voluntary adoption of such norms. It was with this background that the task of developing a document was initiated on "**Best Management Practices for Ornamental Fish Production**" which could be of use to producers to optimize the production in an environmentally sustainable manner and to facilitate developmental & regulatory agencies to formulate developmental schemes and control mechanism.

What is BMP?

BMPs could be described as a set of practices, techniques, methods and processes either individually or in any combination of these, when applied to any production system such as "Ornamental Fish Production"results in:

- Improving and optimizing the use of all available resources,
- Standardization of production and operational processes,
- Improvement in the quality of product & optimization of outputs,
- Economizing the cost of all inputs,
- Ensuring sustainability of the production system,
- Safety of people involved in carrying the operation,
- Ensuring bio-security and safety of surrounding environment.

The BMP could be an addition of new structure or a change or a modification in the existing structure, improvement in the operational plan and application of certain tools & technologies which involves less cost and high effectiveness.



Chapter 2

An overview of freshwater ornamental fish production industry in India

Atul Kumar Jain

Inside...

1. Introduction

Kolkata, Chennai & Mumbai are the major centres of ornamental fish production in India

In India, the number of people keeping an aquarium either at home or work place has grown manifold during last two decades. Although, there is no authentic information available on the total number of aquarium hobbyists in the country, it is stated based on a visible fact that the aquarium shops which were earlier limited to metro or major cities in few numbers are now seen even in towns of the country and in large numbers in cities. This trend of growth in numbers of aquarium hobbyists in country could be mainly attributed to:

a. The increasing number of middle income group category along with increase in their income as well as changes in their spending behavior.

b. The easy availability of ornamental fish and other aquarium accessories in neighborhood at competitive prices.

c. The easy accessibility of information on ornamental fish keeping through internet.

d. A good transportation facility and connectivity from the source of of ornamental fish to retailers in different parts of country.

e. The increasing belief of people in "Vastu", "Feng-shui" and other streams of faith.

f. The need of a pet for companionship by increasing number of nuclear

families specifically in metro cities and the ease of keeping fish as a pet over other animals.

g. The initiatives of developmental agencies like MPEDA, NFDB, ICAR institutes, SAUs & State fisheries departments through R & D and extension activities.

The existing scenario of ornamental fish trade in the country has triggered a cyclic relationship in between the number of hobbyists and the producers & traders of inputs which includes ornamental fish, aquarium accessories, other decorative items etc (Fig.1). The ornamental fish industry is passing through a phase of transition. Since the skill and knowledge base of traders is limited that has led to scarcity of quality fish and hence, a strong institutional support is warranted.

Fig. 1 Cyclic relationship of demand and supply

2. Insignificant global presence

The total value of global import is US$ 362million (FAO, 2012) with 5% annual growth and the USA, U.K., Germany, Singapore, Japan, and France are the major importing countries of ornamental fish in the world (Fig. 2). The major exporting countries are Singapore, Japan, Czech Republic, Thailand, Malaysia, Israel, Indonesia, USA, the Netherlands and Sri Lanka (Fig.3). The countries of Asian sub-continent contribute about 56% to global ornamental fish export but the share of India is only 0.32% (US$ 1.16 million).The total value of international export has increased from US $ 175 million in 1998 to US $ US$ 362 million in 2011 but the contribution of India is stagnating at the same level with little change. The major fish exported from India are of wild varieties collected from rivers of the North-east and southern states that contributes about 85% to total export of all types of ornamental fish from country. The ornamental fish are being exported from India since 1969. The south-east Asian countries, presently dominating, were not even in trade at that time but now those are far ahead of India. The presence of India in global export-import trade is felt only for few of its unique wild fishes viz; *Tetraodon travancoricus*, *sahayadriya*

India contributes only 0.32% to total world export of US$ 362 million

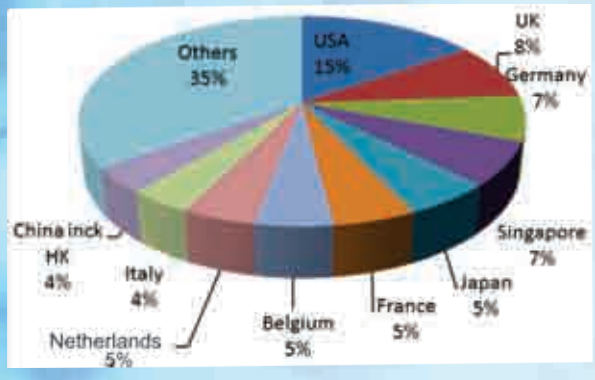


Fig.2: Share of different countries to global import of ornamental fish (FAO, 2012)

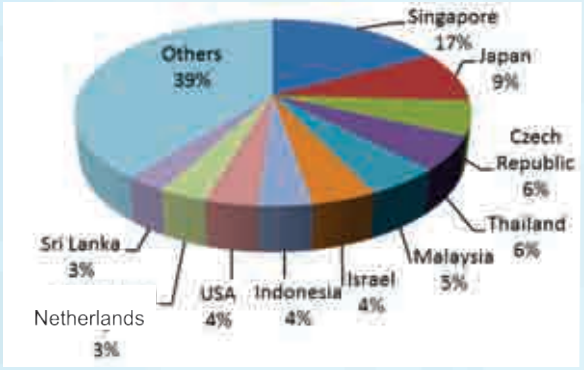


Fig.3: Share of different countries to global export of ornamental fish (FAO,2012)

denisonii, *Channa barca*, *Horadandia aatukorali, Channa aurantimaculata*, etc. otherwise in terms of total value and demand of captive bred fishes, it is insignificant. There are several known reasons that obstruct the development of export of ornamental fish from India. These include poor brand image, sub-standard production facilities, lack of quality control & quarantine facilities, production of low value fish, poor knowledge base of producers, limited R & D support, entrepreneurial scarcity, stringent export-import process and very high freight charges. The developmental agencies have now realized the potential of export and possibilities of high earning of foreign exchange through increased export of both wild and cultivated fish and the process is getting fast momentum.

3. Characteristics of the domestic trade

3.1 The Past witnessed a slow growth

The major centers of ornamental fish production in the past were a few villages in north & south 24 Parganas, Nadia, Hooghly and Howrah adjoining Kolkata in the state of West Bengal and Kolathur village near Chennai in the state of Tamilandu where local villagers were engaged in this activity to marginally support their earnings. The production facilities mainly included one or two small earthen ponds/pits where ornamental fish were reared in hapas. A few people also used to construct brick/ cemented tanks in the backyard of the house. The production system was based on low input technology with least concern on hygiene, health & overall quality of fish. Mumbai was also one of the major centers of ornamental fish production up to 1980s. The ornamental fish were being grown in ponds constructed in several mosques of the city, freshwater wells which were common in houses of old Mumbai and also in aquarium tanks by many house-holds. The ornamental fish production was mainly limited to a few varieties of Gold fish, Koi carps, Barbs, Tetras, Angels, Gouramys and live bearers. The sale of produce was exclusively through middlemen who used to do door to door collection of fish and decide the price. The middlemen were selling the collected fish either at collection centers of wholesalers in the vicinity from where these were being sold to retailers either directly or through another wholesaler in that area. The fish were mainly being transported through rail routes as air freight was very high. Most of the aquarium accessories (air pumps, filters & heaters) and decorative items (plastic plants and toys), though only a few limited varieties were being

manufactured in and around all the four metro cities (Delhi, Mumbai, Kolkata & Chennai) of the country. The process of fabricating an aquarium was not simple as glass panels were being fitted in a frame of iron angles and later in aluminum channels with bituminous pastes. The overall initial cost of the aquarium as well as operational cost was very high and it was considered to be a hobby of rich families (I purchased a packet of 100 gm fish food pellets for Rs.80/- at Udaipur, Rajasthan in 1994 which is available for Rs.30/- presently in 2016). It was primarily a monopolistic market with limited number of sellers within metro cities.

3.2 The present is vibrant

There is a paradigm shift both in production and marketing setup compared with that of earlier practices. The earlier production centers of West Bengal and Tamilnadu still remain major centers of ornamental fish production. However, the earlier system of ornamental fish production in Mumbai is no more in existence. The other additions to the list are villages around Madurai in the state of Tamilnadu, Cochin in the state of Kerala, Bangalore in Karnataka and Ratnagiri & Pune in the state of Maharashtra. The new production facility includes both outdoor and indoor facilities. The outdoor structures consist of large sized earthen ponds and reinforced cemented tanks whereas indoor facilities include cemented tanks, FRP tanks and glass aquarium with re-circulation facilities housed in either proper RCC halls, tin-shades or green houses. The numbers of fish that are bred has also increased, including many varieties of exotic cichlids. The aquarium shops which were found in a few numbers only in metro and major cities have multiplied many folds and found in large towns also. The rail, road and air connectivity has improved. The role of middleman at village level has reduced. At most of the places either old time wholesalers have established their own base near the major production centers or a new group of entrepreneurs has emerged from the earlier fish farmers and middlemen. A new group of distributors is also established on a regional basis with the dominance of Chinese products which command about 90% share in aquarium accessories segment. The list of products, both accessories and decorative items, has grown very long. The process of fabricating an aquariums has become easy with the introduction of all glass aquariums and now moulded glass aquarium. The overall cost of the aquarium has become affordable and now it is no longer considered a hobby of the rich. The domestic market has become highly competitive and shifted from monopolistic to perfectly competitive type of market with large number of producers of ornamental fish and aquarium traders. The number of buyers has also increased.

Indoor facilities of an ornamental fish breeding farm at Vijayawada, Andhra Pradesh

Outdoor facilities of an ornamental fish breeding farm near Madurai, Tamilnadu

Table-1: An overview of progress of ornamental fish industry in India

S.No.	Parameter	BEFORE 1990	AFTER 1990
1.	Major Production Centers in country	Villages in the North & South 24 Parganas, Nadia, Hooghly and Howrah districts adjoining Kolkata in the state of West Bengal, Kolathur village near Chennai in the state of Tamilandu & parts of old Mumbai	Villages around Madurai in the state of Tamilnadu, Cochin in the state of Kerala, and Ratnagiri & Pune in the state of Maharashtra in addition to earlier centers excluding Mumbai
2.	Production Facilities	Mainly outdoor facilities consisting of few earthen ponds & small sized cement tanks	Both indoor and outdoor facilities consisting of brick tanks, FRP tanks, glass tanks and large sized RCC tanks
3.	Production System	Traditional & Low input	Shifting from traditional to scientific, semi-intensive
4.	Species Cultured	Mainly low value fish including gold fish, koi carps, barbs, tetras, Angels, gouramys & live bearers	Both low and medium value fish including many varieties of exotic cichlids in addition to all the old varieties
5.	Product Cost	High : MRP of 100 gm standard pellet feed was Rs.80	Relatively Low: MRP of 100 gm standard pellet feed is Rs.30
6.	Marketing set up	Monopolistic with few numbers of producers of ornamental fish and aquarium traders with no competition	Perfectly competitive with many numbers of producers of ornamental fish and aquarium traders
7.	Location of retail outlets	In few numbers only in metro cities	In large numbers in metros and major cities and few numbers in small cities and towns
8.	Availability of aquarium accessories	Only few varieties with limited choice	Large number of varieties with wide choice
9.	Manufacturers of Aquarium accessories	Only few around metro cities and high demand for their products	Number of Indian manufacturers further reduced with limited demand for their products. It is mainly Chinese products that are dominating the market
10.	Knowledge base of producers and traders	Traditional know-how and absence of qualified personnel	Improved but still limited presence of formally trained and qualified personnel
11.	Product choice	Limited	Very vast

3.3 The value of domestic aquarium trade

Any authentic information which is supported by a systematic study is not available about the total value of domestic aquarium trade and annual growth rate. It is arbitrarily reported that the total value of ornamental fish trade in domestic market is Rs.50 crore which appears to be an underestimation. Secondly, it is also not clear if it refers to the trade value of only ornamental fish or the entire aquarium trade that includes aquarium and its accessories. It is also reported that domestic aquarium trade is growing at 20% annually which appears to be an overestimation. However, the total value of domestic aquarium trade could be estimated based on total number of retail aquarium outlets in the country which is about 5000. Accordingly, the total value of domestic aquarium trade could be about Rs.300 crore with an average annual turnover of Rs.6.00 lakh of each shop.

Table-2: Total value of domestic Aquarium trade

1.	Number of aquarium shops in India*	5000
2.	Average annual turnover of an aquarium shop (In lakhs)	6.00
3.	Total value of domestic aquarium trade (in crores)	300.00

*Based on listings at different web directories

3.4 Share of ornamental fish in domestic aquarium trade

The total revenue at an aquarium shop is received from sale of fish, fish feeds, aquarium & aquarium accessories and aquarium servicing. The sale of fish contributes about 20% to total sales whereas fish feeds, aquarium & aquarium accessories and aquarium servicing contribute about 6%, 11% and 63% respectively. As such the ornamental fish constitute only Rs. 1.20 lakh of the total annual average sale of Rs.6.00 lakh of a shop. Hence, the total value of ornamental fish marketed in domestic trade is Rs. 60 crore only of the total domestic aquarium trade of Rs.300 crore (Fig.4).

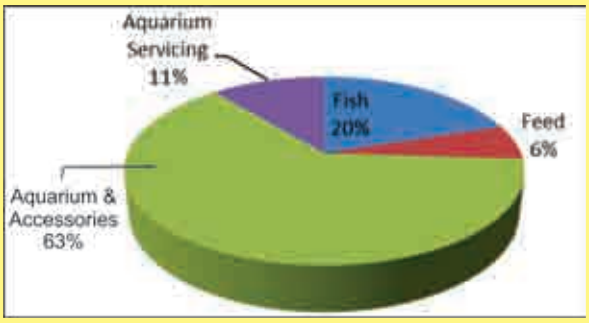


Fig. 4 Percentage share of fish in total domestic aquarium trade

3.5 Varieties of ornamental fish in the trade

The price of the fish is the main decision making factor for an Indian fish hobbyist. Hence, all the fish that are marketed in domestic market can be grouped into four classes viz; low, medium, high and premium value fish (Table-3). The domestic trade of ornamental fish is mainly dominated by production and marketing of low value fish which contributes about 60% to total trade (Fig. 5). It is the gold fish (including all varieties) among low value fish that top the list. The other varieties that are in demand in order of preference are; golden Koi, black tiger shark (*Pangassius sutchi*), milky Koi, gouramys, barbs, tetras and live bearers. The high value fish as well as marine ornamental fish & invertebrates are in demand mainly in large cities by few hard core hobbyists and rich customers only.

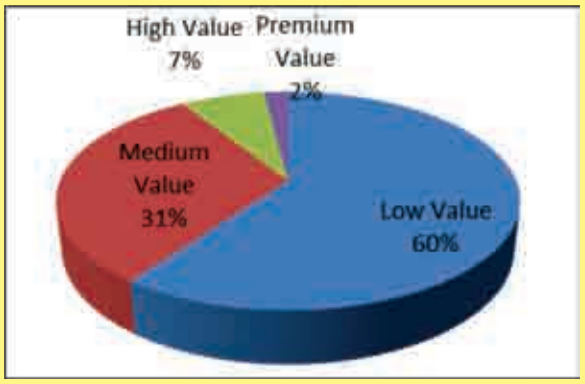


Fig.5 Market share of different types of fish in domestic trade

Table-3: Value* based categorization of ornamental fish produced and/or traded in domestic market

CATEGORY **	NAME OF VARIETIES (Common Names)
LOW VALUE FISH (MRP: Rs.15-50 each)	Varieties of Gold fish, Koi carps (Golden, Milky), Sharks (Tiger, Albino), Gouramy (Blue, Kissing, Golden), Angels (Black, Tiger, Golden), Barbs (Rosy, Tiger, Tin foil), Tetra (B.A., Tetra, Widow, Serpae), Live Bearers (Mollies, Sword tails, Guppy, Platies), Fighters etc.
MEDIUM VALUE FISH (MRP: Rs.50-200 each)	Varieties of Gold fish, Koi carps (Golden, Milky), Sharks (Silver, redtail, rainbow), Gouramy (pearl, giant), Angels (Platinum, Diamon, Koi), Barbs (filamentosa,denisonii,ticto), Tetra (neon,cardinal,rummynose), Live Bearers (BaloonMollies, Sword tails, Guppy, Fighters, Oscars, Silver Dollars, Fire mouth, Shevrum, Feather fish, shrimps
HIGH VALUE FISH (MRP: Rs. 200-2000 each)	Varieties of Gold fish, Koi carps (Golden, Milky),Oscars, Silver Dollars, Parrot, Texas, Flower Horns, Varieties of Discus, Red devil, Green terror, Lobsters, Several varieties of chichlids, Marine ornamental fish
PREMIUM VALUE FISH (MRP: Above Rs. 2000 each)	Flower Horn, Discus, Arowana, Marine ornamental fish

** Maximum Retail Price (MRP)*

*** Based on size few varieties are grouped in more than one category*

3.6 Knowledge base of aquarium traders

The number of aquarium shops was very few in the country before 1990s. The aquarium traders during those days were mainly aquarium hobbyists who turned their hobby into a profession. Secondly, those who were keeping aquarium were mostly dedicated hobbyists and used to gain knowledge of fish keeping at their own. It was only after 1990 that the number of aquarium shops started growing in the country. Most of the new aquarium dealers were neither having any formal education or technical skills in ornamental fish keeping. They have started an aquarium shop either because they found that an aquarium shop in the neighborhood is doing good business or they have worked as a sales persons or serving boy at an aquarium shop (it was still better).This new breed of aquarium traders was not aware of the basic knowledge of ornamental fish keeping and importance and functioning of different accessories. As aquarium traders they themselves were not adequately knowledgeable about fish keeping so they were not able to

A list of common pieces of advice given by aquarium traders to aquarium hobbyists

1. Regularly add methylene blue in aquarium to keep the water clean.
2. Change the water at 10-15 days interval.
3. Add antibiotics or any other medicines at regular intervals in aquarium.
4. Use common salt or methylene blue for control of white spot which is the most common problem.

impart the knowledge about fish keeping to a naive hobbyist. The major objective of these dealers was to sell the product to customer even if it was not required. As a result of this, many a time's several naive hobbyists discontinue to keep aquarium in the first year of aquarium keeping. The discontinuing of an aquarium by a new hobbyist causes a multiplying negative effect on the promotion of hobby as they try to convince other prospective hobbyists that the hobby of fish keeping is very difficult. Now, this situation is changing somehow as many fisheries professionals and educated youth are entering into the trade and they try to gain knowledge of the subject and also guide the naive hobbyists in healthy fish keeping. However, it still remains a grey field that is adversely affecting the hobby of ornamental fish keeping.

Rezimental Bazaar, Secunderabad is popular for buying aquarium fish and other related products at very competitive prices as there are more than 30 shops in the a lane.

3.7 Knowledge base of ornamental fish producers

The ornamental fish production was a backyard activity in few selected places of country and were being grown using traditional methods of production. Those who were involved in the activity had learnt the basic skills of breeding a few selected varieties of fish and rearing the young ones to a marketable size. These breeders and fish growers were not aware of other issues viz; genetic improvement, quality control, health management, development of new strains, colour enhancement etc. The various types of live feeds viz; Moina, Daphnia, Tubifex worms, Blood worms and mosquito larvae collected from sewage channels were the major source of feed for feeding to brood fish as well as to young ones. As a result of these types of practices and limited knowledge base of breeders, the ornamental fish grown in captivity in India were not in demand in international trade. The old system of fish production still continues though a shift is being noticed. The new units that are being established now are owned by a new generation of fisheries professionals and other educated youth. They do understand the importance of quality and quality control and willing to upgrade their knowledge so as to produce quality fish to cater to international market.

3.8 An Indian aquarium hobbyist

The number of hobbyists keeping an aquarium in India is very less compared to developed countries of the world. It is estimated that only 1.25% of a total of 78.86 million urban house-holds in the country are keeping an aquarium (Table-4) whereas it is as high 21% in USA, 16.6% in U.K. and 13.5% in Canada. It is very less a number. However, it is estimated that the number of aquarium hobbyists is high in metro cities of the country and highest in Chennai and Kolkatta (Table-5).

Table-4: Estimate of number of house-holds keeping aquarium in India	
Number of Retail outlets in country	5000
Average number of hobbyists linked to each retail Outlet	200
Total number of hobbyists in the country	1000000
Total number of Urban House-holds (UHh) in the country as per Census 2011(In millions)	78.86
Percentage of UHh keeping an aquarium with that to total number of UHh in the country	1.25

One house-hold is considered equal to one hobbyist

***Source**: Self study of author*

Table 5: Number of Aquarium shops and hobbyists in metro cities of India

Name of City	Total Urban Population	No. of Urban House-holds	No. of aquarium shops	No. of house-holds keeping Aquarium
Mumbai	12,478,447	2,779,943	500 (10.12%)	100,000 (3.60%)
Delhi	11,007,447	3,435,999	254 (05.14%)	50,800 (1.48%)
Bangalore	8,425,970	2,393,845	600 (12.15%)	120,000 (5.05%)
Hyderabad	6,809,970	881,512	302 (06.11%)	60,400 (6.85%)
Chennai	6,560,242	1,154,982	459 (09.29%)	91,800 (7.95%)
Kolkatta	4,486,679	1,024,928	375 (07.59%)	75,000 (7.32%)
All India	377,105,760	78,865,937	4939 (100%)	987,800 (1.25%)

Source: Jain & Mercy (2015)

The ornamental fish hobbyists of India could be categorized into three : i) a naive hobbyist, ii) a mature hobbyist and iii) a rich hobbyist. The definition of an aquarium for a major percentage of naive hobbyists is a tank of glass which is filled with water, decorated with some pebbles, plastic plants & toys, installed with an air pump (optional) and stocked with some fish and thereafter fish should never ever die. Many a time people want to start their hobby with a glass bowl and willing to keep a large pair of gold fish. The aquarium trader is also not willing to guide them but to sell an aquarium only. This is a dangerous situation and results in pre-mature termination of the hobby. It is observed that 25-30% naive hobbyists will discontinue keeping the aquarium within the first year of the purchase. Many a times a rich hobbyist is also like a naive hobbyist but he can be convinced to install all the essential accessories. But, he also states that "Do install whatever you want but fish should not die. It is the group of matured hobbyists who tries to learn the science and art of aquarium keeping. They are willing to pay the price for all essential accessories and also spend reasonably on purchase of fish. They may buy even high value fish but overall the demand of only low value and medium value fish is high (Table-6).

Table-6: Factors influencing decision of aquarium purchase by hobbyists of different categories in domestic market

S.No.	Parameter	CATEGORY OF INDIAN AQUARIUM HOBBYISTS		
		Naive Hobbyists	Matured Hobbyists	Rich Hobbyists
1.	Factors influencing	Cost, Easy availability	Experience, Knowledge, Liking, Maintenance & operational ease.	Liking, High product value, Uniqueness of product
2.	Category of Aquarium	Freshwater Aquarium	Freshwater, Planted Aquarium, Marine/ Reef Tanks	Freshwater, Planted Aquarium Marine/ Reef Tanks
3.	Type of Fish	Low value to medium value	Low value to high value	Medium & high value

4. Potential of domestic aquarium trade

A middle class house-hold is considered to be the most potential buyer of consumer goods and the percentage of middle class house-holds is constantly increasing in the country. The total number of house-holds in the country was 246.7 million as per Census 2011. It included 167.8 million rural house-holds and 78.9 million urban house-holds. It collectively included 31.4 million middle class house-holds which crossed a level of 50 million in 2015-16 and estimated to reach 113.80 million by 2025-26. It is further predicted that about 5% of all the urban house-holds will be keeping an aquarium in the country as in case of metro and major cities (Table-5) and the total value of annual domestic trade may reach to a level of Rs.1200 crore (Table-7).

Table-7: Potential of domestic aquarium trade

Number of Urban House-holds (millions)	78.86
Estimated number of hobbyists considering 5% of UH-h will be keeping an aquarium (millions)	3.94
Required number of aquarium shops @ average one shop for 200 UHh	19716
Existing number of aquarium shops	5000
Present value of domestic aquarium trade @ Rs.6.00 lakhs annually per shop (In crores)	300
Future value of domestic aquarium trade @ Rs.6.00 lakhs annually per shop (In crores)	1200

Source: Self study of author

5. Trade regulations & accreditation

There is a mechanism to control the export-import trade of ornamental fish in the country but there is no regulatory authority and accreditation body to regulate the domestic aquarium trade. The ornamental fish trade is strictly regulated in developed countries as well as in other Asian countries. As a result, these countries have emerged as leading exporters of ornamental fish. The Marine Products Export Development Agency formulated a Green Certification Scheme to regularize the production of ornamental fish in the country. It was planned to be implemented in phases, initially voluntarily and subsequently compulsorily. It was a very serious exercise by MPEDA involving many well known experts in the field but it is yet not implemented. The phase-wise implementation of Green Certification with few modifications and amendments so to cover even aquarium fish traders will be highly useful for the industry.

The Animal Welfare Board of India (AWBI), a statutory body under Ministry of Environment and Forest (Government of India) has also proposed to implement Fish Marketing Rule 2010 simultaneously. It will be applicable on all those establishments that are selling or keeping fish for public display. The MOEF did not accept the proposal initially as it was not approved by Ministry of Law and Justice. But, later it was forwarded to Law Commission of India. The Law Commission of India under the chairmanship of Hon'ble Justice A.P. Shah has recommended the implementation of same vide report No. 261 "Need to regulate pet shops and dog and aquarium fish breeding" issued in August, 2015. The FRM-2010 is very complicated and difficult to follow and may result in a serious setback to the existing aquarium fish trade in the country both export as well as domestic.

6. Institutional system

A strong institutional support was lacking to support development and promotion of ornamental fisheries in the country for a long time. There were neither any major schemes of financial support to entrepreneurs nor it was recognized as a thrust area of R & D and extension. It was with the beginning of XI five year plan (2007-12) that National Fisheries Development Board (Ministry of Agriculture, Government of India), Hyderabad and Marine Products Export Development Authority (Ministry of Commerce & Industry), Cochin realized the domestic and export market potential of the sector both for generating the employment opportunity and augmenting the foreign exchange earnings. The MPEDA and NFDB simultaneously introduced several entrepreneurship development & promotional scheme for fast growth of the sector. It mainly included setting up of micro-scale units to be established in clusters (Grade-1 Units), small scale individual units (Grade-2) and larger multi-species individual units (Grade-3). The total project cost was Rs.1.50, 4.00 and 15.00 lakh respectively for Grade-1, Grade-2 and Grade-3. The total financial assistance was 50% of total project cost. The scheme of MPEDA was initially

A Grade-3 unit established at village Veerpura, Dist. Udaipur, Rajasthan

launched in five coastal states viz; Kerala, Karnataka, West Bengal, Maharashtra and Tamilnadu and later in several inland states which were Rajasthan, Madhya Pradesh, Himachal Pradesh and Uttrankhand. The scheme of MPEDA facilitated establishment of several Grade-2 and Grade-3 units in all these states which were not known earlier for ornamental fish production. The MPEDA has modified the pattern of assistance and limited it to Self Help Groups only which has sharply reduced the demand of MPEDA schemes. The NFDB is in the process of improving and modifying the schemes. Both the institutions are also supporting the HRD programmes through organizing awareness programme and funding for organizing training programmes.

A Grade-2 unit established at Village Makasar, Dist.Hanumangarh, Rajasthan

7. Conclusion

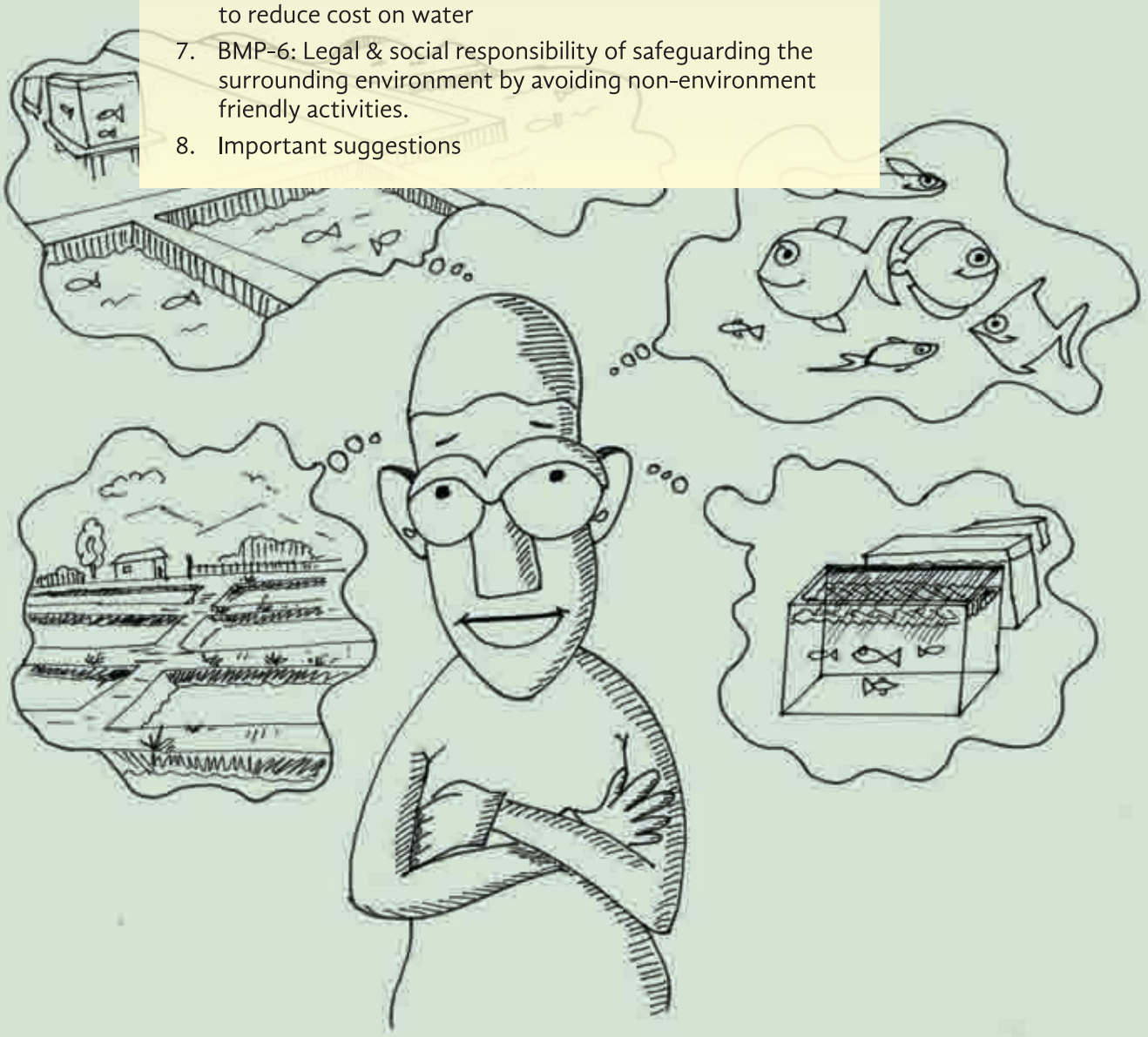
The ornamental fish industry is in existence in India since pre-independence. However, the farming was limited to a few specific villages and locations around Kolkata, Chennai and Mumbai as a house-hold activity. The availability of aquarium shops was also restricted to only metro cities that too in a less numbers so the number of hobbyists was also less and aquarium keeping was considered a hobby of rich people only. The economic reforms in the country post 1990 resulted in increase in income of the common man and also the number of middle income group house-holds. It changed the spending behavior of a middle class Indian house-hold and people started spending money on pursuing the hobby. It increased the demand for ornamental fish and allied products in the market which inspired many unemployed youth and entrepreneurs to set up ornamental fish farming units and aquarium shops for livelihood. The aquarium shops that were earlier limited to metro cities later opened in major cities and now even in large towns of the country. The increased availability of products and competitive pricing resulted in increase of number of hobbyists as well as the value of domestic aquarium trade with opportunity of further growth. However, India could not make any significant impact on the global market while other Asian countries viz; Singapore, Thailand, Malaysia, Indonesia, Japan, etc. established themselves as major suppliers of ornamental fish to world market. India contributes only insignificantly to global export trade mainly through wild varieties of ornamental fish collected from natural water bodies of north-east and southern India. The developmental agencies have now realized the export and domestic market potential of ornamental fish industry and started supporting development of same both through financial assistance and human resource development so that ornamental industry could provide employment to large number of rural and urban youth and also make effective presence in international market.

Chapter 3

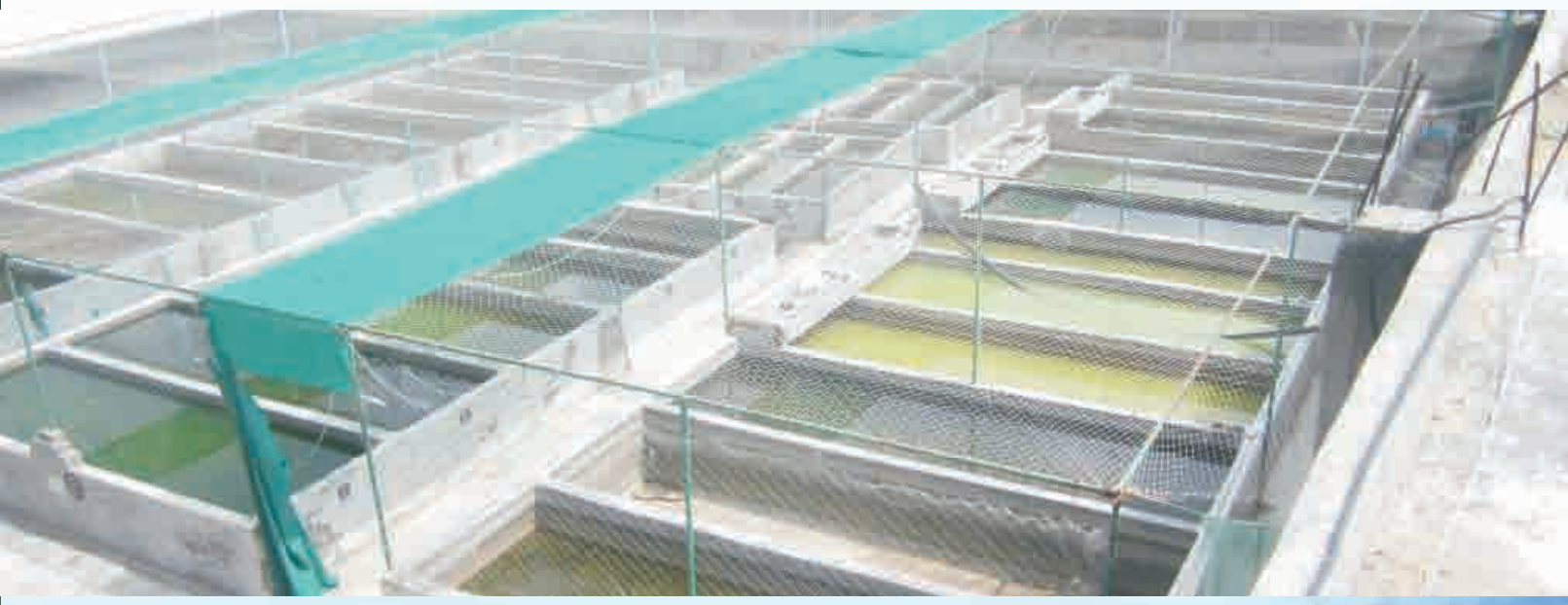
Setting up of freshwater ornamental fish production facilities

Atul Kumar Jain

Inside...



Setting up of freshwater ornamental fish production facilities



1. An overview

The ornamental fish farming in India prior to beginning of 21st century was limited to selected villages of a few coastal states mainly located in the states of West Bengal and Tamilnadu. The farming facilities were primarily backyard units based on low input traditional practices. The farm designs and facilities were very simple as these were built based on availability of space and included a few earthen ponds, earthen bowls and a small number of brick/cemented tanks. Secondly, the production units were in a cluster so, the individual efforts on location and site feasibility were not of much concern. Moreover, ornamental fish farming was not a primary income generating activity but a secondary activity so it used to marginally support the family income where all members of family were engaged in the profession.

It was only since the beginning of present century that ornamental fish farming was adopted as a mass scale commercial activity and several medium to large size units were established in several parts of the country that included both coastal and inland states. Many of the old production units also remained to continue either as such or with modifications and up-gradations. The new farming units are not in a cluster and located far apart from each other that necessitate examining the location suitability and site feasibility. Now a days, it is no more a backyard type house-hold activity but a major activity that involves large investment through bank financing. However, it has been observed that many of the units are not operating successfully and profitably in spite of high initial investments. Many a times it is because of improper selection of location, unsuitable sites, poor quality and inadequate availability of water and unplanned construction & designing. With this background, a set of "Best Management Practices" is being suggested related to setting up of a freshwater ornamental fish production facility.

Proper site selection is the key to success of a production unit

2. BMP-1: Identify an ideal location to enhance the chances of success

Selection of ideal location should be done by balancing multiple factors

The identification of a perfect location i.e. the place (city/village) where an enterprise could be established is the first and most important factor towards the success of any business entity. The selection of an ideal location for ornamental fish farming requires **balancing of multiple factors** specifically in those places where a cluster of production units is non-existent and an individual unit is being established. In case of those entrepreneurs who need to purchase land to set up the unit, it is much more important.

Guiding factors for BMP-1

2.1 Permission from the competent authority

Visit the local or nearest office of the state fisheries department/MPEDA and find out if any permission is needed from any government agency to set up an ornamental fish production facility in that area.

2.2 Assessment of the activities of similar farm units in the locality

Prepare a list of numbers of ornamental fish production farms, the species cultured at their farms, the list of wholesalers and retail outlets in the vicinity. A discussion with the owners/managers of existing units will be always helpful. It is the common practice of existing business owners to discourage the new entrants but many a times a negative image presented by them helps an entrepreneur to take innovative decisions.

2.3 Identification of potential market and connectivity

Find out the nearest market where you can sell your product and the number of wholesalers and retailers in the market. It will be more important in case yours is the first unit in that area. It is also important to find out means of transportation and connectivity to the targeted market. In case of export oriented units, it is important to check the distance of production facility from the nearest international airport.

2.4 Assessment of demand & supply

Assess the total demand of market both in terms of quantity as well as species. A visit to aquarium shops in the targeted market can provide an overview.

2.5 Socio-cultural values of local region

Study the socio-culture values of local villagers. Sometimes the villagers may oppose fish based activities in their village.

2.6 Others

The availability of labour, raw materials for routine activities, electricity and service providers (electricians, mechanics, plumbers, etc.) should also be assessed. A review of local law and order situation is also helpful.

3. BMP-2: Assess the availability of water and suitability of chosen site for proposed activity

The selection of suitable site is the next important issue following identification of location. It is the address of the establishment within the specified location. An evaluation of site, based on all the suggested guiding factors is very important particularly in those cases where land is being specifically purchased to implement the activity. A wrong selection of site may lead to failure of venture or increase the operational and management expenses.

Guiding factors for BMP - 2

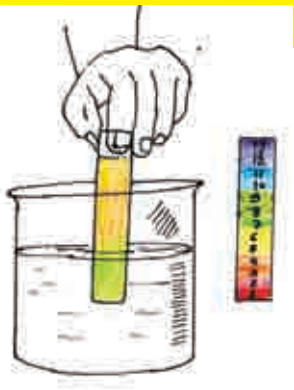
3.1 Water Resources

An assessment should be made of all the available water resources at the site viz; ground water, nearby rivers, streams, irrigation canals, etc. In case of ground water, it will be useful to find out potential of the ground water. It could be done through discussion with local villagers as well as with the help of a hydro-geological engineers. In case water is to be drawn from a nearby river, stream or irrigation canal, it will be important to know the period of availability of water. It will also be useful to know if there is any industrial discharge to the river/streams and the nature of discharge.

3.2 Water quality

It is very essential to test the water that will be used at production facility. The important parameters that need to be tested are pH, alkalinity, hardness & salinity which should be in the range of 6.5-8.5, 50-300 mg/L, 100-200 mg/L and 0-2.0 g/L respectively. In case of major deviation from this range, it should be ensured that the cost of corrective measures will be

SIMPLE METHODS FOR WATER TESTING IN FIELD



1. **Litmus paper test for pH:** A litmus paper strip is easily available at any shop supplying chemicals. It is very economical as a pack of 10 strips costs about Rs. 25 only. Take a strip from the pack and put 2-3 drops of water on it. Now, match the changed colour of litmus paper with the colour codes given on pack of litmus paper and find out the pH.
2. **Testing of water for alkalinity:** Take a sip of water. A bitter taste is an indication of alkalinity. The level of alkalinity is acceptable for ornamental fish production if you are able to drink it. In case it is not potable it is unacceptable.
3. **Boiling water test for hardness:** Take about 1 liter of water in a steel/aluminum bowl and heat it to boil. Cover it with a lid and leave it for about one hour. Deposits of a whitish powder on the margins of bowl as well as white precipitation on the bottom of bowl are indicators of hard water. Wipe the inside margins of the bowl with a finger. Appearance of a whitish tinge only on fingers is an indication of acceptable level of hardness but the presence of a layer of powder suggests of a non-acceptable level.
4. **Tear testing for salinity:** Put 3-4 drops of water at your fore-tongue. A taste similar to taste of your tears is acceptable level of salinity for freshwater ornamental fish production.

within control. Much detailed information about water quality is provided in Chapter-4 of this publication. The facility of water testing for all common parameters is available at the laboratories of agricultural universities, state agriculture departments, Krishi Vigyan Kendra, etc. A few private laboratories also provide the facility of water testing but their charges are higher. A few simple methods of water testing in field conditions are given in the box .

3.3 Soil quality

It is also important to ensure the quality of soil at site. The important parameters that are to be tested include pH, clay percentage, organic carbon and nitrogen, which should be in the range of 6.5-8.0, 20%, 1-5-2.5%, and 50-75/100 gm of soil respectively. It will be advisable to avoid highly acidic (pH < 6.5) and highly alkaline (pH > 8.0) soils in case earthen ponds are to be constructed. The testing of soil for water retention capacity is an important parameter which is indicated by percentage of clay in soil. However, it can also be done by a simple method given in the box.

A SIMPLE METHOD OF SOIL TESTING IN FIELD

Dig a pit of 1.5 to 2.0 ft depth at four different locations at a site and take about 1 kg of soil. Moist the soil with water so as to make four balls one each for one soil sample. Now stand straight and drop the soil ball on the ground from about 3 ft height. If the soil does not spread on ground it means that it has good water retention capacity. Repeat the same procedure with all the four balls

3.4 Other general features

It will be also useful to collect information that the selected site is neither in the down- stream of a reservoir or part of a seasonal river or stream. It may get flooded during the rainy season.

4. BMP-3: Identify the species of ornamental fish to be cultured before initiating construction

The design of the farm and facilities to be developed will be different according to the species to be cultured. In case of low value fish, it will be economical to develop outdoor facilities consisting of a few earthen/poly-lined ponds and cemented tanks whereas in case of high value fish, it will be needed to have sufficiently enough indoor facilities consisting of cemented tanks, FRP tanks and Glass tanks with an effective re-circulatory system. It is also to be decided if the objective will be to produce fish for domestic market or export purpose.

It is a combination of knowledge and skill which improves technical competency

Guiding factors for BMP-3

4.1 Selection of varieties based on market demand

An entrepreneur needs to assess the demand of different varieties of ornamental fish in the market. It could be done by visiting outlets of different wholesalers and retailers. It may be more useful for a new establishment to tie up with an established wholesaler and produce the fish as per his requirement even though he may pay less.

4.2 Select easy-to-breed varieties to begin with

A naive fish producer should choose only easy-to-breed varieties (Live bearers) in the beginning unless he/she is technically experienced to breed some specific variety or able to afford hiring some technically experienced personnel to manage the activity. The farming of easy-to-breed varieties may not be much profitable but it is helpful to gain experience on rearing of young ones and other farm management. However, procurement of some unique strains even in case of live bearers could be quite profitable.

4.3 Availability of brood stock

The availability of good quality/pure lines of brood stock (matured males and females) is always a problem. Established fish breeders will never sell their stock of brood fish. Therefore, a new breeder requires developing his own stock which is explained in much detail in Chapter-5.

5. BMP-4: Draw a sketch for location of different facilities at site and its detailed design

It is felt a number of times after the completion of construction that if this road was not there but on the other side of pond it would have been more useful, purposeful and beneficial. It happens with the design of the facilities also. Therefore, a detailed drawing and re-drawing initially of hand sketches for location of different facilities even including the position of a bore-well, store house, water supply lines, etc. and evaluating the benefit of each is very helpful as well as economical. Once, a hand sketch is finalized, it is advisable to have final drawing made by an architect/civil engineer using auto-cad software. The level of production viz; traditional, extensive, semi-intensive or intensive system is also to be decided at this stage.

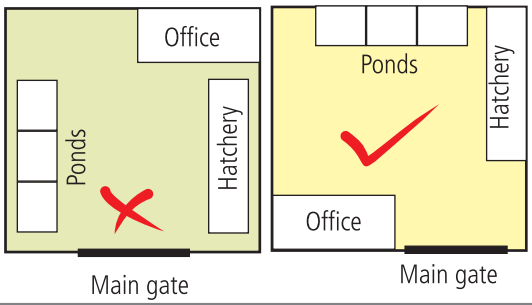
Proper layout planning & designing initially reduces the cost of construction and improves profits later

Guiding factors for BMP-4

5.1 Economics of space and cost

The land is an important resource and could be limited though the requirement of land for ornamental fish production activity is comparatively less than culture of edible species. Since, a production facility near a city is more useful, it limits the availability of land. Therefore, there is need of proper planning so to effectively utilize all the available space.

AN EXAMPLE OF SPACE UTILIZATION AND COST SAVING

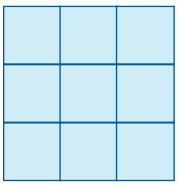
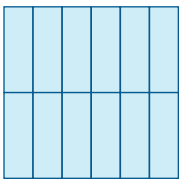


Unknowingly, you constructed your office and the shade housing the indoor facilities about 500 m inside the main gate. Now, you had to construct an additional road of 500 m up to the shade/office building from main gate. Secondly, all the visitors who are coming to your office will be watching all your activities on both the sides of road up to 500 m which you never desired. In case, this facility was only 100 m inside from the main gate, there will be saving on cost of road construction and visitors would not get access to the area beyond 100 m.

5.2 Developing a technically feasible, operationally convenient and cost effective design

It is important to consider all technical feasibility, operational convenience and total cost of facility while developing a design. These are best explained by following two examples given below.

EXAMPLE-1 CONSTRUCTION OF CEMENT CISTERNS FOR AN INDOOR FACILITY

S.NO.	ITEM	PLAN A	PLAN B
1.	Total Area (Sq.ft.)	3000	3000
2.	Dimension (Sq.ft.)	30 x 100	30 x 100
3.	Proposed size of tanks (ft.)	10 (L) x 10 (W) x 2 (D)	15 (L) x 5 (W) x 2 (D)
4.	Number of tanks	30	40
5.	No. of tanks in each row	10 tanks each in 3 rows	20 tanks each in 2 rows
6.	Thickness of walls	6”	6”
7.	Lay out		
8.	Total Area of walls (sq.ft.)	1460	1920
9.	Cost of Construction (Rs.300/ sq.ft.)	Rs. 4,38,000/-	Rs. 5,76,000/-
10.	Effective tank size (ft.)	9.45 (L) x 9.33 (W) x 2 (D)	14.25 (L) x 4.45 (W) x 2 (D)
11.	Water Volume of each tank	5025 liters	3614.5 liters
12.	Water volume of all the tanks	150750 liters	144580 liters
13.	Productive age of tanks	10 years	10 years
14.	No. of labors required to net out the fish	2 person with drag net	1 person with hand net
15.	Cost of labor for productive age of tanks @ Rs.6000/p.m.	Rs.14,40,000/-	Rs.7,20,000/-

Advantage of Plan B:

i. There is a walkway on both the sides of tanks in Plan B whereas the accessibility to tanks in middle row is difficult in Plan A.

ii. One person could net out fish using hand net in tanks of Plan B, whereas always two persons will be required in Plan A.

iii. The operational cost of labour is reduced by 50% in Plan B.

EXAMPLE-2 FABRICATION OF GLASS TANKS FOR INDOOR FACILITY

S.No.	Item	Plan A	Plan B
1.	Total water holding capacity to be developed	12700 liters	12700 liters
2.	Proposed size of glass tanks (ft.)	2.5 (L) x 1.50 (W) x 1.25 (D)	6 (L) x 2.5 (W) x 2.5 (D)
3.	Capacity of one glass tank (liters)	133	1065
4.	No. of glass tank needed	96	12
5.	Cost of one glass tank (Rs.)	1080	14700
6.	Total cost of glass tanks (Rs.)	103680	176400
7.	Placing area required (sq.ft.)	120 in 3-tier system	180 at one level only

Other advantages of Plan A: Easy handling of aquarium and the more number of glass tank units will be helpful to stock more varieties/stages of fish.

5.3 Deciding the production system and the type of facilities

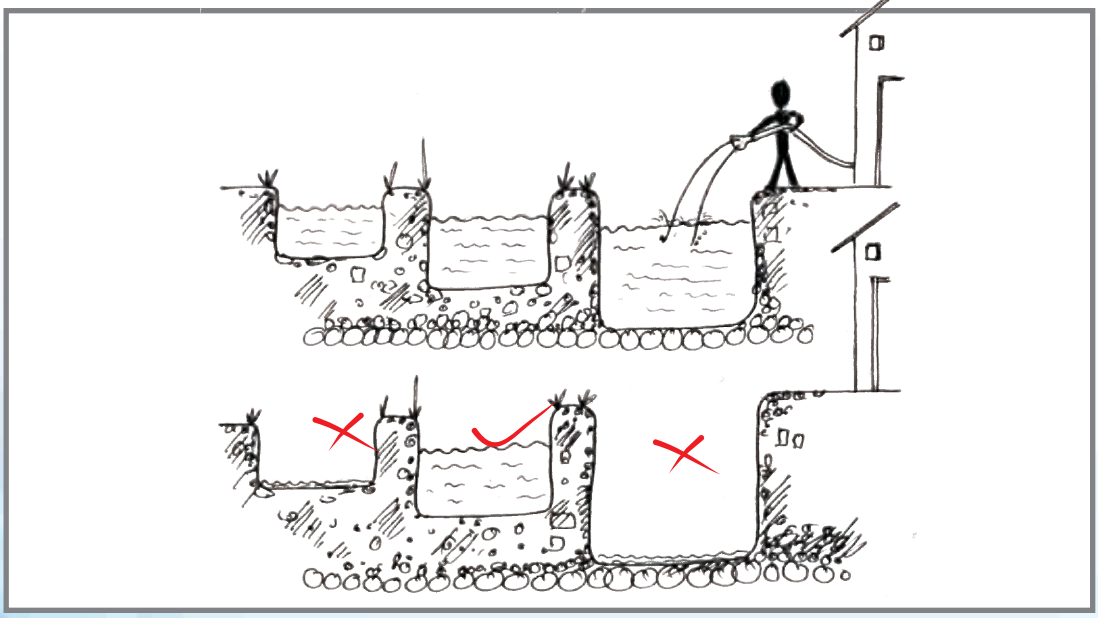
A decision about level of production system i.e. traditional, extensive semi-intensive or intensive will be very useful before the construction is started as it will determine the type of facilities to be developed. In a traditional system of production, the costs of construction, operations and management is less but simultaneously production is also less. The production level increases as one moves towards intensive system of production but it is also associated with increased cost of construction, operation and management. The risk level is also high in intensive production system. The type of production facilities that are required to be developed may include earthen ponds, poly-lined ponds, cement tanks, FRP tanks and glass tanks. A list of guiding factors to be followed for developing each of these facilities is described.

a. **Earthen Ponds**: There is no need for large size and many numbers of earthen ponds at an ornamental fish breeding farm. Only few ponds of smaller size (0.01-0.05 ha) with a water depth of 3-4 ft. water depth are sufficient. Earthen ponds could be used for keeping brood fishes of large size varieties e.g. Koi carps, Oscars etc. as well as for rearing of young ones.

CONSTRUCTION OF AN EARTHEN POND

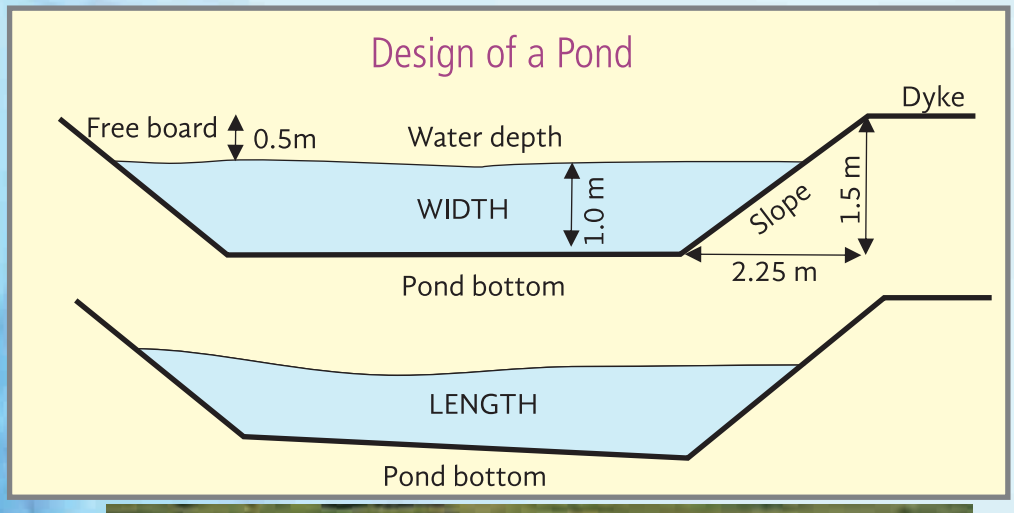
Site Selection: A suitable site for pond construction is one which is not rocky, able to retain water, do not allow seepage loss of water and do not get flooded during rainy season. A soil with a clay content of above 20% is considered suitable for pond construction. The method of testing suitability of soil is already described above. However, the water retention capacity of soil could vary at different depths which could be tested by the following method.

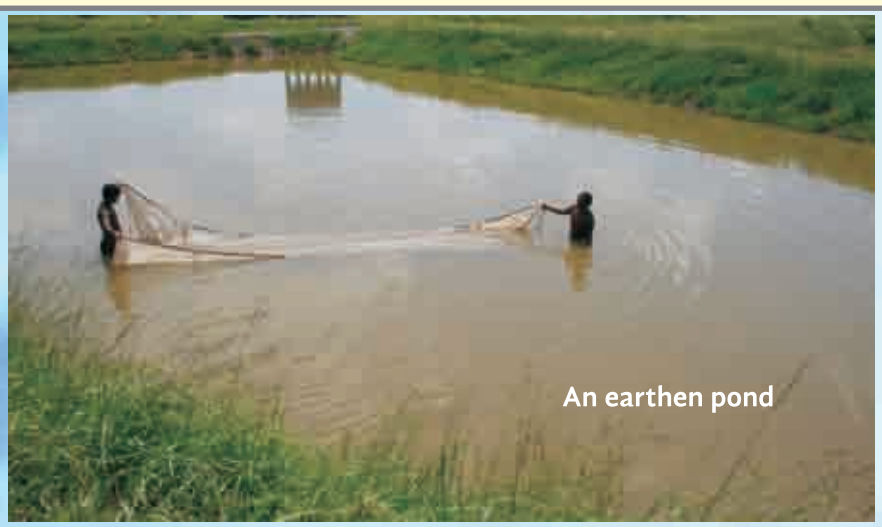
Dig 3 pits of about 1 feet diameter each with depths of 1, 2 and 3 ft. Cover walls of all the 3 pits with moist soil and fill up with water. The pit in which water is retained for longest period is the best suitable depth for pond construction i.e. if water is retained in the pit which was dug only 2 ft deep, then only 2 ft deep soil need to be removed from the top.



Precautions of pond construction

a. The width of the pond dyke should be sufficient so as to have proper movement.
b. It should have a free board of about 2 ft. and should not have steep slope.
c. All the vegetation and top soil should be removed before digging the pond.
d. A proper bottom slope shall be maintained so as to facilitate easy drainage.
e. The soil at dykes shall be properly compacted.
f. The positioning of inlet pipe shall be proper so that dykes are not damaged.




An earthen pond

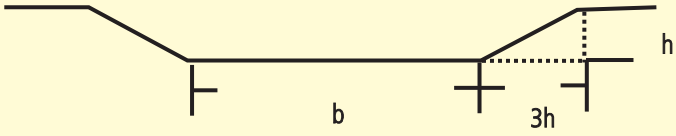
The major advantage of rearing ornamental fish in earthen ponds is the fast growth and attractive body colours but predatory (snakes & birds) losses are very high. Therefore, rearing is done inside net enclosures (hapa) of suitable mesh size which are installed in ponds. These net enclosures could be circular or rectangular depending on the requirement.

b. Poly-lined ponds

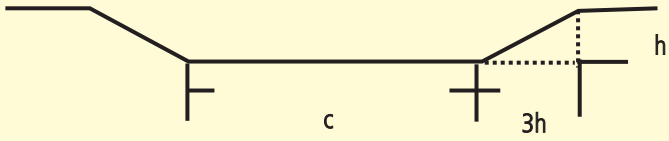
The poly-lined ponds are earthen ponds that are covered with a Low Density Poly-ethylene (LDPE) film of 150-500 microns. The poly-lined ponds are highly successful in rocky and sandy soils where seepage loss is very high. It is a cost effective and long lasting method of seepage control in ponds. The cost of poly-lining including poly-film of 250 micron and labour cost is about Rs.10 per sq.ft only at present.

STEPS INVOLVED IN CONSTRUCTION OF A POLY-LINED POND

a. Prepare an earthen pond as mentioned above.
b. Remove all rocks and stones from the bottom as well as sides.
c. Treat the soil bottom with some weedicides at relatively higher concentration (5 ml/liter) so to suppress the growth of weeds.
d. Calculate the required size (length and width) of poly-film by following formula:
Length of Film $L = b + 2\sqrt{(9h^2 + h^2)} + 2$ mts.



Width of Film $L = c + 2\sqrt{(9h^2 + h^2)} + 2$ mts.



Total Size of Film = L x W mts.

e. Cut a film of required dimension from the roll. As the size of ponds for ornamental fish culture is small, the poly-films of required sizes will be readily available. In case a film of larger size is required it could be pasted through thermal sealing.
f. Spread the layer of poly-film uniformly in the pond by providing at least 5% extra length covering bunds.
g. Remove all the wrinkles from the middle part and collect at the corner of pond.
h. Fix all the four ends in the bunds and overlay the sides with about 2 ft deep layer of soil.
i. Cover the bed of pond initially with 5 cm layer of fine soil followed by 40 cm layer of earth.
j. The side slopes can be covered by dry stone pitching preferably with round river boulders. Stone pitching is done by placing large boulders at the bottom of slope followed by gradually reducing the thickness of the boulders. The gap between boulders is subsequently filled with soil. The stone pitching in free board section could be plastered with cement mortar (1:6) for longevity.
k. The poly-line pond will be ready for use.

c. Cemented Tanks

The cement tanks of different sizes and water holding capacity both indoor and outdoor are highly essential and useful facility at an ornamental fish breeding farm. However, the decision about size and water holding capacity should be subjected to technical and operational feasibility as it was described above. The cemented tanks could be made up of either ferro-cement, reinforced cement concrete (RCC), or bricks depending on the need.

i. The ferro-cement tanks are circular/rectangular tanks that are normally available in different size in the market as ready to use tanks. These tanks are very useful for keeping and breeding of small size fishes such as live bearers, barbs, tetras as well as for keeping brood stock of gold fish, gouramys, etc. A good quality ferro-cement tank may last for many years if kept undisturbed on a plain surface.

ii. The reinforced cement concrete (RCC) tanks are made up of steel bars and cement-concrete mortar similar to construction of buildings. These types of tanks are constructed when tank size is very large as the cost of construction is very high. These are

primarily used as a culture facility in place of earthen ponds. The maintenance of these ponds is easy and survival rate is also high as entry of predators can be easily controlled. These tanks shall be constructed with the advice of a civil engineer only. However, certain useful tips to remember are:

- The RCC tanks should be normally constructed above the ground level so to drain out the tanks through gravity only.
- A drainage channel should be constructed to receive drain out water from tanks.
- Application of adequate type of water proofing substances should be ensured so to completely control the water leakage as it will be difficult to control it later.

- The provision of walkways should be made along the wall of the tanks so as to have easy accessibility to every tank.
- The provisions should be made to cover the entire structure with bird nets so as to restrict the entry of birds in tanks.

iii. Brick tanks

The brick tanks are the most common type of tanks at ornamental fish farms as these are easy and fast to construct as well as economical. The decision about the size of brick tanks is already described above. However, it is seen that these tanks do not last long and there is problem of water leakage followed by large structural cracks. It happens because most of the time, the construction of brick tanks is not considered as a serious job and advice of the masonry workers is only considered. It is advisable to consult a civil engineer for the structural design. In case, you decide to construct at your own then consider following suggestions:

- The tanks up to water volume of about 3000 liters could be constructed with bricks. In case the water volume is more, RCC tanks should be constructed.
- The foundation wall of each tank should be sufficiently deep (4-5 ft) and wide (2 ft at bottom and 1 ft at top) and constructed with good quality stone.
- The top surface of foundation wall should be covered with about 4" thick concrete-cement mixture and once it is dried then brick wall of desired thickness should be constructed. A brick wall of about 6" thickness (with plastering) is perfect for tanks of smaller volume (3000 liters) or tanks with width up to 4-5 ft.
- The bottom of each tank should be packed with stones laid vertically for about 1.5-2 ft depth and gaps between the stones shall also be packed with smaller stones, gravels, etc.

Repairing of tanks

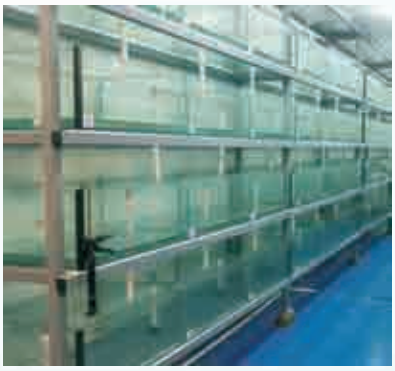
Water leakage in brick tanks and RCC tanks can be repaired by using water proofing compounds along with a geo-textile membrane

- Now stoned bottom should be covered with a 4-5" thick layer of concrete-cement mixture. The suitable water proofing compounds (available at any hardware stores) should be mixed in the concrete-cement mixture.
- Once the brick wall is constructed upto the desired height, it should be coated with a water proofing compound. Thereafter, it shall be plastered.
- Each tank should be provided with a properly grouted outlet pipe (2" dia G.I. Pipe of 12" length) at the bottom and another outlet pipe at the top which is about 4" below the top surface of tank.
- The slope of the tank should be maintained towards the outlet pipe.

d. FRP Tanks

The tanks made up Fiber-reinforced Plastic (FRP) are very popular in aquaculture specifically in hatcheries and intensive culture systems. FRP is a composite material made up of a polymer (epoxy, vinylester, etc.) matrix reinforced with fibers (glass, carbon, etc.). The FRP tanks are also used in ornamental fish farming as an indoor facility. The cost of an FRP tank is about three times higher with that to a brick tank but these are movable, easy to clean and maintain the hygiene. FRP tanks can be fabricated in any size or shape i.e. circular, rectangle, square, etc. However, these have to be procured from the manufacturers of the tank. Now a days, manufacturers of FRP materials could be found in smaller cities also but it has to be ensured that they are familiar with the process of manufacturing tanks. Many a times it is observed that FRP tanks of sub-standard quality are supplied which do not last for more than 2-3 years. It is advised to take care of following points while ordering for an FRP tank.

- The rates of FRP tanks are based on the thickness which is measured in mm. One should ensure the thickness of tank while finalizing the order. The minimum thickness of FRP tanks should be 3 mm up to 1000 liter capacity and increase proportionately.
- Each tank shall be housed in frame of M.S. A good manufacturer will reinforce the M.S. along with FRP during the manufacturing process.
- The stand of the FRP tanks shall be strong enough to hold the weight of the water. The larger size FRP tanks are placed on raised platforms.
- A good quality tank should not bulge from any side when filled up with water.
- The texture of fibers on outer surface should not be visible. In case, it is visible, it could be a manufacturing defect.



e. Glass Tanks

The glass tanks of different sizes are very useful at an ornamental fish breeding and culture farm. The major advantage of glass tanks is that large number of fish could be maintained in a small volume of water which is easily manageable and all the activities of fish are visible from front unlike cement tanks. Glass tanks are very good option for indoor hatcheries. The glass tanks of small size can be built in-house after a little training and it will cost about 40% less than to market price. The glass of required thickness and dimension can be purchased from a local glass supplier.

PROCESS OF FABRICATING A SMALL SIZE GLASS TANK

A. Materials required

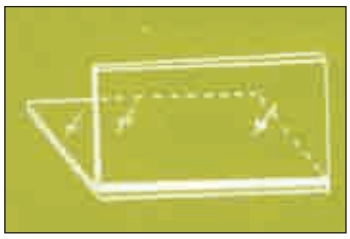
i. Glass panes of desired size and thickness
ii. Silicon sealant
iii. Squeezing gun
iv. Adhesive tape
v. Plain wooden board
vi. Cutter, measuring tape, carborandum stone

B. Thickness of glass and size of glass panes

S.No.	Size of the tank (In inches)	Thickness (mm)	Size of glass panes L x W (In inches)			Remarks
			Front & Back	Bottom	Sides	
1.	24 x 12 x 12	5	24 x 12	24 x $11^{1/2}$	$11^{1/2}$ x $11^{3/4}$	No extra support
2.	30 x 18 x 15	6	30 x 15	30 x $17^{1/2}$	$17^{1/2}$ x $14^{3/4}$	No extra support
3.	36 x 18 x 24	10	36 x 24	36 x $17^{1/2}$	$17^{1/2}$ x $23^{1/2}$	Connect front and back
4.	48 x 24 x 30	12	48 x 30	48 x $24^{1/2}$	$24^{1/2}$ x $29^{1/2}$	panels from both sides at top with a glass plate of 4" width and 10 mm thickness

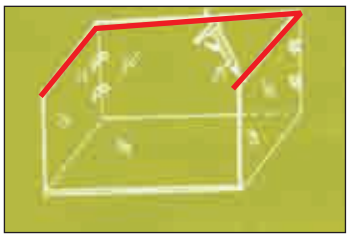
STEPS OF AQUARIUM FABRICATION

1. Place back glass on a plain surface and apply silicon sealant

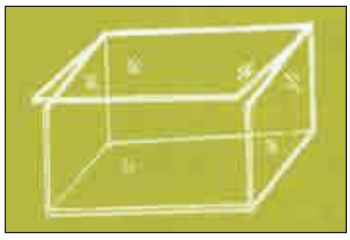


2. Raise bottom panel.

3. Apply sealant on bottom and back glass panels and fix the side glass panel



.4. Place another side glass panel



5. Place front glass panel

6. All glass aquarium is ready

5.4 Selection and installation of different machines/equipment

There are many types of machines and equipment that are needed for day to day activities at an ornamental fish farm. The most important of these are a set of water pumps, air blowers, DG Set/Inverter in addition to other general purpose facilities. It is important to determine the total requirement both in terms of numbers and capacity of each before procurement. An unplanned decision results in purchase of unwanted equipment/facilities.

5.5 Planning of a water storage and distribution system

The distribution of water from source to different points of uses is an important process at any ornamental fish production facility. The important characteristics of water storage and distribution system are:

a. There is sufficient quantity of stored water for day to day operations as well in case of emergency (electric failure, etc.).

b. The water flows through gravity to all the points of uses.

c. There is proper network of water supply lines.

d. The time taken to fill up a pond/tank/glass is not much.

In order to facilitate all these process it will be required to construct an over head tank (OHT), develop a proper network of supply lines from OHT to different point of uses and also regularize the flow of water.

i. Over head tank (OHT): An OHT is required to store water for supplying to different point of uses. The water holding capacity of the OHT shall be decided based on average daily requirement of water to be exchanged. Suppose, the daily requirement of exchangeable water is 10000 liters, it will be advisable to have an OHT of 20000 liters capacity so to have reserved stock of water in case of electricity failure or unavailability of water for any other reason. The OHT shall be constructed at the highest available point so that water reaches to all the points of uses through gravity with high velocity. A height of 15-20 ft is optimum. The OHT of higher capacity shall be constructed with RCC whereas smaller tanks could be of brickwall. The use of LDPE tanks shall be avoided as water gets heated during summer period.

ii. Water supply lines: A proper network of water supply lines shall be laid from the OHT to different point of uses. It may result in initial high cost but later it provides lot of operational convenience and reduction in cost of labour. The water supply lines can be installed by using UPVC or CPVC pipes. These are light weight pipes, about 70% less costly than G.I. pipes and easy to fix. You could even fix it at your own with little effort. It requires an

understanding of different products viz; elbow, three ways, four ways, sockets, nipples, valves etc., which can be simply fixed by pasting with UPVC/CPVC solution. The velocity of inflow water could be increased by installing main supply line of large diameter and distribution lines of smaller diameter.

6. BMP-5: Develop a rain water harvesting system and water re-circulation facility to ensure availability of water and also to reduce cost on water

The rain water is an excellent source of good quality water especially for those ornamental fish breeding farms that are breeding fish which require water of very low TDS such as angels, tetras, etc. and also those located at places where water availability is limited. An ornamental fish breeding farm with a large roof top area for indoor facility and semi-covered outdoor facilities with drainage system offers an excellent structural advantage to collect rainwater. It is only required to construct some rain water collection chambers below the ground level and there is not much extra costing involved in it.

Rain water harvesting and collection structure at an ornamental fish production farm

Guiding factors for BMP-5

6.1 Plan for a rain water harvesting system in the beginning

The planning of a rain water harvesting system is an integral part of the initial farm design so that proper pipelines are fitted and channels are constructed so to direct all the rain water into collection chambers. The

water holding capacity of collection chambers could also be decided in relation to total area of roof top and quantity of rainfall.

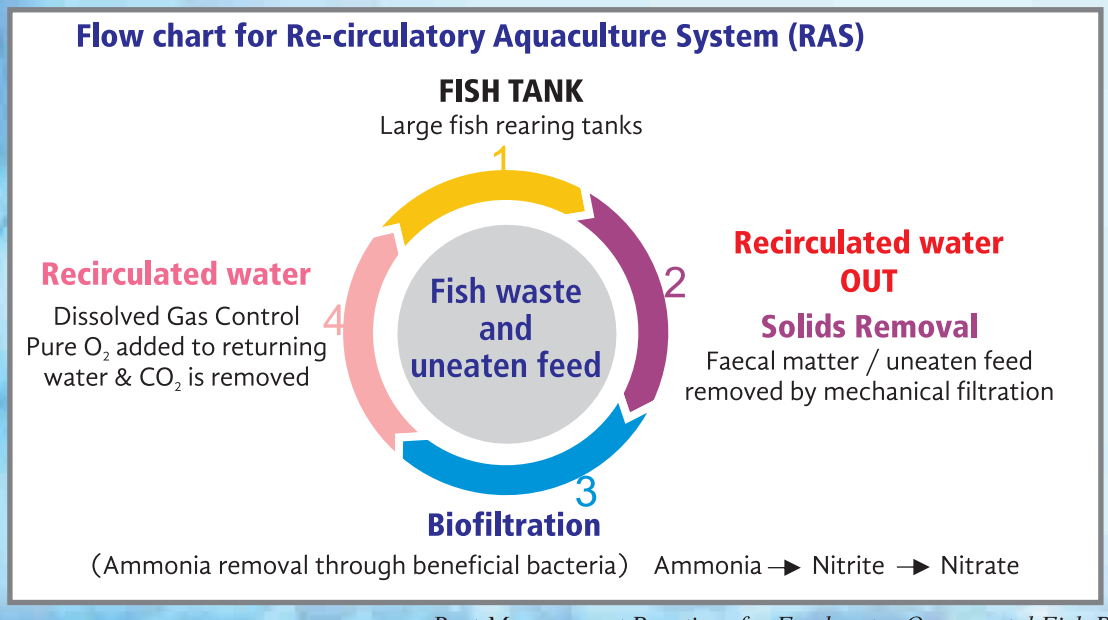
6.2 Ensure proper storage of harvested water

It is to be ensured that all the harvested rain water is stored properly without any contamination and any losses both due to leakage from tanks as well as evaporation. It could be controlled by properly cleaning of all the roofs, drainage channels and collection tanks well in advance before the rains. Collection chambers are to be coated with water proofing compounds at the time of construction and kept properly covered so to avoid any evaporation losses and entry of any unwanted material.

6.3 Setting up of a common water filtration system to facilitate re-use of water

The daily requirement of exchangeable water is quite high at an ornamental fish breeding and culture farm. It could vary from 10-30% depending on level of operations. This much quantity of water shall go waste if provisions are not made to re-use the same. The re-use of water is highly useful. It helps in conservation of water and also economizes on cost of water treatment at those facilities where any new water is to be treated for water quality improvement. In order to facilitate re-use of water, there is need of a common bio-filtration system which shall be part of the initial design.

A bio-filtration system is not a complicated structure to install once we understand its working principle. All the discharged water from all types of fish holding tanks contains high load of organic material in the form of uneaten feed and metabolic wastes. The decomposition of these increases level of obnoxious gases in the water and reduces level of dissolved oxygen. The purpose of a bio-filtration system is to remove all types of waste from the water with the help of few useful groups of bacteria (*Nitrosomonas spp, Nitrobacter spp.*). Hence, all the incoming water is passed through a filter bed which allows growth of these bacteria. These bacteria decompose all the complex compounds in to simpler gaseous forms that are released out from the water. The out coming water from the filter bed is as good as fresh-water. The filter bed is nothing but a systematic arrangement of coarse gravel, activated charcoal, granular zeolite and a layer of foam.



The layer of foam removes all particulate materials from the incoming water. The layer of activated charcoal and granular zelite absorbs all soluble ammonia whereas coarse gravel provides surface for the growth of bacteria. A large surface area supports large number of bacteria that increases efficiency of the filtration system. The quality of filtered water could be further improved by passing the same through UV light and injecting ozone through an ozonizer. The UV light helps in removing any harmful bacteria from the water whereas ozonizer acts as a sterilizer as well increases concentration of dissolved oxygen in the water.

7. BMP-6: Legal & social responsibility of safeguarding the surrounding environment by avoiding non-environment friendly activities

The water which will be discharged from the ornamental fish production farm may be contaminated with dissolved or suspended organic matters, nutrients, chemicals, antibiotics, etc. It may also have young ones of all those fish which are being kept in the premises. The discharge of contaminated water and exotic ornamental fish in the open system may directly or indirectly result in degradation of surrounding environment. Therefore, it is the legal & social responsibility of the farm owner in the interest of the society as well as in his own interest that any of his activity should not cause damage to surrounding environment.

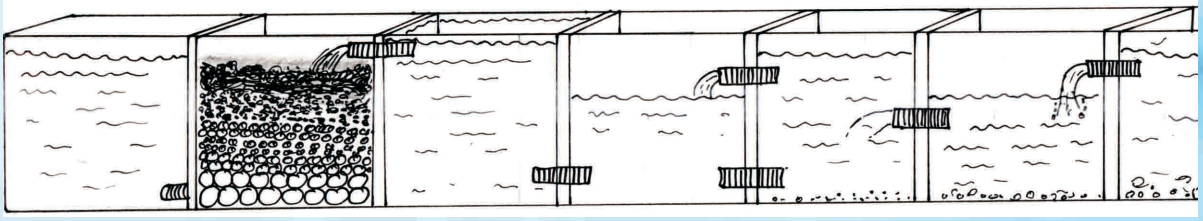
Guiding factors for BMP-6

7.1 Do not introduce any exotic variety of ornamental fish in any open water system

The culture of exotic varieties of fish in a closed system has been an issue of discussion and serious concern because at several occasions these accidentally escape to the natural environment. There are several examples in past where irreversible damage has been made to aquatic environment. The number of exotic varieties in case of edible fish is few but there is a long list in case of ornamental fish. The permission of importing these exotic varieties of ornamental fish has been granted by concerned authorities for aquarium keeping but few of these are also being bred indigenously. But, it shall be ensured that none of these get released accidently or intentionally in to open water system. It can be controlled by draining all the discharge of the farm in a closed pond only.

7.2. Develop an eco-friendly approach to manage the effluents

The effluents that are discharged from an ornamental fish production facility contain suspended organic matters and nutrients. However, the total quantity of effluents is less compare to that of shrimp farms and as such



the risk of environmental degradation is also less. However, it may not be advisable to release the effluents directly in open water systems. It has been advised of installing a re-circulatory system above. The drainage receiving tanks of re-circulatory system can be so designed that all the suspended solids get settled in these tanks only before entering into bio-filter chambers. The efficiency of these settling tanks can be improved by constructing a series of tanks where water moves down from one chamber to other and all the suspended solids get easily settled. All the settled waste which is rich in nutrients can be removed at a fixed interval and can be used as manure. It could also be used for hydro phonic cultivation.

Zeolite rings helpful in ammonia absorption

8. Important Suggestions

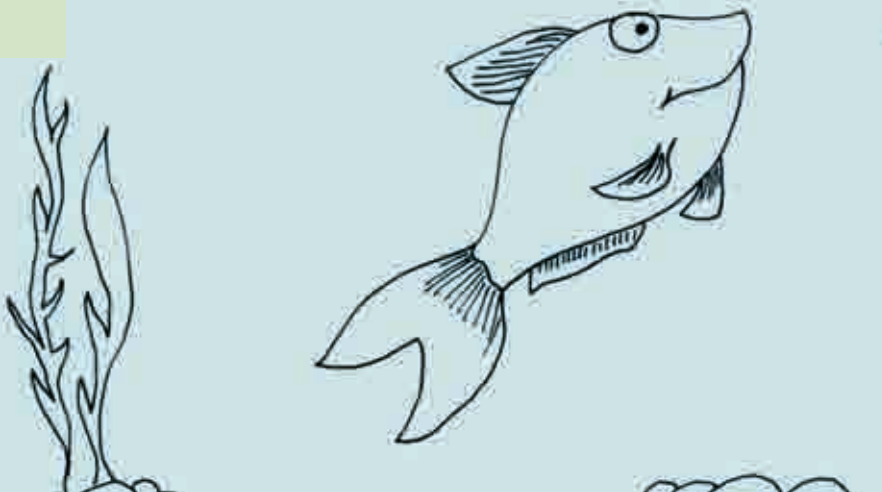
- Select a suitable location to set up an ornamental fish production farm based on assessment of activities of similar farm units in the locality, demand and supply gap in the local or selected market, future development potential, connectivity and means of transportation, socio-culture values, availability of electricity, availability of labour as well as local law and order situation.
- Make a visit to local office of state fisheries department or MPEDA and find out if any permission is required from any government agency.
- Identify a specific site at the selected location based on sources of water supply, potential of each resource, quality of water, quality of soil including its water holding capacity and connectivity to main road. In case a bore well is to be installed at the site, it shall be done on the basis of hydro-geological survey.
- Identify the species and varieties of ornamental fish to be produced based on demand assessment of market and select some easy-to-breed fish only initially. Effort should be made to procure good quality brood stock.
- An entrepreneur should try to gain both knowledge and skill of ornamental fish breeding and culture technology either through attending a training programme or on-farm experience, if these are not available to hire experienced persons.
- An ornamental fish producer shall also consider the option of setting up a retail outlet for trading of fish as well aquarium and aquarium accessories.
- An outline sketch shall be drawn specifying location of different facilities/units including roads, etc. that are planned to be developed before starting the construction. The advantage and disadvantage of the same shall be analyzed so that a technically feasible, operationally convenient and cost effective design is developed.
- The type of facilities viz; earthen, RCC or brick ponds and level of production system viz; traditional, semi-intensive or intensive shall be decided before starting the construction.
- The design shall be finalized in consultation with a structural engineer. It shall include detailed design of all the structures as well as cost estimates.
- An ornamental fish production farm shall have both indoor and outdoor facilities. The outdoor facilities may include few numbers of earthen/poly-lined ponds and cemented tanks whereas indoor facilities may include cemented, FRP and glass tanks.
- The size of earthen or poly-lined ponds shall be small (0.01-0.05 ha) and the ponds should have a depth of about 3-4 ft., slope of 1: 1.5, dyke width of 5-7 feet and free board of 2 ft. The ponds shall be protected from entry of predators mainly snakes and birds.
- The construction of poly-lined ponds is very successful in sandy soils. The cost of poly-lining of ponds using 250 micron LDPE sheet is about Rs.10 per sq.ft.
- The ferro-cement tanks of circular/rectangular shapes with a water holding capacity of 200-300 liters are highly useful for keeping of brood stock of small sized fish as well as breeding and rearing of live bearers, tetras and barbs varieties of fish.

- The cemented tanks of above 3000 liters capacity shall be normally constructed of RCC.
- The average width of brick tanks should be about 5 ft so that only one person can net out the fish with the help of a hand net.
- All types of cemented tanks should be treated with water proofing compound at various stages of construction so to avoid problems of water leakage in future.
- The fabrication of more number of small size glass tanks is much more economical than few numbers of larger size tanks while the water holding capacity remains the same. The glass tanks of small size can be fabricated in-house with about 40% cost saving.
- The use of submersible pumps over external pumps is more effective for different uses at farm as submersible pumps require less maintenance than external types of water pumps.
- It is more beneficial to use air compressors of smaller capacity separately for different sections of production facility than a single air blower of larger capacity.
- The construction of an over headtank is highly useful. The water holding capacity should be about 2 times of the daily exchangeable water requirement and OHT shall be placed at 15-20 ft height so that water reaches to all the points of uses through gravity only with high velocity.
- A proper network of water supply lines should be laid from the OHT to different points of uses. The water supply lines can be installed by using UPVC or CPVC pipes which are light weight, about 70% less costly than G.I. pipes and easy to fix.
- Attend time to time to repair and maintenance of all civil structures and mechanical/electric equipments. A sudden failure results in heavy losses and higher maintenance cost.
- The availability of good quality water can be ensured through developing a rain water harvesting facility. The size of storage tanks should be decided in relation to total area of roof top and amount of rainfall.
- All the roofs, drainage channels and water collection tanks should be properly cleaned before rainy season so to avoid any type of contamination to the harvested water. The collection tanks shall be kept covered.
- Installation of a bio-filtration system is highly useful at any ornamental fish production farm so to facilitate re-use of water.
- Any type of exotic fish should not be released in to open water systems. Proper measures should be adopted even to control accidental escape.
- The effluents of farm that are rich in suspended organic matters and nutrients should not be directly released into open water system but could be used as manure for growing plants or in hydroponics.

Chapter 4

Water quality management for production of freshwater ornamental fish

G. Gopakumar



1. An overview

The quality of water is the primary factor for the success of ornamental fish production business. Fish perform all their bodily functions in water viz; respiration, feeding, growth, excretion, osmoregulation, reproduction, etc. Therefore, monitoring of physical and chemical qualities of water is critical to the success of ornamental fish production system. Many of the ornamental fish producers do not give much attention to water quality maintenance which results in low performance, high incidence of disease occurrence and high mortalities. It is felt that if efforts are made to monitor and maintain water quality, both the quantity and quality of the produce can be increased. Although the aquatic environment is a complex eco-system consisting of multiple water quality variables but only a few of these parameters play decisive role. These critical parameters are temperature, suspended solids, pH, dissolved oxygen, ammonia, nitrite, CO_2 and total alkalinity. Each individual parameter is important, but it is the aggregate and interrelationship of all these parameters that influence the health and growth rate of the fish.

The quality and quantity of water are most critical limiting factors for ornamental fish production

The different fish species have their own specific tolerance and optimum range within which they can survive, grow and reproduce. It is therefore very important for fish producers to ensure that the physical and chemical quality of the water remain within the optimum range as much as possible. Fish will exhibit poor growth, erratic behaviour and disease symptoms or parasite infestations outside these optimum ranges. Fish mortality may occur where the water conditions remain poor for a prolonged period of time. In view of

this, a set of "Best Management Practices" are being suggested so as to maintain good water quality at an ornamental fish production farm.

2. BMP-1: The quality of source water should be good and it should be available in sufficient quantity

Water is one of the limiting factors at most of the commercial ornamental fish production facilities. Many of the negative chemical and environmental factors associated with most operations have their origin in the source of water selected. Therefore, the final site selection should be based on the quality as well as quantity of water available. The most common sources of water used for ornamental fish farming are wells, springs, rivers, lakes and water supplied by municipal bodies.

Guiding factors for BMP-1

2.1 Estimation of total water requirement

The quantity of water required for commercial production should be accurately estimated taking into consideration all operations and natural losses like evaporation and seepage. As a thumb rule, water exchange of 20% of the total system volume per day is necessary. Further, while calculating the amount of water required, the information regarding the fish species to be cultured, stocking density and management practices (semi-intensive, intensive, indoor, outdoor, etc.) should be also known.

2.2 Measure the potential of water source

It is also essential to know the potential of water source and period of availability e.g. depth of ground water table, discharge rate of a tube well/hr and period of availability of water in nearby rivers, streams and canals (if these were to be used).

2.3 Quality testing of source water

The water quality testing facilities are available at the Krishi Vigyan Kendras, State Agricultural Universities, ICAR-Fisheries Research Institute, etc. Approach nearby facility for water testing and if some parameters are not in the range, one can ask the experts for correction procedures.

2.4 Optimum range of important water quality parameters

Collect information about optimum water quality parameters required for ornamental fish species you have selected for culture and breeding. The optimum range of few important water quality parameters is mentioned in Table-1.

2.5 Use of test kits for regular monitoring

Very simple to use portable water analysis kits are available with chemical suppliers for testing all routine water quality parameters. These may be also kept handy.

Table 1: Critical water quality parameters with optimum levels

Parameter	Optimum Range
Temperature	24-30^{0}C
Dissolved oxygen	> 5 mg/L
pH	6.5 – 8.5
Total Hardness	100-200 mg/L
Total alkalinity	50-300 mg/L
Ammonia	Nil
Nitrite	Nil
Co_2	< 15 mg/L
Total suspended solids	< 50 mg/L

3. BMP-2: Monitor and maintain the water temperature of production and fish keeping facility within optimum range

Fish are cold blooded i.e. poikilothermic animals, the body temperature of which changes according to that of environment, affecting its metabolism & physiology and ultimately the growth, reproduction and production. A higher temperature increases the metabolic rate of fish along with oxygen demand. It further causes decreased solubility of oxygen and also increased level of ammonia in water.

Guiding factors for BMP-2

3.1 Find out optimum temperature tolerance range of species to be cultured

Fish are generally characterised as warm water species (25-30^{0}C), cool water species (15-25^{0}C) and cold water species (≤ 15^{0}C). Most of the freshwater ornamental species are under first two categories with an optimum value of 24-28^{0}C. The growth of fish increases with increase in temperature till some defined level, thereafter it decreases and leads to stress conditions followed by mortality. An increased temperature also decreases solubility of gases in water that leads to lower dissolved oxygen which is an added effect of thermal stress. All these conditions result in poor growth, continuous stress & even death under severe conditions. Hence, it is important to find out the temperature tolerance range of fishes that are being cultured.

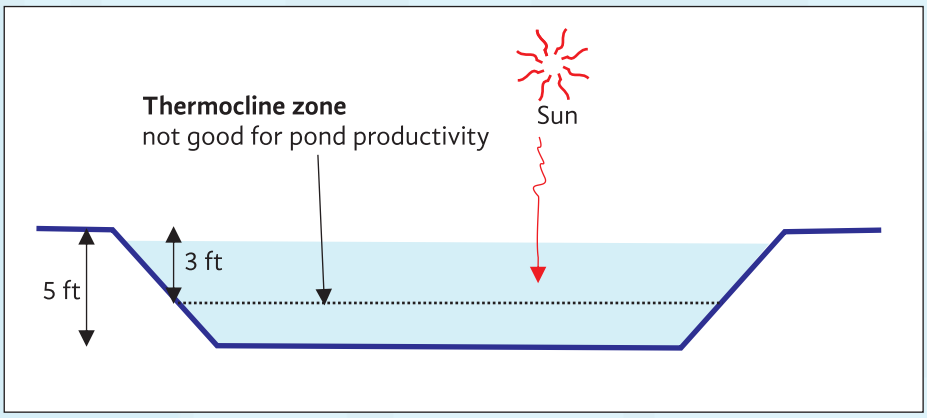
3.2 Protecting fish from temperature variations due to environmental change

Most of the ornamental fish breeding farms are located in coastal regions where both air and water temperatures remain same throughout the year

and fish breed all over the year. It is only in inland regions that there is a summer and winter season of four months each. There is not any breeding activity at the farm during winter months when extra efforts are needed to protect the brood stock. It is advised to have a green-house facility and a poly-house facility so as to successfully continue the operations both during summer and winter season. An indoor house with an environment controlled facility including air coolers for summers and solar water geysers for winters could also be established. It may increase the initial cost but it increases the overall profitability.

3.3 Maintain optimum water depth to avoid stress due to thermal stratification

In a pond culture system for ornamental fish, the water depth of the culture pond should be such that sunlight penetrates up to the pond bottom. It results in equal productivity of the pond. An ideal water depth for ornamental fish culture is 3-4 ft, but during extreme winters or summers, water depth should be increased so to avoid stress to fish due to extreme seasonal temperature variations.



3.4 Protect your fish from a temperature shock

Ornamental fish are very sensitive to sudden variation of temperature. A sudden change of 1^{0}C even within the temperature tolerance range of that fish results in a serious stress to fish. Therefore, fish should be gradually acclimatized whenever shifted from one tank to another.

4. BMP-3: pH of water needs to be maintained in favourable range to optimize biological productivity of the culture system and to avoid stress to fish

pH plays an important role in the physiological activities of fish, decomposition of dead & left over matter, release of nutrients and fish growth. Fish have an average blood pH of 7.4; hence a pH range of 6.5 to 8.5 is more optimum and conducive to fish life. A fish become stressed in water at lower and higher pH with consequences of death at a pH of < 4.0 or > 11.0.

Guiding factors for BMP 3

4.1 Understand the meaning of pH

pH is an indicator of acidity or alkalinity of water which ranges from 1-14. A value of 7 is considered neutral whereas values below 7 are acidic and above 7 are basic. A buffering system to avoid wide swings in pH is essential in aquaculture.

4.2. pH of pond water can be corrected by following simple methods:

a. Low pH (<7.0) can be corrected by application of limestone-calcium carbonate ($CaCO_3$) @ 30-50 mg/L.

b. High pH (>9.5) is corrected by repeated application of Alum-aluminium sulphate [$Al_2(SO_4)_3$] @ 5-10 mg/L. However, alum should not be used in waters with total alkalinity of less than 20 mg/L as $CaCO_3$ because even small amount will drastically lower the pH to a dangerous level.

4.3 Soil PH needs to be maintained at right level to keep a check on water pH by following simple steps

a. Drying the pond for at least two weeks after each harvest before refilling and restocking.

b. Applying lime (preferably agricultural limestone) to the pond after each harvest. Normally lime should be applied to the pond bottom before it is refilled, but if necessary, it can be applied to the water surface after filling the pond.

5. BMP-4: The dissolved oxygen is one of the critical parameters for normal activity and growth of fish and needs to be regularly monitored

Fish also require oxygen for respiration like humans. The amount of oxygen consumed by a fish is the function of its size, feeding rate, activity level and temperature. Fish extracts DO from water not only for respiration but for oxidation of toxic metabolites (ammonia and nitrite) by the nitrification bacteria.

Guiding factors for BMP-4

5.1 Maintain optimum level of DO

Fish must be cultured at optimum levels of dissolved oxygen (DO) to achieve high survival and good growth. It should remain well above 5 mg/L. A value of less than 5 mg/L can result in undue stress to the fish resulting in mortality below 2 mg/L. The DO can be tested by using digital potable DO meters which are available with scientific equipment suppliers.

5.2 Maintain water temperature at optimum level to maintain optimum DO levels

The water temperature of fish holding tanks shall be maintained in between 25-28^{o}C. The amount of DO decreases at higher temperatures (Fig.1) as

well as with increase in altitudes. Sun light increases water temperature and hence decreases oxygen solubility. The oxygen consumption of fish doubles for each 10° C rise in temperature.

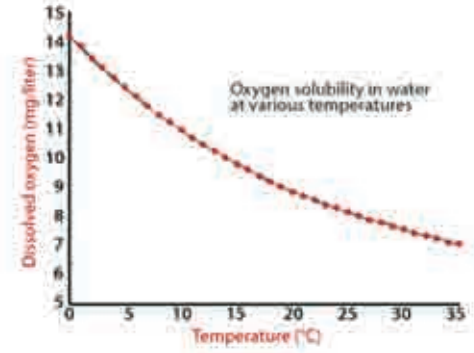


Fig. 1 Oxygen solubility in water at various temperatures

5.3 Avoid accumulation of excessive organic material

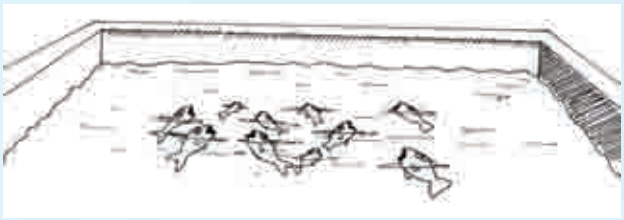
The decomposition of organic materials (algae, bacteria and fish wastes) is the single greatest consumer of oxygen in aquaculture systems. It results in release of excessive ammonia and depletion of DO. Hence, it is required to ensure that there is no excessive organic material in the culture system. The excess of ammonia could be controlled by frequent application of zeolite @ 5-10 mg/L.

5.4 Avoid formation of phytoplankton/algal blooms

The excess availability of nutrients and prolonged duration of sun light results in phytoplankton blooms in a pond culture system due to photosynthesis. It results in depletion of DO during early morning hours which is harmful to fish.

5.5 Be careful while using groundwater

The ground water shall never be pumped directly in tanks stocked with ornamental fish. The amount of DO in ground water is about 2 mg/L which is a very low level and many times fish are unable to recover from stress caused by prolonged exposure to DO deficient water. Ground water shall be used through an over head tank and well aerated before use.



5.6 Symptoms of DO depletion in water

As soon as DO falls below 5 mg/L, the fish will depict an erratic swimming behaviour and start coming to surface gasping for air. In a glass tank, the water will become turbid due to excessive presence of ammonia.

5.7 How to measure the DO of water at the farm

The estimation of DO is essential in semi-intensive and intensive production facilities. It can be measured either by a chemical (Winkler's) method or using a DO meter which is costlier than chemical method but convenient and quick.

5.8 How to maintain DO level in a production system

The regular exchange of water, controlling increase of temperature and avoiding excessive accumulation of nutrients are some of the good practices for DO maintenance in any production system. However, there is always need of a supplementary aeration system for maintaining optimum level of DO.

a. Pond based culture System: There is no need of any supplementary aeration system normally when ornamental fish are cultured in the pond because stocking densities of ornamental fish are not very high in ponds.

However, paddle wheel aerators could be used in case of high stocking densities. A paddle wheel aerator agitates the water so that more amount of environmental air is dissolved in pond water. Now days, paddle wheel aerators of different make and capacities are easily available in domestic market.

b. Tank based culture system: In tank culture system, atmospheric air is diffused in the tank water with the help of air pumps and air blowers. The size of the air pump and air blower could be decided depending on total number of outlets required. Many a times, at small size farms, it is easier and cheaper to use air pumps than air blowers.

5.9 Precautions of using air pumps and air blower

An air pump or air blower is only diffusing atmospheric air into the water. So, ensure that neither the air is contaminated nor these are placed in a hot area as the diffusion of hot air will increase the water temperature. It shall be ensured that the air supply lines are quite above the water level in tank, otherwise the water may reach inside the pump/blower in case of electricity failure. A large number of smaller size bubbles will diffuse more amount of oxygen than few larger size bubbles.

6. BMP- 5: Avoid super saturation of gases in water of culture tanks

The dissolved gases, especially nitrogen, are usually measured in terms of "percent saturation." Any value greater than the amount of gas the water normally holds at a given temperature constitutes super saturation. A gas super saturation level above 110% is usually considered problematic. It results in formation of gas bubbles which could be entrapped in body of fish and cause mortality.

Guiding factors for BMP-5

6.1 Understand clinical signs of gas bubble disease

A fish suffering with gas bubble disease will exhibit abnormal buoyancy and may float to surface. Fish may also exhibit violent head shaking and convulsions. Subcutaneous bubbles can accumulate in tissues of the head, mouth, fin rays and gill arches. Air bubbles could also be seen in gill lamellar capillaries.

6.2 Identify the cause of gas bubble disease

Gas bubble disease occurs because of super saturation of oxygen or nitrogen in the water. Super saturation occurs either under conditions of high pressure or low temperature because of following reasons:

a. Source water is supersaturated with oxygen due to high photosynthetic activity of aquatic plants and subsequent rise of temperature.

b. Air is entrained in pipes or pumps where pump pressure or gravity head forces gas into solution.

6.3 Control of gas bubble disease

Gas bubble disease can be controlled with little care. Few of the important tips are:

a. Immediately shift the fish to another tank which is filled up with some old stored water.

b. Aerate/agitate the water so as to get rid of super saturation.

c. Check if water pump at source is sucking any atmospheric air.

7. BMP-6: Maintain optimum level of total water hardness in the culture system

Hardness is chiefly a measure of calcium and magnesium, but other ions such as aluminum, iron, manganese, strontium, zinc and hydrogen ions are also included. When the hardness level is equal to the combined carbonate and bicarbonate alkalinity, it is referred to as carbonate hardness. Hardness values greater than the sum of the carbonate and bicarbonate alkalinity are referred to as non-carbonated hardness. The excess and scarcity of both calcium and magnesium is harmful to fish. Calcium is required by a fish for bone formation, blood clotting, other metabolic reactions and can be absorbed directly from water or food. It also helps in reducing the loss of other salts (sodium and potassium) from fish body fluids.

Guiding factors for BMP-6

7.1 Understand categories of water on the basis of hardness

Water with a total hardness of 0-75 mg/L is considered soft, 75-150 mg/L as moderately hard, 150-300 mg/L as hard and above 300 mg/L as very hard. It is the moderately hard water which is considered suitable for ornamental fish production.

7.2 Improving the total hardness

The total hardness can be improved by application of agriculture lime ($CaCO_3$) as per requirement. In case, total alkalinity is in desirable range, total harness alone can be enhanced to optimum levels by using gypsum ($CaSO_4$) without affecting the alkalinity. A proper management of hardness and alkalinity will usually eliminate the need to worry about pH.

7.3 Reducing the total hardness

A high value (> 200 mg/L) of hardness also interferes with the normal growth and reproduction of fish. It would have been preferable to avoid selecting such sites for setting up of ornamental fish production facilities but if it was a problem which occurred later, it could be best managed by installing a Reverse Osmosis system for reducing water hardness. The initial cost of the RO system may be high but it is very useful. However, one has to be careful about water wastage which could be reduced by simultaneously installing a re-circulatory system.

8. BMP-7: Maintaining carbonate buffering system/total alkalinity is important for maintaining the required pH

Alkalinity is the capacity of water to neutralize acids without an increase in pH. This parameter is a measure of the bases i.e. bicarbonates & carbonates (CO_3^{-2} and HCO_3^{-}) and in rare instances, hydroxide (OH^{-}). Total alkalinity is the sum of the carbonate and bicarbonate alkalinities. Some waters may contain only bicarbonate alkalinity and no carbonate alkalinity.

Guiding factors for BMP-8

8.1 Know the importance of buffering capacity for any fish culture system

The carbonate buffering system is important to the fish culture regardless of the production method used. In the absence of a buffering system, free carbon dioxide will form large amounts of a weak acid (carbonic acid) that may potentially decrease the night-time pH level to 4.5. Whereas, during peak periods of photosynthesis, most of the free carbon dioxide will be consumed by the phytoplankton and as a result, drive the pH levels > 10. Fish grow within a narrow range of pH values and either of the above extremes will be lethal to fish.

a. A culture system is considered well buffered when pH varies between 7.5 - 9.0 and total alkalinity of 100-150 mg/L.

b. In a poorly buffered system pH varies between 6.5 - 10.0 and total alkalinity of < 20 mg/L.

8.2 How to manage the total alkalinity in ponds

The total alkalinity of water can be increased by addition of lime which should be done in phases by monitoring the value of pH. A pH value of above 8.0 is not desirable for most of the species and even should be slightly acidic in case of tetras, angels, etc. There is no practical method to reduce total alkalinity of ponds. However, it can be reduced significantly by regular replenishing of water and suspending feeding and manuring for some time.

9. BMP-8: Manage amount of suspended solids to reduce turbidity and avoid harmful blooms

In reference to fish culture, suspended solids is a term usually associated with plankton, fish wastes, uneaten fish feeds, or clay particles suspended in the water. Suspended solids are large particles which usually settle out of standing water through time. Turbidity caused by excess growth of phyto-planktons may result in algal blooms that reduce availability of oxygen during dark hours while presence of organic wastes as suspended solids could result in poor water quality, increase nitrogen load in water and choke the filtration system. A high turbidity due to presence of clay can cause behavioral changes in fish, restrict light penetration and limit photosynthesis. Sedimentation of soil particles may also suffocate fish eggs and destroy beneficial communities of bottom organisms such as bacteria.

Guiding factors for BMP-8

9.1 Measuring of optimum level of turbidity

The turbidity and transparency of water are inversely related to each other. A transparency level of 20-35 cm is an indicator of favourable level of turbidity which can be measured by stretching and immersing an arm vertically into the water until the hand disappears from sight. Now, note the water level along your arm. If it is well below your elbow, plankton turbidity is very high, If it reaches up to your elbow, plankton turbidity is moderately high and If it reaches well above your elbow, plankton turbidity is low.

9.2 Correction of the transparency / turbidity in pond culture system

The problem of turbidity may not occur in tank culture system as water is replaced regularly. It will occur mainly in pond culture system where it can be corrected as follows:

a. If transparency is < 15 cm or turbidity is high than required level, stop manuring/fertilization and supplementary feeding for some time. However, in case of plankton turbidity and turbidity due to suspended organic or inorganic matter, apply lime.

b. If transparency is > 40 cm or turbidity is very low : Apply Manures/fertilizers for plankton production.

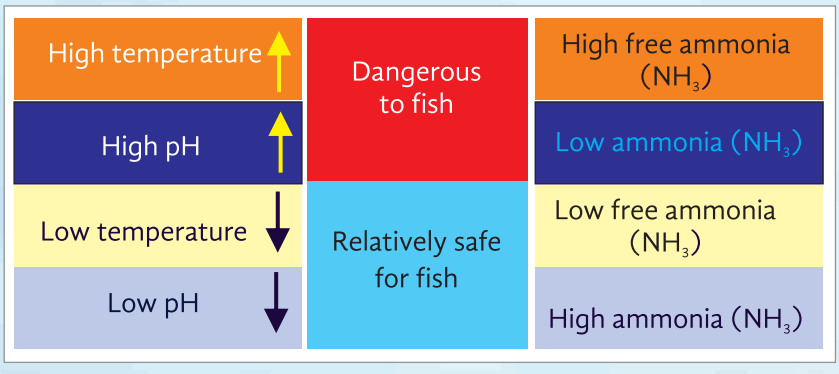
10. BMP-9: Do not allow building up of excessive ammonia in culture system. It could be very critical for the survival and growth of fish

Fish excrete ammonia and lesser amounts of urea into the water as wastes. Ammonia occurs in aquaculture systems in two forms i.e. ionized and un-ionized. The un-ionized form of ammonia (NH_3) is extremely toxic while the ionized form (NH_4^+) is not. Both forms are grouped together as "total ammonia." Decomposition of dead organic matter also adds NH_3 in aquatic ecosystem.

Guiding factors for BMP-10

10.1 Do not allow high level of unionized ammonia in culture system

The unionized or free ammonia is safe below 0.02 mg/L and toxic above this level. As the temperature and pH of the culture system increases the level of free ammonia increases and of ammonium ions decreases. Hence, the balance between free ammonia and ammonium ions is determined by the pH and temperature of the water.



10.2 How to reduce toxic levels of ammonia

The toxic level of ammonia can be best reduced by installation of biological filters in a culture system. A biological filter convert the end product (ammonia) of the decay of excreta and uneaten food or dead animals, to first nitrites and then to nitrates and finally nitrogen through the process of nitrification and denitrication with the help of useful groups of microbes. Biological filters could be developed for individual tanks in plastic drums and for entire production facility in large cement tanks.

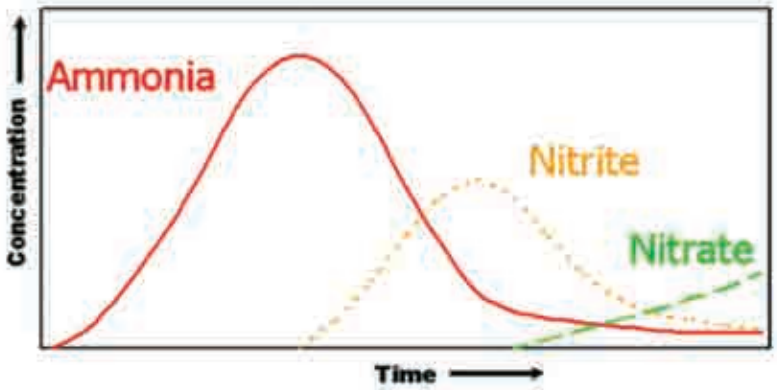


Fig. 2. Conversion of ammonia to nitrate in a biological filter in relation to time

10.3 How to increase efficiency of biological filters

The more efficient a filter, the more fish a tank could support. The efficiency of biological filter can be improved by adopting following practices

a. A larger surface area of the filter bed is more important than the depth of the filter bed. It is because of the reason that microbes require oxygen to function and as the water flows through the filter bed, oxygen is depleted and nitrification decreases, thus the top half inch of the filter bed does almost the entire work.

b. The gravel size should be small enough so to provide a large amount of surface area for a high bacteria population and to provide some mechanical filtration, yet large enough to allow good water flow with some freedom from particulate clogging.

c. A strong air flow broken up into small bubbles are essential to provide the necessary water flow through the filter bed.

d. Colonization of good bacterial population, ammonia-nitrite-nitrate conversions and working of biological filter (N_2 cycle) in full swing needs some time. Proper time should be given to the filter, so that it can work efficiently.

e. The use of granular zeolite helps in fast removal of ammonia.

f. Overfeeding and overcrowding should be avoided in culture tanks.

11. Important suggestions

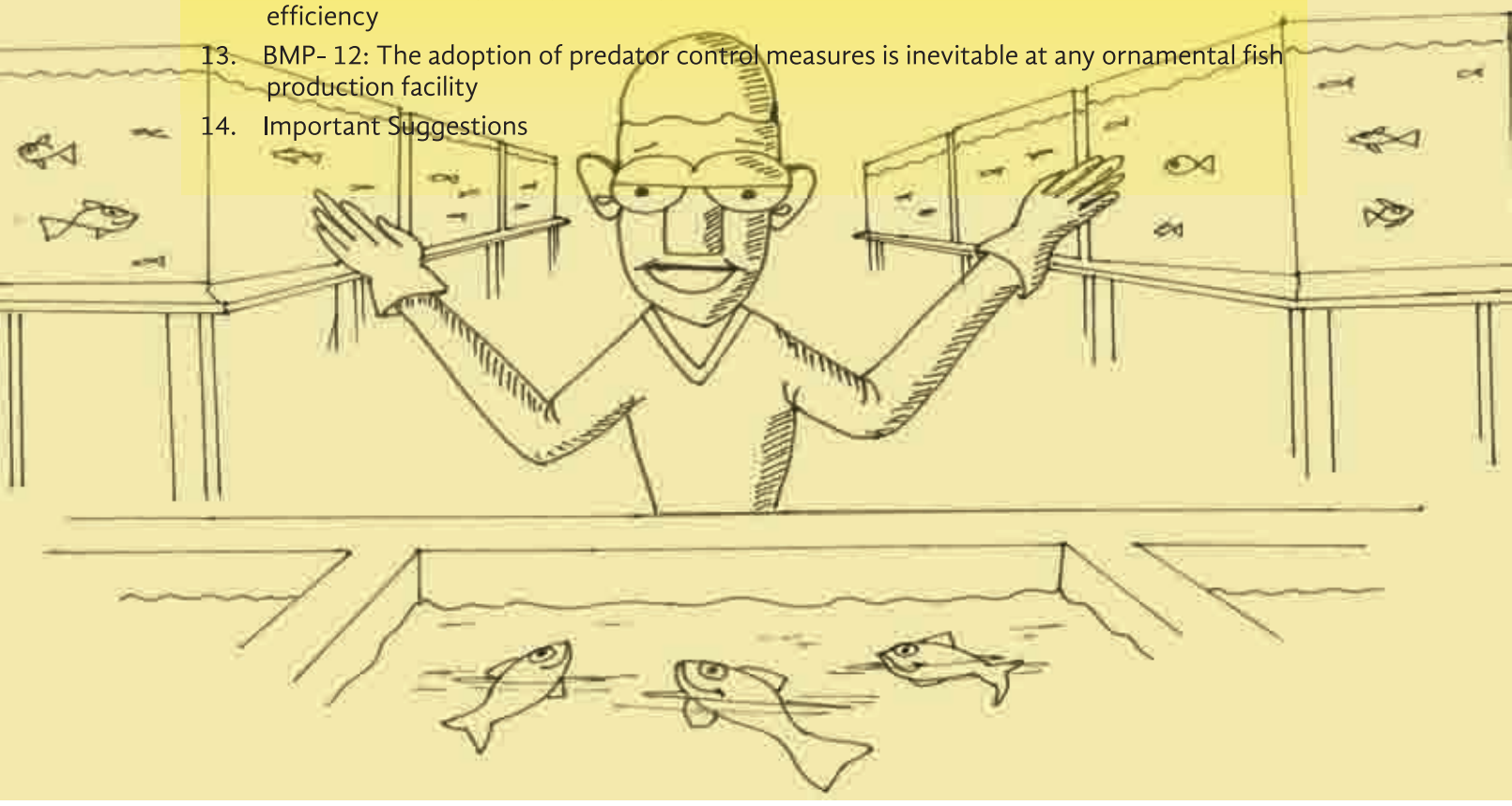
- Maintaining the water quality is vital in all aspects of ornamental fish production *viz*., hatchery production, nursery rearing and grow out.
- The total quantity of water required and availability of the same should be properly evaluated and ensured.
- Species selection should be based on the prevailing water quality conditions and can also be altered to some extent to suit the selected species.
- Most critical among the water quality parameter *viz*. temperature, dissolved oxygen, pH, hardness, ammonia, nitrite and carbon dioxide need to be taken care of to avoid any kind of stress and keep the system healthy.
- As a water quality parameters are inter-related, try to understand their interaction to have a balanced environment.
- The ammonia and nitrite formed in the production system have to be kept at zero levels for successful ornamental fish production. The use of simple biological filter to convert the toxic ammonia to harmless nitrate is recommended.
- The water should be dechlorinated before use if tap water of municipal supply is being used in a small set up.
- Effective aeration systems should be installed to maintain the dissolved oxygen content at optimum level.
- Apply appropriate management measures (chemical application) to correct the water quality of the production system.
- Install mechanical and biological filtration systems to control the unwanted debris material, suspended solids and toxic ammonia.
- The use of a re-circulation system is helpful in enhancing the water quality of the production system and leads to increase & sustainable production.
- Avoid overcrowding and overfeeding of fish to maintain water quality at optimum levels and to reduce fish stress and mortality.
- The water quality in an ornamental production system has to be monitored and assessed frequently with the help of reliable quality digital meters and test kits and proper record keeping has to be made.

Chapter 5

Hatchery and grow-out technologies for freshwater ornamental fish production

Shivakumar Magada, Joy Joseph, V.P. Saini and Atul Kumar Jain

Inside...



1. An Overview

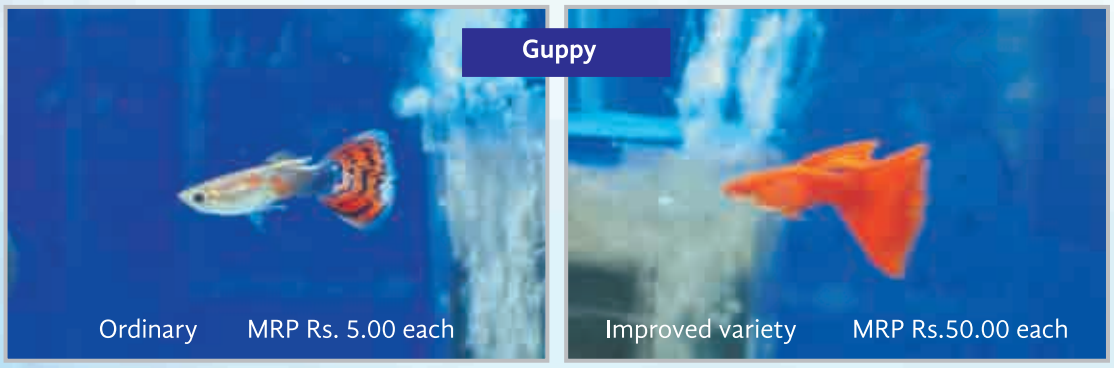
The freshwater ornamental fish production technology in the country was mainly limited to backyard production facilities about two decades back. Most of these units were working on low input principle with traditional know-how. It was only during last two decades that several large units were established which have adopted semi-intensive culture practices involving scientific management. The captivity-bred freshwater ornamental fish constitute about 90% of the total demand of ornamental fish in the domestic market and only 15% in the export trade. In terms of monetary value, it is only Rs.55 crore in domestic market and Rs.7.00 crore in export trade. It is estimated that there are about 5000 freshwater ornamental fish production units in the country mainly in the coastal states.

Non-availability of high quality brood stock limits development of ornamental fisheries in the country

It is realized that the total number of freshwater ornamental fish that is produced by all these 5000 units is very less and the production of quality fish is still limited. It is mainly because of the reason that large numbers of production units are still functioning based on traditional know-how and unaware of scientific management practices. Therefore, a set of "Best Management Practices" is suggested related to breeding and culture of freshwater ornamental fish so to improve both the quality and quantity.

2. BMP-1: The selection of a unique variety of fish for commercial production will increase product demand in the market

A unique product is more in demand than a common product and will also fetch a higher price. For example, a simple Guppy fish will be of less value than a value added colorful Guppy while the breeding process of both the fish remains same. Hence, a producer should try to produce a unique variety of fish.



Guiding Factor for BMP 1

2.1 Assessment of species demand

The breeders should know the status of the market in the region in which they are interested to start a breeding unit. One can only compete in terms of variety, price and number. Even if the price is high, variety which is of high demand will become a "**Unique Sellable Point**".

2.2 Assess the availability of brood stock

The availability of quality brood stock is of paramount importance. In case the quality brood stock is not available, it is advised to procure young ones and grow them for serving as future brood stock. Choose only the best looking fish for breeding purpose.

2.3 Know the breeding technique

It will be useful and helpful to acquire the knowledge of breeding of new species.

2.4 Fish with unique trait be selected

There are few fish among the same species with a different trait (e.g. finage, scale, colour pattern, body shape etc.). The fish with such characteristics will always be in high demand.

3. BMP-2: The development of quality brood stock is the key element for commercial success of the production Unit

There are no certified pure-line brood fish suppliers in the country. It will be advisable to procure sub-adult


A matured female of gold fish

fish from good farms or shops and rear them at the production farm. Only matured fish with good health, good finnage and other selective traits should be selected for multiplication. Later, one could develop their own brood stock bank.

Guiding Factor for BMP-2

3.1 Size and age of the fish

Each species matures at a different age. The selection of right age with required characteristics is essential. Depending on the fecundity and production targets, one can decide the number required. Live bearers mature within 45-60 days and egg layers take 240-300 days, except some specific species. However, the age of optimum fecundity and effective breeding age varies which should be known.

3.2 Selection of brooders

Selection of brood stock is a key issue for the success of the ornamental fish business. Jumpers (fastest growing fish among the stock) should not be selected for breeding. We may select aggressive trait by doing so instead of a selective trait. The performance of brooder will be better when the population size is reasonably large. Selection is based on, best colour, health, finnage and market demand.

3.3 Population size

Brooders must be selected from a relatively large number of populations so that expression of required trait will be better. It has been demonstrated that inbreeding which is cumulative and caused by using small numbers of parents in each generation results in negative effects on performance related traits. If a hatchery has reduced the level of variation in a stock by using low numbers of parents for several generations, its effect cannot be reversed. It is thus important that "Effective population size (Ne)" i.e. the number of brood stock contributing to the next generation is maximized by maintaining progeny at the hatchery from as many parents as possible with preferably equal number of males and females

3.4 Individual selection

All the seeds reared at farm will not have the similar traits or phenotype. Generally, there will be three phenotypes, some of the individuals will be better looking than their parents, the second type will be more or less similar to their parents and the third type may be inferior in looking as compared to their parents. It is always advisable to choose most superior ones and they should be maintained as future brooders. Thus, the selected brooders are bred in next breeding season and their progeny reared. Again, the process of superior selection is repeated during the next breeding cycle. This process will enhance desired trait from generation to generation.

3.5 Brood stock diet

The brood stock diets are different from regular diets. In order to get required quality and better fecundity, special brood stock diets must be used. It is most desirable to use live fish food for the brood stock. In case the live food is not available, then the high protein diets enriched with omega-3

fatty acids, coloring pigments, vitamins and minerals should be supplemented in brood fish diet (Please refer Chapter-6).

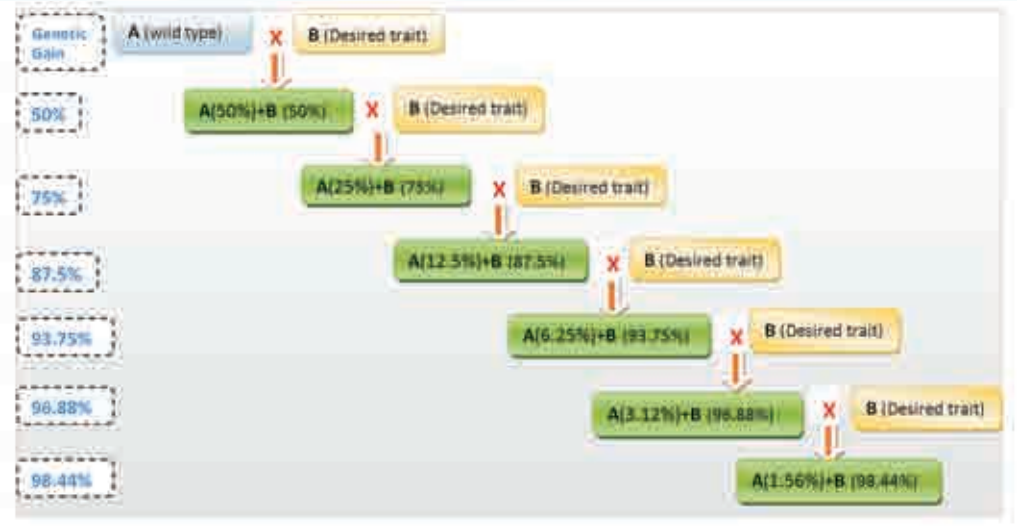


Fig.1. Breeding plan for the development of pure line brood stock

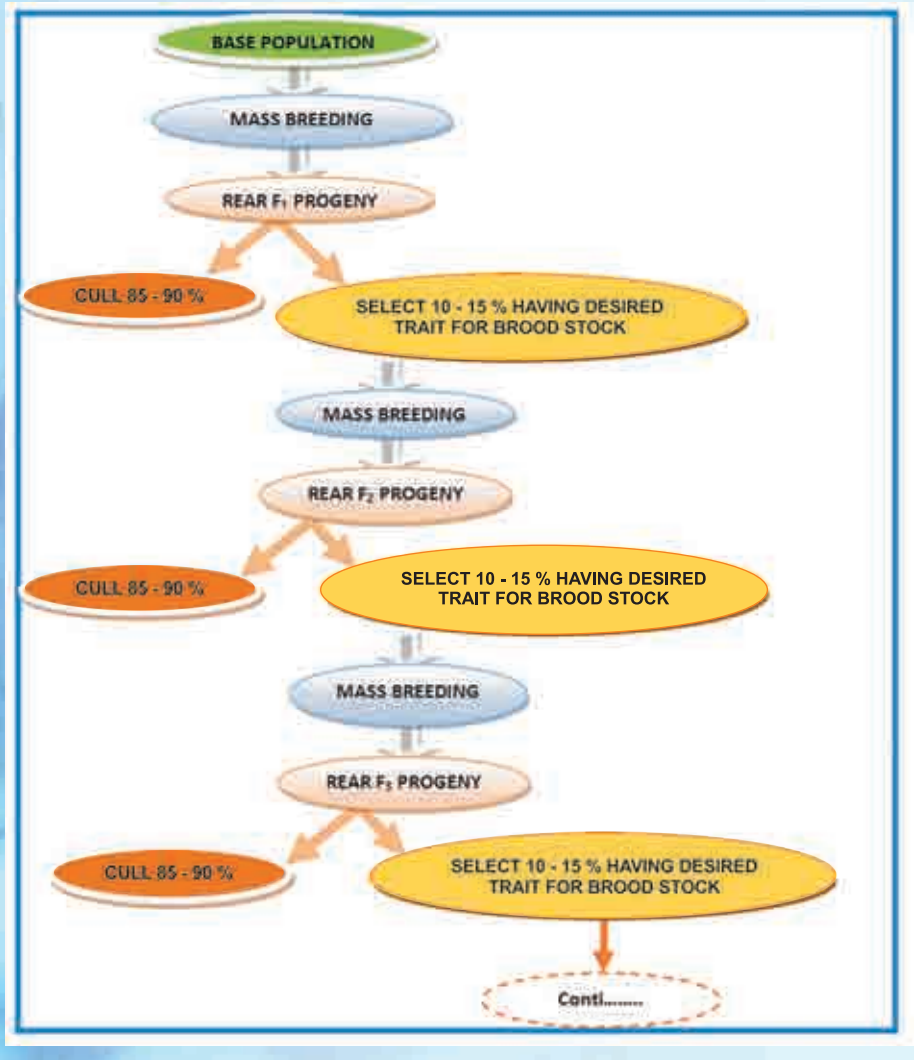


Fig.2. Breeding plan for the development of quality brood stock

3.6 Mixing of stocks

A brood stock procured from any exotic source should not be mixed with current brood stock available at the farm without proper performance evaluation. A proper planning is required before incorporating new stock into the hatchery. All the offsprings produced from these crosses should be sold and not retained for further propagation. Hybrids should never be kept as brood stock, unless it has any desired trait and specifically required.

3.7 Vigorous culling

Fish can be used for multiple breeding but it is advised to discard the old stock after effective breeding age which varies from species to species. A practice of vigorous culling, change of stock and maintaining of right population number will enhance the performance.

4. BMP-3: A proper production plan should be developed as per the availability of facilities

Setting up of production targets and developing a production plan help in smooth functioning of a production unit

An important consideration in ornamental fish production programme is the availability of adequate facilities mainly in terms of tanks, water supply, brood stock etc. The facilities required for keeping brood stock and rearing young fish are different. These also vary with the type of fish to be cultured and the culture technique to be adopted viz; extensive, semi-intensive or intensive. Therefore, a suitable production plan shall be developed considering the available facilities and production targets.

Guiding Factors for BMP- 3

4.1 Identify the production activity

Mainly three types of activities i.e. breeding or rearing or both are performed at any ornamental fish farm. An activity shall be selected depending on the requirement and available facilities.

Plan for Commercial Guppy Production
(Production Target: 1.0 lac/month)

a. Total area required: 500 sq.m.
b. One production cycle: 100 days
c. Requirement of Brood stock
   - Male: 2500 Nos.
   - Female: 10000 Nos.
d. Requirement of Tanks
   - Brood fish tank: 12 Nos. of 2000L each (Approximately @2 liter per fish)
   - Rearing tank: 16 Nos. of 2000L each (Approximately @1 liter per 8 fish)
e. Production (@ 25 larvae/female/month)
f. Fry (100 days old): 40% of 2.5 lacs larvae=1.0 lacs

4.2 Select a suitable species

All species of freshwater fish cannot be bred or reared in any type of water. Fish like angel, tetra, discuss etc. will not perform well in hard water. Therefore, the selection of fish species should be decided on the basis of water quality, weather conditions and demand of fish in the market.

4.3 Set production targets

It is advised to fix the monthly/yearly production targets. This will be helpful in deciding the production and marketing strategies.

4.4 Decide the requirement of inputs to achieve targets

Once the targets are set for a particular year, enlist all the requirements of input (i.e. breeding tanks, rearing tanks, number of brood stock, feed, chemicals, etc.).

4.5 Prepare production schedule

Prepare a production plan and activity schedule i.e. blueprint of day to day activities to be undertaken so to achieve the production targets.

5. BMP-4: The adoption of mass breeding technique & protection of young ones from the parents enhance the survival rate of the live bearers

Live-bearer (guppy, molly, platy and sword tail) is a group of fish in which fertilization and hatching of the eggs take place within the body of the female. The development of the embryos occurs within the female until live young ones are released from mothers' body. However, the parents may eat away their own young ones mainly just after spawning. Hence, separation of young ones plays an important role in the success of live- bearer production system.

A gravid live-bearer female lays 3-4 batches of young ones till next mating

Guiding Factor for BMP-4

5.1 Mass breeding

Mass breeding technique is generally considered best for livebearers.

5.2 Breed livebearers in a net enclosure

The brooders could be kept in an enclosure consisting of HDPE nets of a mesh size which will not allow exit of brooders. Perforated plastic baskets could also be used. Male and female in a ratio of 1:4 are kept inside the enclosure @ 12-15 fish/c.ft). The enclosure should be fixed inside cisterns or FRP tanks. As soon as young ones are released they will come out of the enclosure or baskets to free-living area from where they can be collected every day. Brooders are left in the enclosure till the breeding process continues.

A breeding set up for live bearers

Aquatic plants as hiding substratum for live bearers

5.3 Provide hiding substratum for young ones

In another process, either aquatic plants can be grown in the tank or some other synthetic substratum (strips of plastic sheets) could be released in the breeding tank which acts as a hiding place for young ones. The aquatic plants like *Valisneria*, *Hydrilla*, *Chara* etc. are some good substrata. The young ones once released hide themselves in the leaves of aquatic plants which can be collected the next day.

5.4 Do not allow thick growth of aquatic plants

The aquatic plants shall be allowed to cover only 10-15% of the tank area and the excess growth shall be removed. The excess biomass of plants may result in oxygen depletion during night hours, which may be harmful to both brooders as well as young ones.

6. BMP-5: It is essential to know the proper breeding behaviour of egg-laying fish in order to establish their breeding setup

All ornamental fish other than the live bearers are egg-laying fish but the breeding behavior of one group is much different from the other. Therefore, the requirements of breeding set-up, the substratum and operating protocols are also different.

Guiding factor for BMP-6

6.1 Understand breeding behavior

The egg-laying fishes could be grouped into three categories based on breeding behavior which are:

a. Eggs which could be adhesive or non-adhesive and left unguarded after breeding.

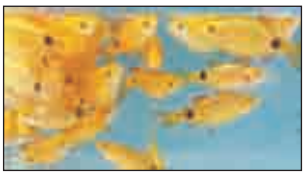
b. Eggs are guarded by one of the parents after breeding for few days.

c. Eggs are carried by one of the parents till they hatch out.

6.2 Select suitable substrate for your fish

It is advised to select a suitable type of substrate for the successful breeding of fish species you choose. In the absence of suitable substrate, fish will not respond to breed or the response will be very poor in term of spawning, fertilization and hatching. Therefore, the substrate for breeding should be selected very carefully.

A breeding set up of shining barb



Females

Males

Breeding enclosure

6.3 Substrate should be treated before use

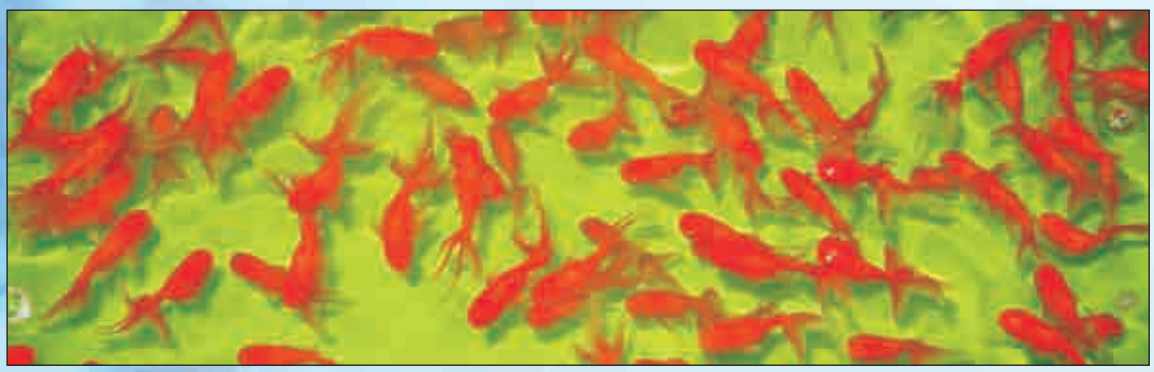
The eggs remain in contact with the substrate for a very long period. In case the substrate is contaminated, there are chances of spoilage of eggs. The adhesive eggs are infected by a fungus *Saprolegnia* sp., if substrate is not cleaned properly. Therefore, it should be properly cleaned using some disinfectant.

6.4 Substrate for adhesive egg scatterers

Gold fish and Koi are examples of this category. These fish need submerged aquatic weeds as substrate e.g. *Valisneria*, *Hydrilla*, etc. which could be replaced by plastic strips while breeding in captivity. The use of aquatic plants causes problem as it starts deteriorating and spoils water quality. However, the fish of barbs group require a different setup while they also lay adhesive eggs. A white ceramic plate arranged on the bottom below the perforated enclosure of a mating pair of barb will increase the survival of eggs.

Breeding of Gold Fish

- Mature males and females should be kept in different tanks a few days before breeding.
- Matured females and males in a ratio of 1: 2 are transferred to a breeding tank in the evening. This ratio could be 1:1.5 in case of mass breeding.
- Breeding tank is provided with a suitable substrate such as plastic strips to facilitate egg laying.
- Breeding tank is provided with a mild flow of water and aeration.
- Eggs are laid in the early morning. A change of temperature acts as a triggering factor for successful egg laying.
- The exhausted parents are removed from breeding tank after 1-2 hours of breeding, else they will start to eat their own eggs. Brood fish shall be given a bath in $KMnO_4$ solution before releasing back into holding tanks.
- Add a pinch of malachite green in breeding tank to avoid growth of fungus.
- The eggs will hatch in about 48 hour's time. The water temperature should be maintained at 25-28^{0}C for higher success of hatching.
- The hatchlings will become free swimming in 60-72 hours time and should be fed with infusoria.
- Exchange about 50% water is needed every day until larvae are shifted to bigger tanks for rearing.



6.5 Substrate for non-adhesive egg scatterers

Danios are important species of this group. The breeding tank can be furnished with a layer of glass marbles or marble size pebbles so that parents are not able to eat their eggs as eggs are sheltered in between the marbles. Both the parents shall be immediately removed after breeding.

6.5 Substrate for egg anchorers

The most important species of this group are Angels in which the selection and maintaining of a breeding pair is very important. A pair of male and female keeping themselves isolated from the entire group in a tank is considered the best breeding pair. A spawner will prefer vertically laid smooth surfaces to lay eggs under very dim light or dark conditions. The eggs are guarded by parents till the larvae are hatched out.

Mass breeding setup for angel fish



Mass Breeding of Angel

- Several numbers of perforated plastic baskets are placed in a cement tank.
- An established pair of Angel is released into each basket .
- A PVC pipe of 1" diameter and 10-12" length is placed slantingly in each basket.
- The act of cleaning of the PVC pipes by male parent is sign of pre-breeding preparation.
- The female will release eggs by next day early morning which will be simultaneously fertilized by male and get settled on PVC pipes.
- The eggs will hatch out in 3-4 days period during which parents will continuously fan the eggs. Thereafter, the parents could be removed.
- Hatchlings will become free swimming after 3-4 days and require exogenous feeding.

7. BMP-6: Selection of healthy brood fish and avoidance of aeration in breeding tanks of bubble nest builders will improve the breeding success

The males of fighter fish and gouramies build bubble nests in the tank where they are kept for breeding. The nest consists of a heap of froth on the surface of water by blowing bubbles which are covered with mucus secreted from the mouth of a male. The female will later deposit eggs in the nest.

Guiding factor for BMP-6

7.1 Avoid aeration in breeding tanks

There is no need of any aeration in the breeding tanks of bubble nest builders as aeration will disturb the formation of nest. The initial filling of good quality water is sufficient for breeding operations.

A Bubble nest

Golden Gouramy

Blue Gouramy

Breeding set up of bubble nest builders

7.2 Keep the matured males separately

The matured males of bubble nest builders shall be kept separately in small containers. It will be more dangerous to keep a female among two male as males will be more aggressive in the presence of a female.

7.3 Selection of healthy male for breeding

Only healthy males shall be selected for breeding. The size of bubble nest is an indication of a healthy male. The larger the size of bubble nest, the healthier the male is.

7.4 Size of bubble nest

The size of bubble nest is of great importance for breeding of bubble nest building fish. It could be managed by placing small pieces of some leaves on water surface which are trapped in the air bubble nest and also provide stability to nest.

7.5 Management of water quality

The water in the tanks of nest building fish should be mature but clean and preferably from the adult fish stock tank. Since aeration and filtration are not recommended in nest building fish breeding tank, ammonia removing resins or zeolite should be added.

8. BMP-7: The care and sourcing of right stage brooders for egg collection in case of mouth brooders increase the availability of viable eggs

The mouth brooders are a group of fish that lay eggs and brood them in their mouth till they hatch. Their fecundity is comparatively low. Keeping them in

isolation will require more space which could be a limiting factor for large scale breeding program. In order to reduce the space requirement, mass breeding program is practiced where all the matured males and females in a ratio of 1: 4 are kept in one community tank of manageable size. The fish are netted out from time to time and observed for presence of eggs in their mouth.

Guiding factor for BMP-7

8.1 Develop a community tank with breeding grounds

A community tank can be developed for commercial breeding of mouth brooders. The size of the community tank should be small so two people could perform netting operation. The bottom should be covered with a 3-4" layer of gravel and certain earthen pots are placed at several location which serve as breeding grounds.

A community tank

Setting up of breeding ground

8.2 Maintain standard ratio of male and female

The community tank shall be stocked in a ratio of 1 male to 4 females. The success of breeding is less in case of more numbers of males, as males are busy in fighting for territory establishment.

8.3 Sourcing of female

The community tank is to be checked at regular intervals for selection of females carrying eggs which is referred as sourcing. The selected females should be kept individually in separate tanks preferably a glass tank in indoor facility.

8.4 Sourcing should be stress-free

It should be ensured that eggs are not lost during the process of netting because of any stress to the fish. Therefore, netting operation should be smooth and fish should be handled gently while checking for the presence of eggs in their mouth.

8.5. Age of fish

The age of fish is also important while you select mating partners. It is better to go for younger fish that are in their prime rather than choosing older fish that have almost reached at the end of the reproductive age. Generally, the percentage of fertilization and hatching are better in younger groups. An exception from this rule can be if you have an older specimen with exceptional coloration, finnage or other qualities that you want to breed.

8.6 Do not remove eggs from brooding female

It is not advisable to remove premature hatchlings or larvae from the mouth of female fish until these are released at their own. A forceful release at a pre-mature stage will reduce the survival.

9. BMP-8:An appropriate incubation protocol will increase the hatching efficiency of fertilized eggs

Artificial incubation of fish eggs is a hatchery practice that will increase the economic efficiency of a commercial ornamental fish culture operation. Hatching rates and survival will be increased using artificial incubation. Developing embryos and newly-hatched larvae and fry are the most sensitive and delicate stages in the life cycle. Therefore, great care must be taken to provide them with the proper incubating and hatching environment. Water temperature, light, water quality, water flow, shock prevention, and type & size of the egg are very important considerations.

Guiding Factors for BMP-8

9.1 Eggs should be treated before incubation

Incubation of eggs is a critical point in getting the better hatching efficiency. Before the eggs are stocked into hatching jar, they should be washed for 10 minutes with methylene blue or treflan @ 0.025 ppm.

9.2 Maintain water flow

A gentle flow of water will improve the efficiency of hatching. However, the rate of water flow is to be decided considering the nature and quantity of eggs.

9.3 Aerate water in incubator

A mild aeration will be helpful in maintaining the level of dissolved oxygen in the incubation tank.

9.4 Maintain clean water in incubator

Water which is used in incubator shall be free from suspended particles or clay, else it will develop a non-permeable coating around the egg which will arrest the development of embryo.

10. BMP-9: Ensure availability of preferential live feed for the first exogenous feeding of larvae

The young ones of any fish will prefer to feed on live feed immediately after yolk absorption. It is the most critical period when majority of the young ones die due to absence of a preferred feed. It may result into mass mortality if the size or quality of the initial feed is not suitable for young fish.

Live feed: Daphnia

Guiding Factors for BMP-9

10.1. The first feed of larvae

Initially the larvae will feed on yolk sac until all the yolk sac is absorbed. Thereafter, the hungry fry will begin to look for other food. The young ones are not capable to feed on deposited or floating feeds. The microorganisms moving slowly and freely are the first choice of young ones.

Feeding of larvae on Daphnia

10.2 Size of live feed

It is the size of live feed which will determine the acceptability of feed by young ones. In most of the ornamental fish, the infusoria also termed as mother milk, is the most preferred first exogenous feed. Infusoria is the smallest type of live exogenous feed. As the mouth size of the growing fish will enlarge, live feeds of larger size viz; *brachionus*, Artemia nauplii, Moina etc. could be used.

10.3 Quantity of live feed

It should be ensured that sufficient quantity of live feed is available in the rearing system. A young one needs to put least effort to search feed. An increased effort will result in utilization of more energy in search of food leaving less energy for growth.

10.4 Green water culture

Spirulina culture tank

Green water culture technology is also very useful for rearing of early stages of ornamental fish larvae. In this type of production system, specific varieties of phytoplankton (*Chlorella, Spirulina* etc.) are cultured in a nutrient-rich culture media and the same is used for feeding of fish larvae. Daphnia is later used as live feed.

10.5 Support development of periphyton in rearing tanks

Periphyton is a group of micro-organisms which serves as feed for young larvae. The development of periphyton can be supported in the rearing tanks through introduction of various types of artificial substrates (e.g. plastic strips) and aquatic plants. The root zone of aquatic plants are a good feeding zone for larvae. The weeds are also helpful in maintaining the water quality through directing the nutrients in growth of aquatic plants.

10.6 Use of freeze dried feeds

In case when live feed is not available, the freeze-dried or refrigerated live food organisms can also be used. However, heavy aeration should be provided in rearing tanks. This will keep all preserved live food organisms in rotating condition and the fish will be easily attracted towards the preserved feed because it will look like a live feed organism.

10.7 Feeding schedule & frequency

The fry usually grow faster after they start feeding on exogenous feeds. Feeding should be done 3-4 times in a day for optimal growth and survival. A fixed feeding scedule also helps the fish to grow faster.

11. BMP-10 : The production of all-male population in a few varieties of fish will enhance profitability

There are several varieteis of fish in which males are more colourful and attractive and fetch more price e.g. Guppy, Fighter, Sword tail etc. Hence, isolation of males from the population and production of all-male population will add value to the product.

Guiding factors for BMP-10

11.1 Isolate males from the rearing tank at young stage

A fish producer is aware of the price difference of males and females in case of guppy,sword tail and fighter. In general practice, both the sexes are reared in the same tank and isolated only few days before marketing. As a result of this, the growth of males is less because a part of energy is spent in chasing the females. A segregation of males and females at an early stage will result in fast growth of males.

11.2 Use of hormonal diets

The use of 17-α-Methyl Testosterone (a male steroid) is well established in production of all-male population of ornamental fish. The hormone is incorporated in the feed @50-70 mg/Kg of feed and fed to the young ones for a period of about 30 days from the day larvae starts feeding on exogenous feed. The required quantity of hormone is mixed in absolute alcohol and added to the cooked feed after cooling.

11.3 Genetic manipulation

The single sex populations could be produced by inactivating the genetic material of female or male before fertilization. However, these are very advanced techniques that require expertise as well as a sophisticated laboratory which may not be practicable and beyond the scope of this publication.

12. BMP-11: The size grading of young ones will increase the survival rate and production efficiency

The size variation is a major cause of cannibalism and other agonistic behaviour among ornamental fish larvae specifically African cichlids. The primary causes of size variation other than genetic differences between siblings are food availability, feeding frequency, lack of food items of the right size & type and low feeding levels. Therefore, there is need of routinely size-grading in order to overcome the problems associated with high size variation. The size grading of fish has advantages in that small fish grows better when their larger siblings are removed due to reduction of competition and social hierarchy. It is best to maintain fish of similar size in the culture tanks to improve the utilization of food. Size-grading at an early age result in better growth.

Guiding Factors for BMP-11

12.1 Grading should be stress-free

Handle fish with care when collecting for grading. Improper handling of fish is one of the most serious and common stressors that result in poor survival, growth and disease occurrence. The grading process should be as quick as possible and the graded fish should be stocked back after prophylactic treatment.

12.2 Size grading of fish using a grader

In large sized production units, fish are usually graded by size using a bar

grader. Bar graders are made with incremental widths between the bars. The preferred type is manufactured with interchangeable baskets that fit into a floating frame. Fish are netted from the holding tanks and placed into the floating grader box. The smaller fish will swim through the grader bars while the larger ones are retained in the box. By changing grader widths, fish of any size can be easily sorted by increments as small as a quarter inch in body length.

12.3 Hand sorting

It would not be feasible to maintain commercial size grader for a small sized production unit. A simple round mesh netting material can be used for the purpose of size grading.

13. BMP-12: The adoption of predatory control measures is inevitable at any ornamental fish production facility

Predators are part of any farming system and link in natural food chain of the nature. Predation may cause heavy economic losses to ornamental fish husbandry practices. The common predators in a pond are heron, cormorant, frog, snake, king fisher and aquatic insects. The problem of predator is less in indoor facilities of ornamental fish production unit, but most of the nursery and breeding tanks are located outdoor and are subjected to heavy predation. The predatory loss could be minimized by better management practices.

Guiding Factors for BMP-12

13.1 Control of aquatic insects

There are many varieties of aquatic insects mainly beetles, bugs and water scorpions that are very harmful to young larvae of ornamental fish when reared in earthen ponds or large sized cement tanks. Hence, it will be advisable to eradicate all aquatic insects before stocking of young larvae in ponds. Aquatic insects can be eradicated by application of a diesel and soap emulsion (5.6 ml : 1.8 g per 1 sq.m) or deltamethrin (a synthetic pyrethroid) @ 0.05 ml/1000 liters of water.

13.2 Control of avian predators

Avian predators are a very serious problem specifically in case of bright colored ornamental fish that are visible from the top. It has been observed that a Kingfisher is so clever that it will get entry in the production facility from a small hole of the net and exit from the same hole after catching a fish. Avian predators can be best controlled by covering the entire farm premises by a bird net. The initial cost of the bird controlling net may be high but it is a very essential investment.

13.3 Control of snakes and frogs

Aquatic snakes and frogs are also one of major causes of loss in outdoor culture system. The tadpoles feed upon young ones of fish whereas a snake

can eat even large size fish very voraciously. The entry of snakes and frogs can be controlled by encircling fine mesh netting or any other barricade around the ponds.

Controlling the entry of snakes by erecting asbestos sheets around the ponds

13.4 Keep the premises clean

The population of frogs and snakes can be controlled by keeping premises clean and clear. Do not allow bushes to grow around the ponds. Water channels should also be kept neat. Screen the ponds as recommended. Screens within the water channels also help reduce frogs' access to the ponds. Frogs tend to come into pond areas via the water channels. Do not leave any dead animals and feed, etc. lying around ponds because birds may come to feed upon them. Dispose of all rubbish and carcasses by burying them away from the pond area. Feed containers should be secured and kept out of reach of predators.

13.5 Provide hiding places

Predators cannot eat fish if they can hide under shelters. Make sure to provide plenty of floating vegetation (i.e. Azolla,Lemna or Eichhornea, etc.) in pond for fish to hide under, and structure to dive below. The weeds should not cover more than 20% of the water spread area. Sections of wide diameter black PVC tubing can be placed inconspicuously on the bottom of pond. These have the added advantage of providing good habitat for fish.

14. Important suggestions

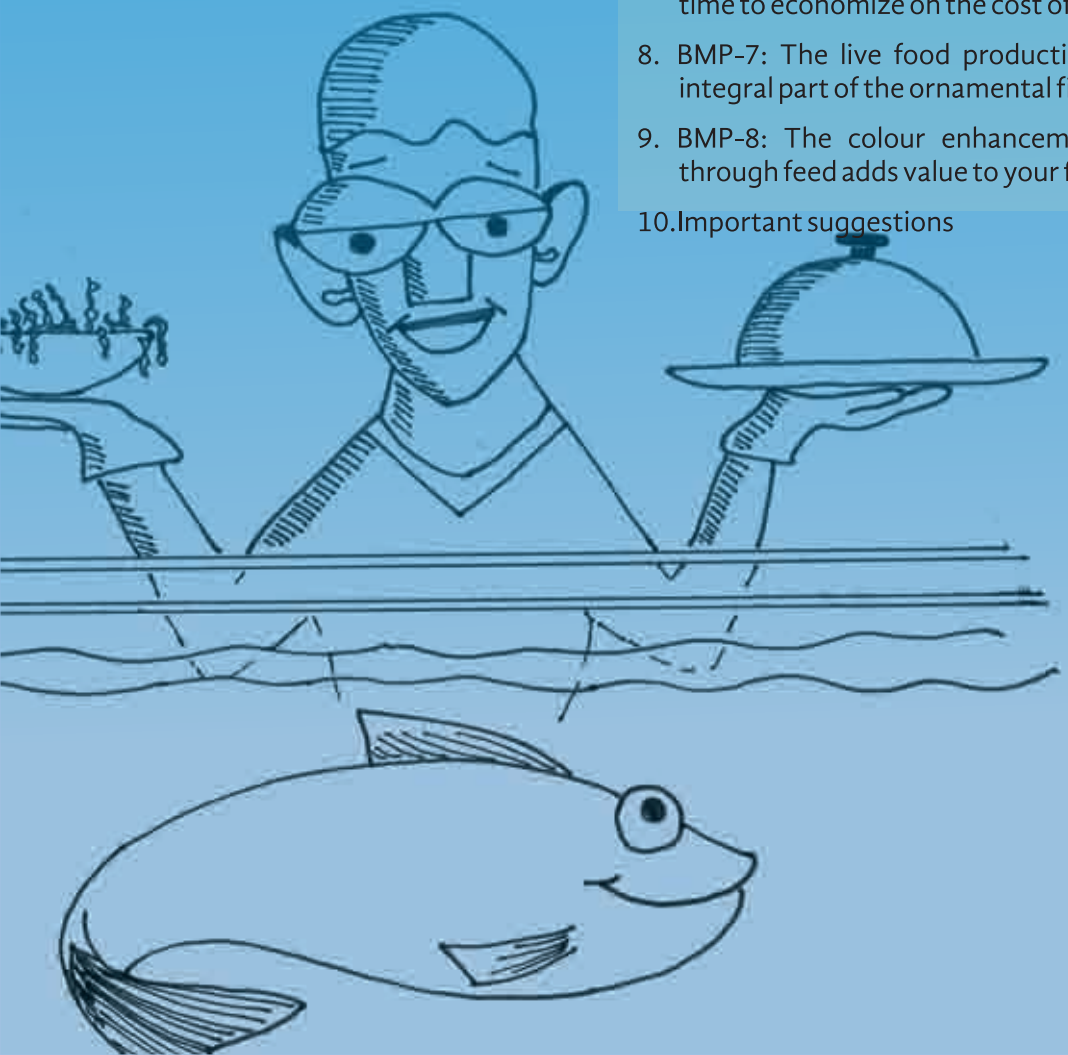
- A species which is in high demand in the market should only be selected for multiplication.
- The brood stock with desired traits (colour, scale pattern, finnage etc.) should be developed through simple individual selection technique.
- A diet enriched with omega-3-fatty acids, vitamins and minerals enhance maturation of fish.
- It will be helpful to develop a detailed monthly/yearly production plan and activity schedule keeping in view of available farm facilities. It will be also useful in proper utilization of resources.
- Growing of aquatic plants is highly useful to protect the young ones of live bearers from predation by the parents.
- The breeding behavior of egg laying groups of fish is highly variable from each other and so is the requirement of substratum and breeding set up. This needs to be properly understood.
- The aeration in the breeding tanks of nest building fish should be avoided as it will disturb the formation of nest.
- The mouth brooding fish should be sourced out at right stage from community tank for good collection of viable eggs.
- An appropriate incubation protocol (i.e. treatment of eggs, continuous flow of well aerated water, etc.) should be followed for successful hatching of eggs.
- The availability of preferential live feed shall be ensured to maximize the survival rate and growth of young ones.
- The entry of any predator should be checked in ornamental fish production systems.
- The young ones should be size-graded from time to time. It helps to maintain fish of similar size in the culture tanks and to improve the utilization of food.

Chapter 6

Feeds and feeding management for freshwater ornamental fish production

Vaneet Inder Kaur and K.N. Mohanta

Inside...



1. An Overview

The objective of feeding fish is to fulfil its nutritional requirements for optimum growth rate and health so as to maximize profit. In natural waters, fish has access to a variety of natural food items, but their overall well being depends upon the availability of their favourite food. However, in a confined system, nutritionally balanced supplementary feeding is indispensable, due to limited availability of natural or live food. In general, ornamental fish are fed with variety of commercial pelleted feeds which are available in the market and commonly imported from Singapore, Hong Kong, Korea, Thailand and many other countries. Although, they are popular with ornamental fish hobbyists, the high cost of these feeds restrict their commercial scale application at farmers' level. Further, as compared to feeding of food fish in a pond, feeding ornamental fish in smaller culture units requires more precision. Therefore, an ornamental fish producer must possess technical know-how regarding nutritional requirements, feeding behaviour and feeding habits of different species in order to formulate farm made feeds using locally available cost-effective quality ingredients.

Feed plays a vital role in enhancing the market value of ornamental fish

In case of ornamental fish sector, despite the ever-increasing economic importance of the venture, the scientific feed and feeding management practices are not followed. Most of the available information with reference to fish nutrition pertains to food of finfish and shellfish species. Further, ornamental fish is traditionally fed with conventional diet and live food (available in nature), which may not fulfil the nutritional requirement of fish. Moreover, quantity and quality of the feed/food given may not be as per the requirement. Fish feed management includes choosing the right feed, using a correct feeding method and optimizing the feeds and feeding cost, so as to make the venture profitable.In view of this background, a set of "BMPs" are being suggested related to feeds and feeding management for freshwater ornamental fish production.

2. BMP-1: Understanding the nutritional requirement of ornamental fish species is the first step of success

It is very much essential to understand the nutritional requirements of an ornamental fish, which is to be cultured. The requirement of proteins, lipids, carbohydrates, vitamins, minerals, etc. is different for various species of ornamental fish in order to achieve optimum growth, reproductive performance and health maintenance. Protein provides necessary material to build up muscle cells and tissues; fats and carbohydrates provide energy, whereas vitamins and minerals regulate the fish health, besides building up and strengthening the skeleton system. In addition, pigments (carotenoids) and probiotics are also added to ornamental fish diet for colour enhancement and disease resistance respectively.

Guiding factors for BMP-1

2.1 Find out the food and feeding habit/habitat of the fish to be cultured

Before fulfilling the nutritional requirements of different ornamental fish species, prior knowledge regarding food and feeding habits need to be collected. An herbivorous fish (plant source) will differ from carnivorous fish (animal source) in terms of its favourite food . Likewise, the food of the fish feeding at the surface will be different from the fish living at the bottom. For example, protein requirements for different ornamental fish species vary with respect to feeding behaviour and they can be supplied through varied sources as described below:

a. Herbivorous and omnivorous juveniles/grower and brood stock: 30-40 % (soybean meal, mustard meal, groundnut meal, wheat / maize gluten)

b. Carnivorous (e.g. cichlids): Above 45 % (Fish meal, squid meal, shrimp meal, clam meat)

c. Larval stages (most of the species): Above 50 % (natural/live food)

d. Maintenance feeds: 25-30 % (mixture of plant and animal-based feed ingredients)

2.2 Select a feed which suits to feeding habit of the fish

Get familiarize with the food & feeding habits and habitat/niche of fish for maximum feed consumption and minimum wastage. e.g.;

a. Surface feeders: Dry mash/meal

b. Column feeders: Mixture of dry/moist feed

c. Bottom feeders: Moist / wet / paste feed

2.3 Collect information on the nutritional requirements of ornamental fish

The nutritional requirement of ornamental fish varies with fish species, size, growth stages and feeding habits. It can be fulfilled by using different feed ingredients. In general, ornamental fish require 30-45 % protein, 4-9 % lipids and 30-50 % of carbohydrates in their regular diet but it varies with respect to development stage as given in Table-1.

Table-1 Percentage nutrient requirement of a fish at different stages

Nutrient	Young	Brood stock*	Sources
Proteins	40-45	30-40	Fish meal, squid meal, shrimp meal, clam meat, soybean meal, mustard meal, groundnut meal, wheat / maize gluten
Lipids	4-6	6-8	Fish oil, vegetable oil (sunflower, linseed, etc.)
Carbohydrates	40-45	40-45	Corn flour, rice bran, wheat bran
Vitamin-mineral	1-2	1-2	Synthetic forms

**Live food should also be provided to the brood stock(both egg layers & live-bearers) for better gonadal development*

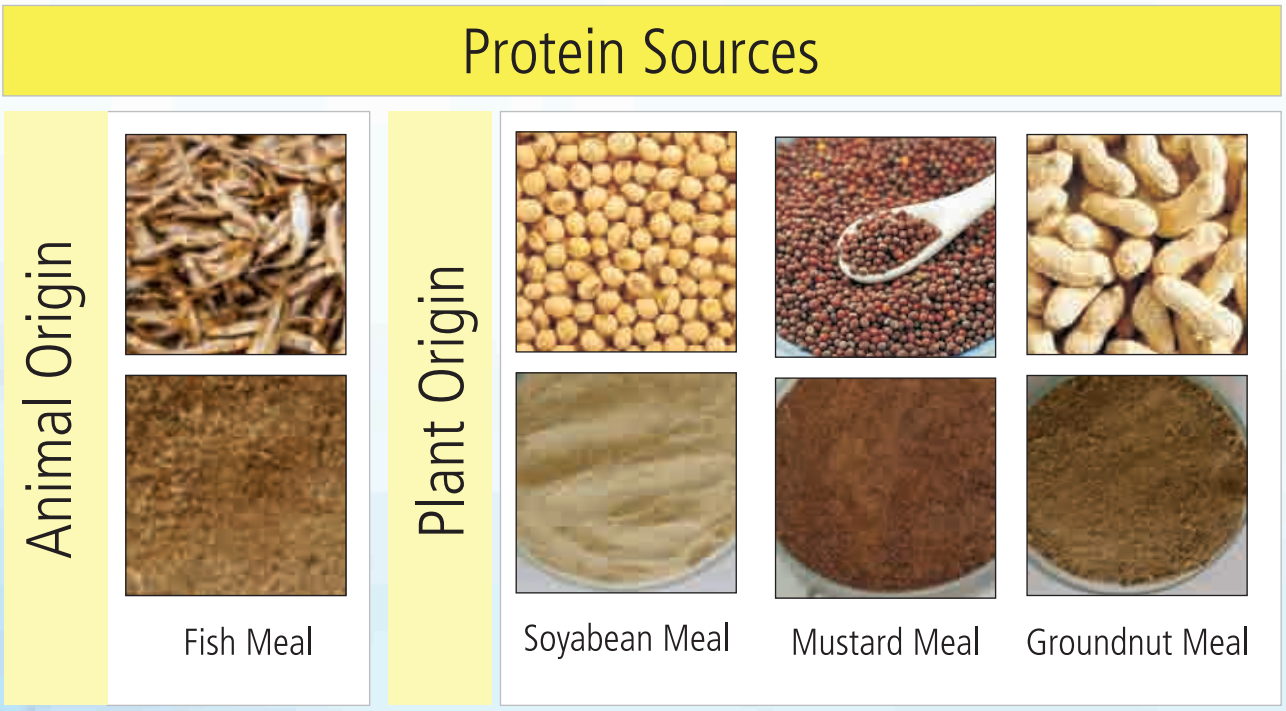
In addition to major nutrients, binding agents (starch, agar, gelatine, etc.) and preservatives (antimicrobials and antioxidants) can also be added to improve the quality and shelf life of feed. Although, commercially available feeds for ornamental fish are fortified with carotenoids, in case of farm made feeds, carotenoid supplementation is essential for enhancing colour in ornamental fish, especially when reared under indoor conditions.

2.4 Selection of right fish feed ingredients for feed formulation

It is very important to identify locally available suitable feed ingredients which are capable of fulfilling the nutritional requirements of species of interest with respect to nutritive value, digestibility and nutrient availability. In addition to availability of quality feed ingredients, cost is another important factor which needs to be taken care while feed is formulated.

Energy Sources

Rice Bran Corn Flour Wheat Flour



a. Use rice bran, corn flour, wheat flour as energy source and binding agent

b. Include animal protein sources (fish meal, squid meal, shrimp meal, etc.) to fulfill the protein requirement of carnivorous fish species and

c. Use plant protein sources (soybean meal, mustard meal, ground nut meal, etc.) for herbivorous and omnivorous species.

3 BMP-2: Choose the right type of commercial formulated feed available in the market

It is not possible for every farmer to prepare the feed at the farm. Hence, a readymade feed can be purchased from the market. Procurement of commercially available readymade feed should be based on quality and cost.

Guiding factors for BMP-2

3.1 Read out the information regarding nutrient content of the formulated feed

It will be useful to verify nutrient composition in terms of protein, fats and carbohydrates along with some additives like carotenoids and probiotics before purchasing any particular formulated fish feed from market.

3.2 Feed ingredient used for formulation of feed

It is also very much essential to know the type of ingredient used for feed formulation. A feed prepared by using animal protein sources will be useful for carnivorous species, whereas feed prepared using ingredients of plant origin will be more useful for herbivorous and omnivorous species.

3.3 Select feed having appropriate size and water stability

Do check the size of feed (granular/pellet/flake) for its suitability to different stages (fry/fingerling/grow-out) of fish. As the mouth size of fish varies according to stage, feed size is to be finalized accordingly. A Feed (floating or sinking) selected for ornamental fish should stay intact in water for 10-15 minutes so that fish can consume it with least wastage.

3.4 Use freeze-dried natural feeds

The natural food such as *Chrironomid* larvae (red worm), *Tubifex* (sludge worm), decapsulated *Artemia* cysts are also available in freeze dried / refrigerated form for long term preservation and can be used in place of live feeds.

4 BMP-3: Formulating a cost-effective and nutritionally balanced feed using locally available ingredients is a key to success

To reduce the cost of feed input and make the ornamental fish production

Freeze dried Chironomid larvae

Freeze dried *Tubifex* worms

A Sword tail feeding on freeze dried *Tubifex* worms

venture more profitable, the feed can be prepared at farm by using cost-effective, locally available quality ingredients (plant/animal based).

Guiding factors for BMP-3

4.1 Identify and select the feed ingredients according to the fish species to be cultured

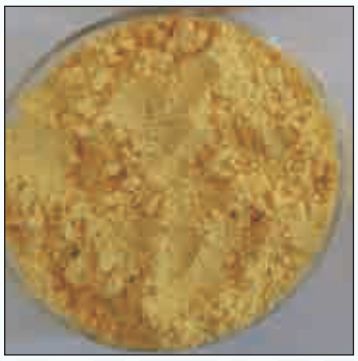
A number of feed ingredients may be available locally to be used for feed formulation. Fish culturist has to identify and choose the best ingredient depending on its easy availability, nutrient status and cost along with nutrient requirement of ornamental fish (size, feeding habits, etc.) to be cultured.

4.2 Formulation of different types of feeds

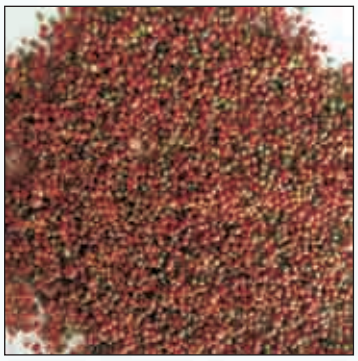
The formulated feeds used for ornamental fish are mainly of two types depending on the moisture content i.e. dry feeds and non-dry (moist/wet) feeds

a. **Dry Feeds:** These are made from dry ingredients with the moisture content between 6-10 %.The different forms of dry feed are:

- **Mash meal:** A simple mixture of dry ingredients that can be used for small sized fish (larvae /fry).
- **Pellets:** The dry feed which is compacted into a defined shape by mechanical means is termed as pellets. A hand operated or electric pellet making machine can be used at small farms, whereas large farms can set up a feed mill.



Mash meal



Pellets

b. **Non-dry Feeds:** These are of two types.

- **Moist Feeds:** These are either mixtures wet and dry ingredients or only dry ingredients with added moisture. The moisture content of moist feeds varies between 18 to 40 %.
- **Wet or paste Feeds:** The wet feeds are made from wet feed ingredients and fed through mesh net or sieved platform. It generally includes trash fish, shrimps, beef heart etc. or live food with 45-70 % moisture. The wet feeds are mainly used for feeding the young ones, carnivorous species and brooders.

Formulate quality feed to fulfill the nutritional requirements of different species according to feeding behaviour, habit and habitat

Hand Pelletizer

Electric operated Pelletizer

Feed mill for preparing pelleted feed in bulk

4.3 Formulate feed according to the growth stage & size of fish

a. **Larvae/fry:** Mash or meal, wet / paste feed / live food

b. **Fingerlings/ grown up/brooders:** Pellet feed / live food

4.4 Select the ingredients and formulate feed with respect to feeding habits of fish

a. **Herbivorous & omnivorous:** Dry/moist (plant based ingredients / live food)

b. **Carnivorous** – Dry feed (animal based ingredient like fish meal) /moist (trash fish, shrimps, beef heart) / live food (tubifex, earthworms, insect larvae, blood worms, etc.).

5. BMP-4: A proper storage facility should be developed for feed storage to prevent spoilage and maintain the keeping quality

A proper storage is very essential to maintain the nutritional quality of feed. The storage facilities of dry and wet feeds are different. A feed has to be stored properly under hygienic conditions to avoid any kind of infestation and spoilage.

Guiding factors for BMP-4

5.1 Storage of dry feeds

The dry feeds are less vulnerable to spoilage due to low moisture content (about 10%), hence are easy to store at room temperature in a moisture free environment for a longer period of time.

5.2 Storage of moist feeds

The moist feeds are highly vulnerable to fungal, bacterial and parasitic infestation due to their high moisture content if not stored properly at low temperature. A fungus infested rotten wet feed with high bacterial load may cause diseases and even fish mortality. Therefore, the wet feeds need to be used fresh or be consumed within the shortest possible time after preparation to prevent spoilage. The moist feed can be stored under refrigeration for a short period. The advantages and disadvantages of different type of feed with storage characteristics are described in Table 2.

Table-2: A summary of advantage and disadvantages of different types of feed with storage characteristics

Particulars	Dry mash/meal	Pelleted Feed	Moist feed	Wet feed
Storage	Store them for 2-3 month in ventilated moisture-free environment		Can be stored at low temperature (-20^{0}C), for one week, but it is better to use in fresh condition	
Hygiene	Low moisture content helpful in preventing microbial growth, if stored properly		Refrigeration is essential due to high moisture content, chances of fungus, bacterial and parasitic infestation are high, if not stored properly	
Nutritional value	Can sometime be less rewarding	Highly nutritious due to right combination of the ingredients	Vulnerable to nutritional degradation	
Environment impact	Remain suspended in water, More wastage and Causes pollution	Minimum loss, if used at right size and density	Variation in size can lead to wastage and pollution	

6. BMP-5: Select a right type of feed dispensing method to minimize wastage and to prevent deterioration of water quality

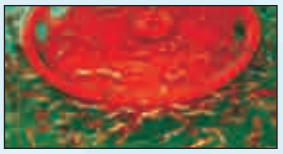
Feeding method should ensure sufficient quantity of feed to the whole stock. Hand/tray feeding can serve all the fish in small sized ponds/tanks/cisterns/pits. However, an automatic or demand feeder is efficient alternative to feed the fish more effectively, without much wastage in large sized culture systems.

Guiding factors for BMP-5

6.1 Hand feeding

A required quantity of feed should be dispensed at a fixed place and fixed time, preferably by the same person every day. In this type of practice, quantity of feed provided to fish should be pre-decided to avoid wastage due to over feeding. Do not feed too quickly or too much to prevent feed wastage and pollution.

6.2 Tray feeding



Provide feed (dry/dough/non-dry) in meshed / plastic trays placed at different places in the culture ponds/tanks. Tray feeding will also give correct information regarding the feed quantity consumed/left by the fish to adjust it in a more precise way.

6.3 Automatic demand feeders

The automatic demand feeders are used to dispense calculated amount of feed depending upon the fish stock in the pond. The fish can take the feed according to the need. The Automatic demand feeders are effective time-saving devices to dispense pelleted feeds.

7. BMP-6: Adopt appropriate feeding rate, frequency and time to economize on the cost of feeding

The feed residues suspended in the column and deposited at the pond bottom can cause pollution, resulting in increased risk of high organic load, high BOD and reduced dissolved oxygen, resulting in poor growth and increased mortality rate. In order to avoid over-feeding or under-feeding of fish, it is very important to work out the correct feeding rate at appropriate time of the day. Feeding rate, time and frequency depend on the stage as well as the body weight of the fish. Further, acceptance and utilization of feed also depends upon the optimum environmental conditions like temperature, DO, etc., because metabolic activities of fish are directly related with these.

Guiding factors for BMP 6

7.1 Estimate correct biomass of fish stock for calculating right amount of feed

It is very important to keep track of total numbers, average size and weight of fish in the tank. The amount of feed required per ration is given in Table-3 which can be calculated as follows:

Total Amount of Feed = Average fish size (body weight) x Feed rate (%) x Total number of fish in the pond/100

Table-3: Estimated amount of feed for different developmental stages

Period	Total Biomass (1000 nos.)	Feeding rate*	Amount of feed
1st to 4th Week 1st month)	1.5 g	4-6 times of the fish body weight (BW). It is best to give frequent feeds in small quantities during initial days	6.0 – 9.0 g daily
Fry	100 g	5-10 % BW	5 -10g daily
Fingerling	1000 g	3-5 % BW	30 – 50 g daily
Grow out	10000 g	2-3 % BW	200 – 300 g daily

* Co-feeding with natural / live food is essential for better growth and development

7.2 Avoid both over-feeding and under-feeding

Fish culture tank is not a dumping pit. Avoid over-feeding

The use of supplementary feed is very essential to obtain high production and good returns. But, it increases the cost of production so it should be used judiciously. The over-feeding increases the cost of inputs and also deteriorates the water quality. It is very commonly stated that a fish may not die due to under feeding but it will die to over feeding. However, under-feeding is also not advisable as it leads to poor growth of fish.

7.3 Know food conversion efficiency of your feed

It is important to know how much of the feed given by you is being converted into fish biomass. It is represented in the form of feed conversion ratio (FCR). Calculate the correct FCR with the following formulae. It gives information regarding the total feed consumption and its output in the form of biomass

FCR = Total feed given (kg)/Total fish biomass (kg) produced

7.4 Select correct time for feeding

Fish will not ask for food.... you should know when and how many times fish have to be fed

Feed intake and digestion capacity of fish depends upon various environmental factors like temperature, pH, DO, etc. Factors like very high/low temperature or DO < 5.0 mg/L affect the fish metabolism directly. Hence, it is important to provide feed at the time when fish can consume it and stay stress-free during the digestion process. Start feeding fish after sunrise at a fixed time daily and never feed during late evening or night.

7.5 Select correct feeding frequency

Fish grows fast during the initial days and there is a need to feed fish at frequent intervals to support their metabolic activity and overall growth. A generalized feeding frequency is presented in Table 4.However, the feeding frequency may also be reduced or increased depending upon various factors including growth rate, water quality parameters, environmental conditions, etc.

Table-4: Frequency of feeding ornamental fish

Fish age	Frequency	Remarks
1st to 4th week	3-4 times a day	Alternate feeding with dry / live food for optimum fish growth / colour enhancement
Up to 3 months	Thrice a day	
After 4 months (for grow out & brooders)	Twice a day	

8. BMP-7: The live food production facility should be an integral part of the ornamental fish production unit

Live feeds are considered as "living nutritious capsule" as they contain all the essential nutrients (proteins, carbohydrates and fats) including micro-nutrients (vitamins and minerals). The use of live feeds enhances the survival, growth and breeding efficiency of the fish, besides providing pigments for colour development. Live feed is available in abundance in many types of water bodies but it is very difficult to collect. Secondly, the quality of food available in natural conditions is uncertain and it could also be a potential source of disease transmission. Therefore, live food culture unit needs to be incorporated as an integral part of the ornamental fish production unit.

Guiding factors for BMP-7

8.1 Select right type of live feed as per requirement of fish

There are many types of live feeds viz; infusoria (protozoan), copepods, cladocerans, rotifers, *Artemia* nauplii etc. and other organisms like *Tubifex,*

Table-5: Size of live feed organisms and stages of preference

Name of Microorganisms/ live food*	Size	Stage of Uses	Important Characteristics	Useful for the fish (stage)
Infusoria	50-300 µm (0.05 – 0.3 mm)	I st instar stage (freshly hatched)	Tiny and unicellular; Ideal for larvae starter food	Larvae
Zooplankton	200-3000 µm (0.2 – 3.0 mm)	Larval stage	Rich protein (60-65 %) source for life stages early	Larvae/Fry
Artemia nauplii	400-500 µm	Larval stage	Filter feeders, can be fortified with PUFA, vitamin C etc. for 6-8 hours after hatching and provided to fish larvae & fry in enriched form	Larvae/Fry
Beer Worms/ Vinegar Eels	Up to 1.2 mm	Larval stage	Highly digestible and very good food for fry after infusoria and rotifer feeding	Fry/Fingerlings
Chironomid larvae (Bloodworm)	10-20 mm	Larval stage	Rich source of iron and pigments (contain haemoglobin)	Fry/Fingerlings/ Adult
Tubifex (sludge worm)	Up to 20 mm long	Fry	-do-	
Earthworms	Size varies according to species	Adult (chopped form)	Rich protein (60-65 %) and fats (9-10 %) source for grow outs and broodstock	Adult/Brood stock

Chironomid larvae, earthworm, etc. Different fish prefer different types of live feed at various stages according to the size of the organism as well the mouth size of the fish (Table-5). So, it is necessary to decide the type of live feed to be cultured.

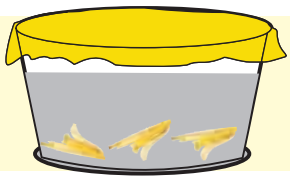
8.2 Culture set up for live food

Small-scale units (cemented tanks/pits for indoor/outdoor culture) need to be set up for regular and clean supply of natural food for the ornamental fish. The type of the natural food to be added into the feeding schedule varies depending upon the mouth size of fish and its nutritional requirements. For example, for larvae (just after yolk sac absorption) of most of the ornamental fish species need to be fed on infusoria (protozoan) and thereafter can be shifted to zooplanktons like rotifers, copepeods and caldocerans. Brooders of egg layer ornamental fishes should be given blood worms/earthworms for proper gonadal development and higher fecundity. Some of the natural food categories are very easy to culture and maintain.

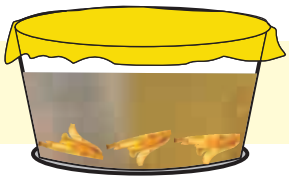
Another important category of live food i.e. worms (*Chironomid* – blood worm and *Tubifex* – sludge worm) can also be cultured by using organic matter (mixture of pond mud and organic manure like cow dung/poultry droppings) in small containers/troughs, etc. *Chironomid* are to be maintained in stagnant conditions, whereas *Tubifex* flourish in flowing conditions.

Culture of Infusoria

Keep banana peelings (2-3) or hay in a big jar/glass aquarium/plastic tub (50 lit capacity) filled with filtered freshwater. Cover the container with the cloth to prevent the entry of unwanted organisms & Keep the container in a cool place



After 1-2 days, water will turn turbid and foul smelling with a film of slime - indicating bacterial growth (food of infusoria)



Water will become clear, transparent with light yellowish colour after 3-4 days. Breakage of slime layer indicates infusoria culture ready for feeding

The process of enhancing zooplankton in a culture tank

Take 200 liters of water in a container

→ Molasses - 20 liters
Jaggery - 20 kg
Rice bran - 20 kg
Oil cake - 20 kg
Yeast - 200 g
Add & Ferment the mixure for 1-2 days

→ Apply this to 1 acre of pond. Repeat the dosage according to plankton status

It will give a boost to zooplankton

A Simple Method of Mixed Zooplankton Culture

Provide Aeration

Release of Obnoxious gases

Slurry tank

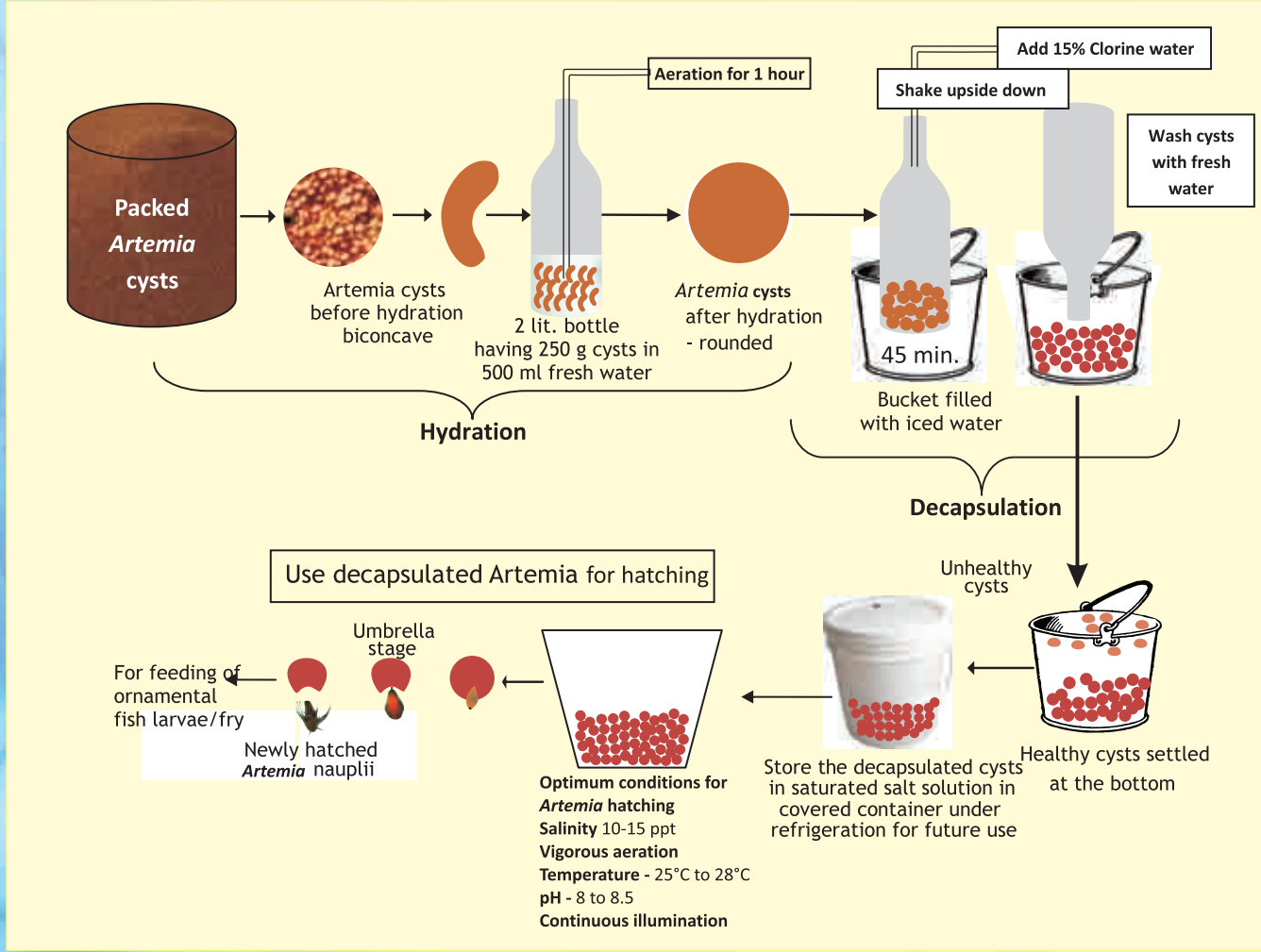
Preparation of Slurry in 250-300 liters of water

10 kg poultry droppings
5 kg groundnut oil cake
2.5 kg single superphosphate

Slurry ready to feed to zooplankton culture tank

Inoculate zooplankton in a separate tank
and add slurry @ 3-4 ml /liter.
The mixed culture of zooplankton will be established in 8-10 days period

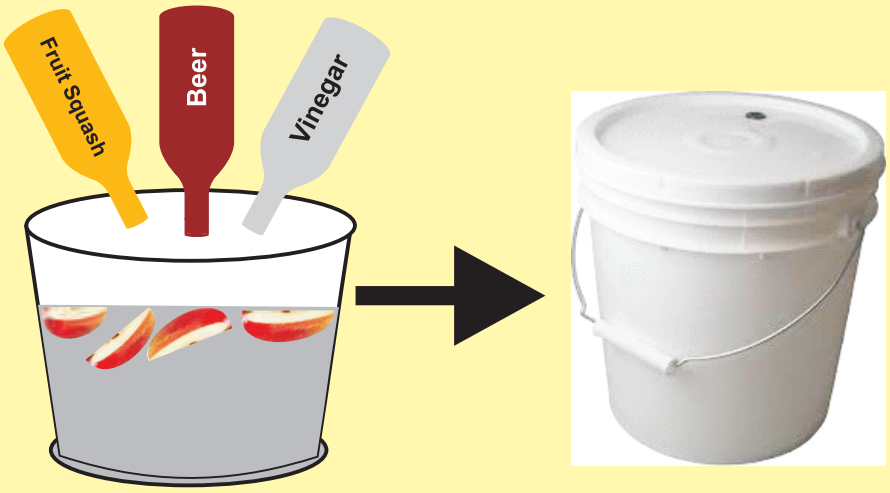
Protocol for decapsulation and hatching of *Artemia* cysts in bulk



Artemia cysts are produced on a commercial scale at different places and are available in sealed cans for hatchery use. *Artemia* cysts shells are contaminated with bacteria, fungus spores and other micro-organisms. While feeding *Artemia* nauplii to fish larvae, if empty shells or unhatched cysts or residues from hatching medium are introduced in the larval tank along with the nauplii, the fish larvae can get infected and cause heavy mortality. Hence before hatching, decapsulation of cysts is recommended.

Beer Worms/Vinegar Eels are one of the favorite food for the growing fry (after feeding with infusoria and rotifer). Culture of these can be maintained easily in 30-50 litre buckets. Pour freshwater in the bucket and add little beer, vinegar, cut apple pieces and/or fruit cordial. Bucket should be covered (to avoid contamination), but not air tight. Inoculate Beer Worms/Vinegar Eels in the prepared media. The culture will be ready in 5-9 days at temperature of 27-32^{0}C. With daily harvesting, culture can continue for one month, but it can last for 3 months or longer with a low harvest rate.

Protocol for culture of Beer-Worms or Vinegar Eels



Bucket having 30-50 liters of freshwater with little beer, vinegar, cut apple pieces and / or fruit squash. Inoculate with Starter Culture of Beer Worms or Vinegar Eels and cover the bucket (should not be air tight). The culture will be ready in 5-9 days at temperature of 27-32^{0}C.

9. BMP-8: The colour enhancement of ornamental fish through feed adds value to your fish

The pigmentation pattern and intensity of body colours determine the commercial value of an ornamental fish. The *de novo* synthesis of carotenoids does not occur in fish like other animals but they can convert one carotenoid to other. An ornamental fish being reared in natural environment easily get colouration due to the availability of plenty of natural food in the form of phytoplankton and zooplankton but under indoor rearing conditions, fish has to be fed on carotenoid supplemented diets.

"Give me carotenoids in my regular diet, so that i should look beautiful and can earn more profit for you"

Koi carp reared under indoor conditions

Koi carp reared under outdoor conditions

Guiding factors for BMP-8

9.1 Identify the carotenoid source and supplement your ornamental fish feed with selected carotenoid to sustain and enhance the pigmentation

Carotenoids are found in a variety of natural and synthetic sources that results in yellow, orange and red pigmentation of fish skin (Table-6).

a. **Sources of natural carotenoids**

   i. **Animal Origin:** Zooplankton, tubifex, chironomid larvae, *Artemia*, crayfish meal, shrimp meal, crab meal, yeast, etc.

   ii. **Plant Origin:** Algae, several types of flowers and vegetables

b. **Synthetic carotenoids:** Astax anthin, β-carotene, lutein, zeaxanthin, etc. are few of the commercially available carotenoids.

Table-6: Type & source of carotenoid and corresponding colour

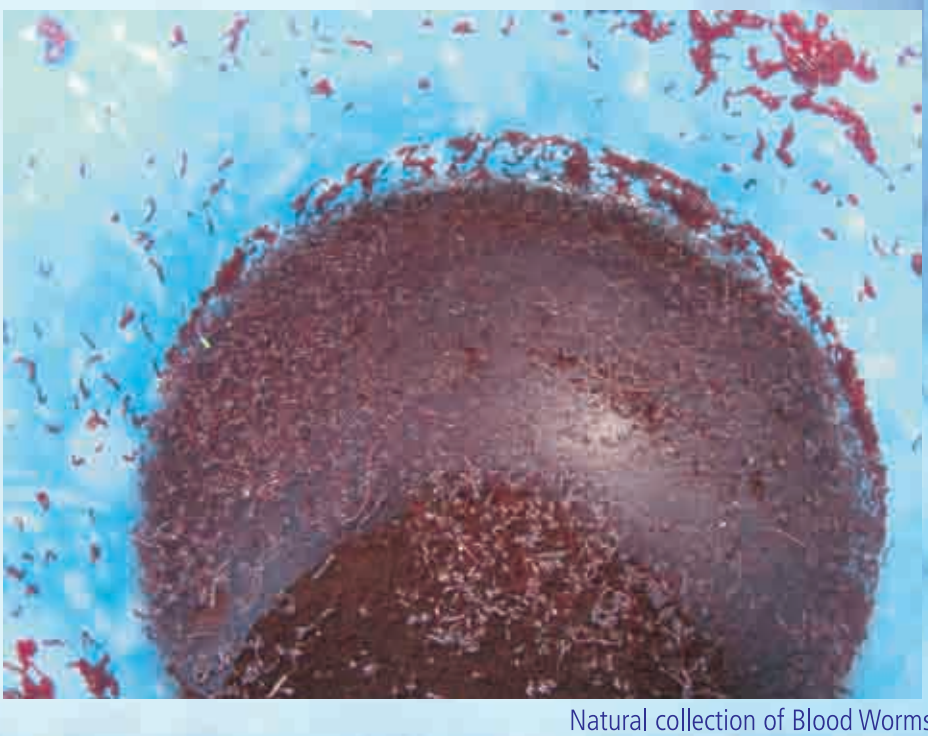
Name of Carotenoid	Corresponding colour	Source
Lutein	Greenish – yellow	Maize, kiwi fruit, grapes, spinach, orange juice, Broccoli, green peas, red pepper
Zeaxanthin	Yellow-orange	-do-
B-carotene	Orange	Carrot, Spinach, Broccoli, green peas, tomato, *Spirulina*
Canthaxanthin	Orange-red	Mushrooms
Astaxanthin	Red	Crustaceans meal, yeast *Phaffia* sp.
Taraxanthin	Yellow	-do-
Tunaxanthin	Yellow	White tuna
Eichinenone	Red	*Spirulina*

9.2 Quantity of carotenoids to be added in the feed

All formulated feeds prepared at the farm can be easily supplemented with catolenoids. The quantity of carotenoid to be added in the feed is given in Table-7. Plant materials, which are to be used as carotenoid source, need to be grated, dried under shade, grounded and mixed with the other ingredients before palletization. Fish are fed intensively on live food for the first one month automatically fulfilling the carotenoid requirement. The carotenoid are supplemented in dry feed for a period of 2-3 months. Carotenoid could also be added in finishing diets for 1-2 months at the end of the rearing period; so that the harvested fish stock to be sold in the market should have bright colouration for maximum profits.

Table-7: Percentage of carotenoid to be added in the feed

Source of Carotenoid	Incorporation level
Carrot	4-5 %
Beet root	3-4 %
Marigold petals	3 %
Rose petals	3-4 %
Gooseberry (Amla)	1 – 2 %
Green Peas	1 – 2 %
Lettuce	1 %



Natural collection of Blood Worms

10. Important Suggestions

- Understand the food and feeding habits / habitats of ornamental fish species to be cultured.
- Choose the right type (nutritional quality, pellet size, carotenoid source) of feed available in the market.
- Formulate cost-effective and nutritionally balanced feed from quality feed ingredients enriched with carotenoids for colour enhancement.
- Optimize feed dispensing method, feeding rate, frequency and time of feeding for the species to be taken up for culture, so as to minimize wastage and to prevent water quality deterioration and to economize on the culture operation.
- Feed should be stored properly to maintain quality and to prevent bacterial/parasitic infestation and hence spoilage.
- Avoid using live food collected from polluted/unhygienic natural water bodies to avoid pathogenic infections in fish.
- Culture live feed at your own farm and make it as an integral part of the ornamental fish feeding system, especially during larval and fry stage and for broodstock rearing.
- Supplement your ornamental fish feed with natural or synthetic carotenoids to make your fish colourful, so that it can fetch higher price in the market.

Chapter 7

Health management in ornamental fish farming

Shivakumar Magada and T.V. Anna Mercy

1. An Overview

Fish are seldom subjected to any disease in their natural habitat as nature provides them optimum water quality and required type of food material with no handling. Whereas, in the confined environment of a production facility, fish are susceptible to various kinds of diseases because of many limiting factors viz., water quality, over-crowding, nutritional imbalance and poor husbandry practices. The quality and overall health of ornamental fish are also affected by stressors that occur during harvest, holding, and transport. Therefore, the key for production of healthy fish is minimizing and avoiding stress whenever possible. The production of healthy fish will improve the profitability where as occurrence of a disease for any reason will reduce the survival percentage, quality, reputation, credibility and profitability.

Prevention of disease is much easier and cheaper than cure

Fish health management is an important issue of concern at any of the ornamental fish production facility. However, it is not given desired attention either due to lack of awareness and knowledge of the staff on fish health management or improper practices of husbandry and treatment in case of occurrence of a disease. As a result many of the producers, specifically in domestic trade, are supplying diseased fish to the consumers which may be carrying pathogens. The presence of ecto-parasites infection could be very commonly observed on ornamental fish kept at wholesaler and retailer aquarium outlets. In view of this a set of "Best Management Practices" is being suggested for health management of freshwater ornamental fish.

2.BMP-1: The adoption of the principle "Prevention is better than cure" is the best option of health management

The popular adage "Prevention is better than cure" is all the more true in the case of ornamental fish. As many a time, it is difficult to arrive at clear diagnosis especially at the farmer level and also as adequate remedies are absent in many cases. It is most important to avoid conditions which lead to diseases.

Apply prophylactic measures to be free from disease problems

Guiding factors for BMP-1

2.1 Application of prophylactic measures

The application of various prophylactic measures which involve treatment of the fish with common salt, methylene blue, potassium permanganate etc. helps in preventing the occurrence of disease (Please see BMP-5 of Chapter-9 for details).

2.2 Maintain water quality within optimum range

Water quality shall be maintained within the optimum range. Frequent fluctuations of water are detrimental and leads to occurrence of disease (Please see Chapter-4 for details)

2.3 Follow bio-security measures

Proper use of bio-security measures will help prevent introduction of infectious disease in a fish facility, and will also help minimize the risk of diseases being passed from producer to hobbyist (Please see Chapter-8 for details).

2.4 Adopt standard quarantine procedures

Quarantine tanks offer peace of mind and a mean to prevent and treat illnesses without compromising the main aquarium system (Please see Chapter-9 for details).

2.5 Check for behavioural changes

Fish should be regularly and closely watched for any change in behavior or appearance. Watch them during feeding. Keep a safe distance so not to frighten them. Make sure all of the fish are eating, swimming and behaving normally. After the feeding, a closer look is appropriate to check on colour, eyes, skin and fins of the fish as well as the breathing.

3. BMP-2: An early isolation of fish with unusual behaviour from the main stock will significantly reduce the possibilities of disease outbreak

A disease outbreak will not occur suddenly in any ornamental fish production facility but fish will show behavioural changes well in advance. However, it will require a close and regular watching of the fish that will provide knowledge and expertise about fish behavior and the facility manager could determine if a fish is actually sick or just behaving in its natural way. This will allow for early treatment and a much higher success rate.

An understanding of behavioural changes of fish helps in early diagnosis of disease

Guiding factors for BMP-3

3.1 Know the signs of odd behavior

The typical symptoms of odd behavior include crowding near the surface, hovering near the bottom, darting, oddly swimming behavior, clamped fins, change in colour, increased or decreased breathing rate with gasping etc.

3.2 Isolation of the suspects

As and when an odd behavior of any fish continuously for some time is observed then illness could be suspected and the suspected fish could be either already infected or may be under stress and susceptible to infection. Such fish should be immediately removed from the main tank and shifted to a hospital tank. However, now there is need of being more watchful both of isolated fish and fish in the main tank.

3.3 Characteristics of a hospital tank

The hospital tank should be a glass tank with a bare bottom and without any objects in it e.g. gravels, plants, etc. The size of the tank should not be very large but in proportion to the size of fish. The water quality should be maintained in optimum range and it will be desirable to have a flow through system.

3.4 Immediately undertake water quality testing

The variation of water quality is basic cause of many diseases. Hence, a water quality analysis of some basic but important parameters viz., temperature, pH, DO, Free CO_2 and NH_3 shall be immediately performed and if any variations are observed those should be managed.

4. BMP-3: The disease should be diagnosed through proper examination and help of experts

A fish may suffer from a disease both because of non-infectious and infectious causes. The non-infectious diseases are mainly related to water quality changes of the production system whereas infectious diseases could be because of infestation of large number of ecto-parasites, endo-parasites, bacteria, viruses etc. A fish producer could diagnose cause of many diseases through experience and help of literature else with the guidance of some subject experts.

Guiding factors for BMP-3

4.1 Determine the cause of origin

It could be determined through a review of all past events including source of fish, water quality, quality of feed, stocking densities, working of filtration system, hygiene, sanitation, etc.

4.2 Undertake clinical examination

Examine the fish for behavioural abnormalities viz., loss of balance, swimming upside down, erratic/spiral swimming, separation from group, staying near the surface, body scraping, increased respiration, fin clamping, etc.

4.3 Examine the fish for physical abnormalities

The isolated fish shall be examined for any physical abnormalities viz., lesions on body, fin rot, production of excess mucus, abdominal swelling, exophthalmous etc. Make a record of all these observations. However, these signs could be because of many reasons (Please see Table-1).


Lesions

4.4 Examine the fish for presence of ecto-parasites

There are many numbers of ecto-parasites belonging to Protozoa, Platyhelminths, Nematodes, Annelids and Crustaceans. These parasites may be attached to body or even gills, visible with naked eyes and easy to identify. The control of all these ecto-parasites is easy at preliminary stage (Please see Table-1 for treatment method).

4.5 Examine the fish for presence of other pathogens

Once it is determined that the occurrence of disease is neither because of non-infectious reasons nor because of ecto-parasites then it could be because of bacterial or virus infection. Many a times it could be confirmed with clinical examination and physical abnormalities but sometimes confirmed by advanced procedures viz., lernaea, skin scrape, gill biopsy, bacterial culture, etc.


Lernaea infection in mouth


Lernaea infection on body


Fin rot

5.BMP-4: Treat the infected fish with well established medicines and treatment protocols

Disease may still occur in spite of all the precautions and safety which may necessitate treatment of the diseased fish. It is essential that diseased fish are treated with well established standard medicines and treatment protocols for early recovery.

Guiding factors for BMP-4:

5.1 Ensure availability of medicines & chemicals:

There are certain common medicines & chemicals that may be frequently needed and these should be readily available at the production facility. It includes common salt, methylene blue, malachite green, formalin, acriflavine, potassium permanganate, oxytetracycline, amoxicillin, entrofloxacin etc. Most of these are available with a scientific chemical supplier or veterinary medicine shops. It shall be ensured to procure products of established brands.

Do not medicate your fish unnecessarily

5.2 Ensure proper storage of medicines & chemicals:

The proper storage and keeping of medicines and chemicals shall be given due attention to ensure timely availability, quality maintenance and effectiveness. These shall be kept at a safe place in a dry & dark environment.

5.3 Prepare a stock solution:

Medication is to be done using prescribed amount of chemicals or antibiotics for a fixed duration of time. A higher concentration may be harmful while a lower concentration may be ineffective. The dosages are prescribed as "Dip treatment for 2 minutes in a solution of 2 ppm acriflavine". Now, the person who wants to treat the fish should know, what is the meaning of 2 ppm? It is actually preparing of a solution by mixing of 2 mg (1 gm is equal to 1000 mg) of acriflavine powder in 1 liter of clean water and then use it for dip treatment of fish.

An example of preparing treatment solution of 2 ppm acriflavine

1. **Prepare a Stock Solution** of a concentration of 1 gm/liter i.e. mix 1 gm of acriflavine powder in 1 liter of water. The concentration of this solution will be 1000 ppm.
2. **Prepare a working solution** of a concentration of 2 mg/L by mixing 2 ml of stock solution in 1 liter of water. The concentration of working solution will be equivalent to 2 ppm.

Please note that:
1 gm is equal to 1000 mg
1 liter is equal to 1000 ml

Precaution:
The stock solution shall be prepared by using distilled water and stocked in dark bottles.

The weighing of 2 mg will require use of a very sensitive balance which is very costly and impractical to keep. Therefore, a stock solution could be prepared which will be of higher concentration and which could be used for preparing the working solution of required concentration easily.

5.4 Methods of Treatment:

There are several methods of treatment for fish. It includes dip treatment, prolonged dip treatment, bath treatment, swab application, oral medication & injection. It will be useful to understand the meaning of all these individually.

a. Dip Treatment: The diseased fish is taken in a hand net and given a dip in the prescribed solution for suggested time. Please ensure that the temperature of solution is same as that of tank where fish is being kept.

b. Prolonged dip treatment: The diseased fish is released in to the tank containing the solution for the suggested time which may be of several minutes. Please ensure that the solution is well aerated and water temperature is maintained during the period of treatment.

c. Bath Treatment: It is normally done when entire stock is to be treated. All the fish are held in a net, brought to the water surface and prescribed solution is poured over the fish slowly. Subsequently, fish are released back in to the culture tank.

d. Swab application: A concentrated solution of the medicine is applied quickly but patiently with the help of a swab on the effected region of fish body and fish is released back.

e. Oral: It is mainly for use of anti-biotics. The required amount of prescribed anti-biotic is mixed in the feed and fed to the fish.

However, feed is to be prepared fresh every day.

f. Injection: It is also for use of antibiotic but only in large size fish which could be injected. The recommended dose of prescribed anti-biotic in a solution form readily available at veterinary medicines shops could be injected. However, it needs to be diluted as per the requirement using a saline solution available at medical stores. An intramuscular injection should be given using a disposable syringe. However, it will need an expert's guidance.

5.5 Avoid use of any antibiotic & chemicals in tanks installed with bio-filters:

It may be understood that any chemical or anti-biotic which is being used for disease treatment is ultimately killing some organism which could be a pathogen. In a bio-filter, these are only the micro-organisms (bacteria) which are supporting its function. The application of any chemical or anti-biotic (until it is selective) will kill all type of micro-organisms in the system including useful group of bacterial needed for bio-filter. Hence, no chemical or anti-biotic shall be applied in a tank which is having a bio-filter facility.

6. Important Suggestions

- The practice of "prevention is better than cure" shall be the major strategy of health management at an ornamental fish production farm.
- Health management measures in ornamental fish production should be effective, practical, cost-effective and utilise readily available resources.
- All the guidelines of bio-security and quarantine shall be strictly followed.
- Fish should be regularly and closely watched for any change in behavior or appearance.
- Any abnormally behaving fish should be immediately isolated from the main tank and shifted to a hospital tank.
- The isolated fish shall be examined for behavioral abnormalities, physical abnormalities, presence of ecto-parasites and other pathogens.
- Few basic chemicals and anti-biotics shall be readily available at the production facility and stored safely and properly in a dry place.
- Keep stock solutions of regularly required medicines ready for use. Any stock solution shall be prepared in distilled water and stored in dark bottles and kept in dark
- None of the chemicals or anti-biotics shall be applied in tanks fitted with bio-filters.
- Any treatment should not be carried out or undertaken in strong sun light.
- Formalin compound shall never be stored below 15°C as it becomes toxic.
- Malachite green should never be used with scale-less fish species.

Table-1: Disease diagnosis and their treatment for freshwater ornamental fishes

S. No.	Name of Disease	Causative Agent	Clinical Signs	Treatment
1.	**NON-INFECTIOUS DISEASES**			
1.1	Crooked body	Injury to spine during young stage Can be hereditary Faulty diet	Deformed body line Wobbling while swimming	Difficult to cure
1.2	Constipation	Imbalanced or poor quality diet	Appearance of a long thread like structure attached to vent, Fish becomes sluggish, Swelling of belly	Keep the fish on fast for some time, Feeding with Daphnia helps as they act as mild laxative, Salt treatment
1.3	Gas Bubble Disease	Super saturation with either oxygen or nitrogen in water	Gas emboli in fins, opercula, eye or gills	Agitate water, Increase water temperature
1.4	Brown Blood Disease	Presence of excessive nitrite in water (>0.1 mg/L) as a result hemoglobin turns into met-hemoglobin	Gills become darker, Excessive pumping of gills, Piping at the surface of water	Flushing of gills under increased flow of water.
1.5	Acidosis	Lowering of water pH	Increased mucus production, Disturbed Osmoregulation	Change the water, Add common salt @3 gm/L

S. No.	Name of Disease	Causative Agent	Clinical Signs	Treatment
2.	**INFECTIOUS DISEASES**			
2.1	**VIRAL DISEASES**			
2.1.1	Lymphocystis	Iridovirus	Nodular white swellings (cauliflower) on fins or body	These diseases are frequently self limiting i.e. resolve on its own, Separate the affected fish, In severe cases, remove and destroy the infected fish as soon as possible, Avoid unnecessary netting or other materials in the pond, which are abrasive to fish skin, Always use disinfected equipments, Provide good nursing care including water quality, high quality feed, clean facilities etc.
2.1.2	Fish pox	Herpesvirus (virus is highly host specific for cyprinids)	Presence of glistering smooth, flat, milky to tan slightly raised plaques on the skin surface, Lesions get ulcerated and secondarily infected by bacteria, Affected sites become darkly pigmented.	
2.1.3	Spring Viraemia of Carps Virus (SVCV)	Rhabdovirus	Dark skin, Swollen belly, Exophthalmia, Haemorrhages in the skin and gills, Protrusion and inflammation of the vent, Internal oedema in all the organs	
2.1.4	Koi Herpes Virus Disease (KHVD)	DNA virus	Gill mottling with red and white patches, Bleeding gills, Sunken eyes, Pale patches or blisters on the skin	

S. No.	Name of Disease	Causative Agent	Clinical Signs	Treatment
2.2	**BACTERIAL DISEASES**			
2.2.1	Mouth Fungus	*Chondrococcus columnaris*	White cotton patches around the mouthfirst as a gray or white line around the lips and later as short tufts sprouting from the mouth like fungus	Bath treatment with antibiotics Oxolinic Acid: 25 mg/L for 15 minutes (Repeat twice daily for three days), Oxytetracycline : 50 mg/L for 15 minutes (Repeat twice daily for three days), Nifurpirinol: 66 mg/L for 15 minutes (Repeat every day third day upto three treatments),
2.2.2	Tail and fin rot	*Aeromonas, Pseudomonas & Myxobacterium*	Disintegrating fins that may be reduced to stumps exposed fin rays, Blood on edges of fins, reddened areas at base of fins	
2.2.3	Columnaris Disease	*Flavobacterium columnare*	Brown to Yellowish-brown lesions on gills/skin, Pale white band encircling the body often referred to as saddle back	
2.2.4	Fish Tuberculosis (Fish Mycobacteriosis)	*Myobacterium fortuitum*	Anorexia, Emaciation, Loss of equilibrium, Exophthalmia, Dropsy, Grey-white nodules in kidneys, muscles, spleen	
2.2.5	Motile Aeromonad Septicamia (MAS)	Gram negative bacteria of genus i.e. *Aeromonas hydrophila, A. sobria, A. veronii*	Ulceration, Exophthalmia, Abdominal distention.	
S. No.	**Name of Disease**	**Causative Agent**	**Clinical Signs**	**Treatment**
2.3	**FUNGAL DISEASE**			
2.3.1	Saprolegniasis	*Saprolegnia* spp.	Cotton like growth on the skin and fins can cover large areas of the fish, Fungal attacks may lead to other health problems like parasitic attack, injury, or bacterial infection.	Bath treatment in water having malachite green, Long term bath in 3 ppm methylene blue

S. No.	Name of Disease	Causative Agent	Clinical Signs	Treatment
2.4	**DISEASE CAUSED BY PARASITES**			
2.4.1	**PROTOZOAN DISEASE**			
2.4.1.1	White spot disease- Ichthyophthiriosis	*Ichthyophthirius multifilis*	Small white nodules first on fins then on entire body, Invade gills leading to breathing problem	Slightly raising of temperature, Bath treatment in a solution of Malachite green and Formalin. **Stock Solution**: Malachite Green: 3.3 g Formalin: 1.0L **Working Solution**: Stock Solution: 2.5 ml Water: 100 L (one hour bath treatment alternatively for three days)
2.4.1.2	Neon Tetra Disease	*Plistophora hyphessobryconis*	Fading of normal brilliant colour, Equilibrium dysfunction, Muscular paralysis, Weight loss, Fin degeneration and death	
2.4.1.3	Trichodiniosis	*Trichodina* spp	Ciliate present on skin and gills, Reduced appetite, Weakened fish becomes susceptible to bacterial pathogens	
2.4.1.4	Costiasis	*Ichthyobodo* spp. (*Costia* spp.)	Heavy and labored breathing, Skin cloudiness caused due to excessive mucus, Flashing and rubbing, Clusters of parasites can sometime be seen on the edges of epithelium	
2.4.1.5	Hexamita (Hole in head disease)	*Hexamita* spp. Discus and other large cichlids are more prone to Hexamita	Small holes in head with a tiny parasite protruding, Ulcerations in lateral line, Loss of appetite, Weight loss	
2.4.1.6	Oodinasis (Velvet Disease)	*Oodinium limneticum*	Clamped fins, Skin shows gray patches, which look like dust giving velvet appearance to skin, The fish may show signs of irritation, The disease is highly contagious and fatal.	

S. No.	Name of Disease	Causative Agent	Clinical Signs	Treatment
2.4.2	**DISEASE CAUSED BY PLATYHELMINTHS**			
2.4.2.1	Monogenean trematods (Flukes or flatworms) borne diseases	*Gyrodactylus* (Gill fluke) & *Dactylogyrus* (Skin fluke)	Fish scrapes itself against objects, Gils and body covered with mucus, Gills swollen, pale and show rapid movement, Scale loss with pink coloured fluid oozing out	Treatment with potassium permanganate / formalin
2.4.2.2	Black spot disease (Digenean Trematodes)	*Posthodiplostomum &Clinostomum*	Increased melanin deposit in skin due to encystment in skin, Respiratory distress as tematode gets encysted in gill tissues	
2.4.3	Disease caused by Nematodes	*Camillanus, Capillaria & Eustrongylides*	Could infect anywhere in the body but visible when they hang out of the anus, Emaciation, stunted growth, lethargy and death	Fenbendazole (an antihelminthes) is mixed with fish feed @ 0.25% and fed for three days and repeated after three weeks.
2.4.4	Disease caused by Annelids (Leeches)	*Piscicolageometra& Cystobranchus* (Acts as ecto-parasites)	Leeches are parasitic on host's blood & visible on fish skin, Heavily infected fish often have chronic anemia, Secondary bacterial and fungal infection at the attachment site	In case of pond, disinfect the pond time to time with lime and bath treatment of fish in 2-3 % salt solution in case of aquarium.

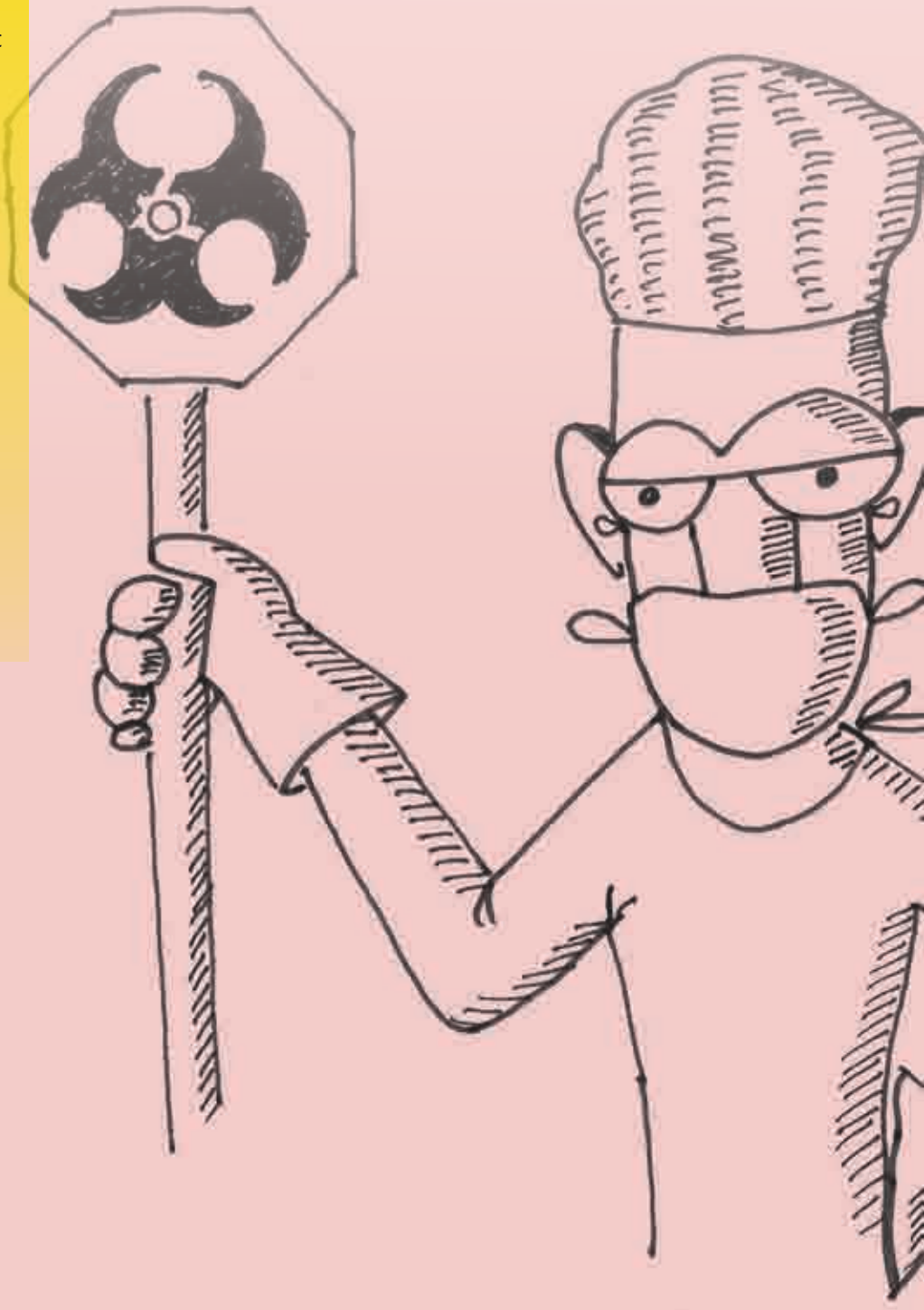
S. No.	Name of Disease	Causative Agent	Clinical Signs	Treatment
2.4.5	**DISEASES CAUSED BY PARASITIC CRUSTACEANS**			
2.4.5.1	Argulosis	*Argulus* (Fish louse)	Visible as a small button like structure on boy of fish, Attaches itself to the body of fish with the help of sucker, Fish rubs itself against objects due to irritation, Fish can develop secondary bacterial and fungal infection at the attachment site	Could be hand picked using tweezers at early stages, Prolonged dip treatment in 5% salt, Bath treatment in 10-20 mg/L of $KMNO_4$ for 30 minutes alternatively for 3 days.
2.4.5.2	Lernaeasis (Anchor worm)	*Lernaea*	Small hemorrhagic (bloody) spots, The fish scrapes itself against objects, Whitish-green threads hang out of fish skin (fins) with an inflamed area at the point of attachment and subsequently spread to mouth and alimentary canal	
2.5	**DISEAES WITH INDEFINITE ETIOLOGY**			
2.5.1	Pop eye	Bacterial or parasitic infection, Poor water quality, Internal metabolic disorder	One or both eyes protrude from the head, Eye lens become cloudy	Isolate the infected fish and treat with broad spectrum antibiotic, Provide good food and water quality conditions, Add Neomycin sulphate @ 50 mg/L .
2.5.2	Dropsy	Bacterial or parasitic infection	Concentration of fluids in body tissues or cavities resulting in abdominal swelling, Scale protrude out from body	Raise the temperature and add salt, it will help the fish to lose some fluid from the body, treat with broad spectrum antibiotics

Chapter 8

Bio-security protocols for freshwater ornamental fish

T.V.Anna Mercy

Inside...




AUTHORISED PERSONS ONLY

1. An overview

Bio-security is a set of the practices and procedures used to prevent the introduction, emergence, spread, and persistence of infectious agents and disease within and around fish production and holding facilities. In general terms, it is a strategic and integrated approach to analyzing and managing relevant risks to fish health and associated risks to the environment. These practices help eliminate conditions that can enhance disease susceptibility among the fish. Bio-security precautions are put in place to exclude and contain fish pathogens. These practices are applicable to all levels of the ornamental fish industry viz; producers, wholesalers, retailers, and hobbyists.

Proper use of bio-security measures will prevent introduction of infectious diseases at production facility and minimize the risk of their transmission from source to final user

The need of bio-security in ornamental fish industry was realised about two decades back by major importing countries when high mortalities were observed in Koi Carps due the infection caused by Koi Herpes Virus (KHP). Subsequently, many countries have developed bio-security measures mainly for ornamental fish that are strictly followed and any unauthorised biological material is not allowed to enter. India also needs to follow bio-security practices at ornamental fish production facilities so to produce pathogen-free fish that will have acceptability in international market.

The basic bio-security procedures could be uniform across the industry, but the plan for this has to be tailored to meet the special needs of each business. As the scope, needs, and finances of the business change, the facility

manager need to modify and adjust bio-security measures accordingly, yet maintain the basic tenets of good bio-security practices.

A fully implemented bio-security program is essential to the success of ornamental fish enterprise. The application of bio-security is the key to the success whether measured in terms of revenue from sales or personal satisfaction in a thriving fish community. There are two basic themes on which to focus when designing and implementing bio-security practices: these are pathogen exclusion and pathogen containment. Pathogen exclusion will involve practices that keep pathogens out of the facility, while pathogen containment will be those that prevent the spread of pathogens within your facility. Remember, Bio-security plan shall be customized to meet the special needs of business which could be modified, adjusted and fine tuned as needs changes and finance allows. In this chapter "Best Management Practices" for decreasing risks of disease introduction and specific procedures for implementing bio-security at any ornamental fish production facility are provided.

REMEMBER

Putting in place some element of bio-security is better than no bio-security at all

2. BMP-1: Purchase healthy fish only from a trusted and reliable source

An obvious route of entry of pathogens into a production facility is via the fish obtained from outside sources. Here are some questions one could ask to himself or the supplier that may assist as a guiding factor to assess the likely health status of the incoming fish and reduce the risk.

Guiding factors for BMP-1

2.1 Do you have a long business relationship with this supplier, and have you experienced any health problems among the purchased fish?

2.2 Can the supplier provide references from satisfied customers?

2.3 Does the supplier receive fish from multiple sources? If so, do they keep same-source fish in separate containment, or do they mix the fish from multiple sources?

2.4 Does the supplier have a bio-security program? Are they willing to share the details with you? Be extremely cautious if the answer is "no."

3. BMP-2: It will be useful to quarantine all new fish that arrive in your facility

Quarantine provides the most important process of acclimation of fish to new water conditions, new husbandry protocols and new feeds. The quarantine system and quarantine period allows the time to the fish immune system to recuperate from the stresses of transport and handling. (Please refer chapter-9 for the details of quarantine process).

Guiding factors for BMP-2

3.1 Fish from separate sources should be quarantined separately.

3.2 Any fish that have had contact with fish or water from other systems shall be quarantined.

3.3 Any wild caught or farm-raised fish or any fish that is returned to your facility shall be quarantined.

3.4 Any fish from other importer, wholesaler, and retail establishments shall also be quarantined.

3.5 Plants and invertebrates should be quarantined, separate from fish, as they can harbour pathogens and intermediate stages of potential pathogens.

4. BMP-3: Fish should not be fed with contaminated live, frozen, fresh or formulated feeds

An insufficient intake of feed will lead to starvation, causes poor growth, low survival, increased susceptibility to disease and loss of reproductive capacity. The problems are further aggravated through use of contaminated feeds.

Guiding factors for BMP-3

4.1 An imbalanced diet due to feeding of one particular food type may lead to deficiencies of certain essential nutrients with diminished survival. Hence, care must be taken to ensure that all fish are receiving an adequate and complete diet.

4.2 Many diets may not meet the needs of certain fish species that have specific needs or feeding behaviors. Seek guidance from those familiar with husbandry or from literature.

4.3 Discard outdated, spoiled, or improperly stored feed as they will lose nutritional value and dietary deficits may occur.

5. BMP-4: The entry of pathogens into the production system through any of the sources should be prevented

The pathogens may get entry into production facility through any known and unknown source. It may include water, air, customers and even staff members. Hence, required precautions shall be followed to control any of these causes.

Guiding factors for BMP-4

5.1 The water should be regularly tested for bacterial contamination, chemical contamination, heavy metals and chlorine. Surface water runs a high risk of containing pathogens. If you rely upon surface water, assessing and treating the water with ultraviolet light or ozone or chlorine is recommended.

5.2 The presence of ventilation airflow from open windows, doors, or ventilation fans can potentially push the water droplets produced by splashing water from waterfalls, water movement and surface agitation produced via pumps, power heads, and air stones. Such droplets if contains pathogen can easily transmit it to the immediately adjacent tanks.

5.3 Many customers may be coming to visit a production facility. They may also be experiencing a disease outbreak or health issues with their home aquarium. Hence, they should not be allowed to dip their hands in tanks where fish are kept. Encourage customers to wash hands using alcohol based hand cleaners or soaps on entering and leaving the facility. Never allow customers in the quarantine facility.

5.4 Staff members shall always wash their hands using alcohol-based hand cleaners or soaps upon entering and leaving the facility and also when moving from one tank to another.

5.5 Footwear should be disinfected upon entering and leaving a facility. There should be only one entry for entering into production facility and disinfectant footbaths shall be placed at the entrance.

5.6 All disinfectants should be changed regularly according to label directions or when they become heavily contaminated with organic material.

5.7 Uniforms or clothing specific for certain work areas will help prevent entry and spread of contaminants into and between different areas of a facility. If any staff members have their own ponds or tanks, do not allow them to bring fish or equipment used in their ponds/tanks into your facility.

6. BMP-5: Effective control measures shall be adopted to prevent vector & fomite borne diseases

Vectors are living organisms that may harbour pathogens and potentially transmit pathogens from one fish to another. These vectors not only cause disease and damage because of their own presence but also potentially transfer other disease causing agents such as bacteria and viruses from one fish to another as they move to feed on new hosts. Non-susceptible fish species may act as vectors by carriage of contaminated parasites. Several ecto-parasites of fish (e.g. fish lice, argulus and fish leeches) have been shown to transmit viral disease causing agent of fish.

Fomites are inanimate objects through which pathogens can be transmitted from location to location. Such transmission generally occurs when there are many shared pieces of equipment between tanks, systems or facilities and they are not properly cleaned and disinfected after each use.

Guiding Factors for BMP-5

6.1 Prevention of vector transmission is best achieved through control of the vectors themselves either through control during quarantine or via prompt identification and control in the display system

6.2 Ideally, all types of water holding systems (aquaria, tanks, ponds etc.) of production and quarantine facility should have their own set of nets, bowls, buckets, siphons, brushes, scrub pads, algae

scrappers, air stones, air line, sump pumps and feeding implements.

6.3 Each area should have its own cleaning, disinfection and drying station. These items should all be dried after each use.

6.4 Essentially any parts of the vehicle that may have had contact with fish water at each site should be cleaned and disinfected. Vehicles can be washed to clean the dirt away and then sprayed with the appropriate disinfectant.

7. BMP-6: Standard operating protocols are to be evolved and displayed at the production centre

Many a times either there are no Standard Operating Protocols (SOPs) in place for certain important activities or not displayed if in existence. The proper displaying of SOPs at points of application helps in constant refreshing of users and encourages applying the same.

Guiding factors for BMP-6

7.1 All the important activities to be carried out at a production facility shall be listed.

7.2 The availability of SOP for each listed activity shall be ensured and if not available then it should be developed either in written and/or illustrated format.

7.3 It should be ensured that all staff members know the importance of SOP's and accept the need for them.

7.4 The language and pictures of SOPs should be simple, easy to understand & follow and clearly visible form a reasonable distance.

8. Important suggestions

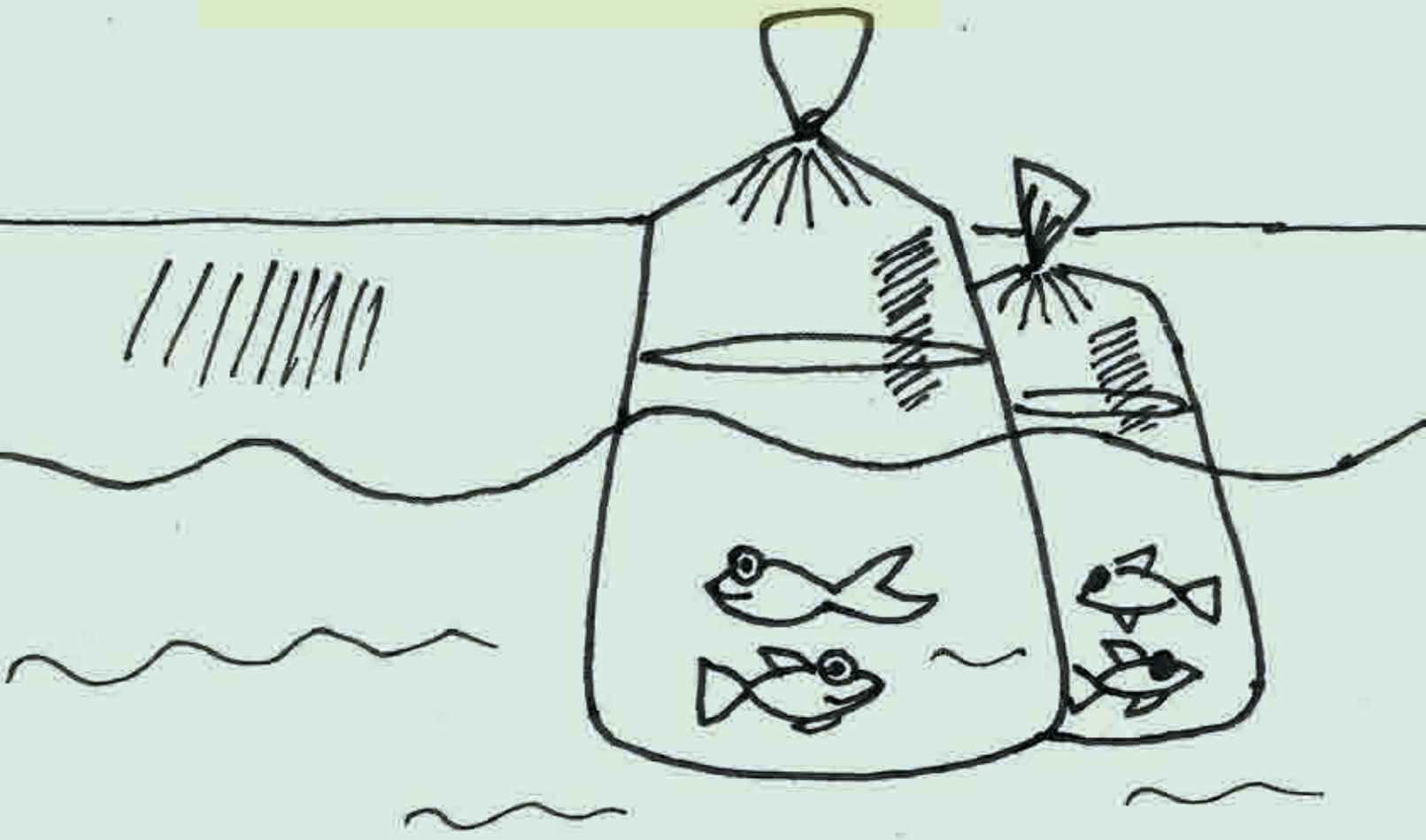
- Purchase only healthy fish from a reliable source.
- Acclimatize the fish properly and quarantine fish, plants & invertebrates.
- Assure that all fish are receiving an adequate and complete diet.
- Make sure that the water supply is not a source of pathogen entry into your facility.
- Disinfectant footbaths should be provided at all entrances.
- Each tank, isolated system, quarantine facility and pond site should have its own set of nets, bowls, buckets, siphons, brushes, scrub pads, algae scrappers, air stones, airline, sump pumps and feeding implements.

Chapter 9

Quarantine protocols for freshwater ornamental fish

T.V.Anna Mercy

Inside...



1. An overview

An ornamental fish which reaches to a hobbyist could be of either wild or farm origin. In both the cases different categories of people are involved in the supply chain before it reaches to the end user i.e. hobbyist (Fig.1). Many a times, a fish covers large distances involving a complicated transport system and several numbers of intermediaries in the chain.

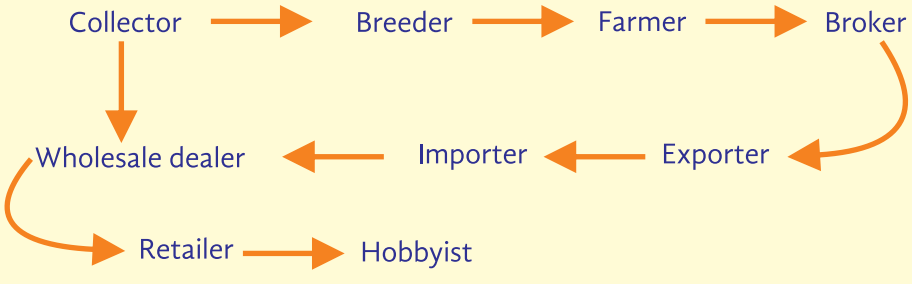


Fig.1 Chain of custody of Ornamental fish from source of origin to end user

As a fish moves from one source to another in the supply chain, it is either stocked in a new-holding facility for a varied period of time or also re-packed or both. As a result, there is repeated & quick change of environment and fish is subjected to stress. Many a time's fish may die because of stress only or it becomes susceptible to infestation by other pathogens initially and subsequently mortality may occur if not controlled. It is estimated that about 50% fish dies in Indian domestic trade during different stages of transit. Hence, there is need of acclimatization of fish as and when it is

introduced to a new environment. A proper quarantine is a must in export-import trade following some standard set of practices.

Quarantine means keeping the newly arrived animal or group of animals or plants in isolation for observation without any direct or indirect contact with other animals so to prevent the spread of infectious pathogens and treated if necessary. Newly introduced animals could be carriers of diseases even if the animals appear to be in good health. Practicing proper quarantine procedures will protect the fishes in the farm from being infected by newly introduced animals. Similarly, fish intended for sale from the farm also could be quarantined before shipment to reasonably ensure that they do not carry any contagious disease.

Quarantine helps a producer to supply healthy fish to hobbyists. It would ensure reputation and credibility of the supplier and ultimately the profitability

2. BMP-1: The quarantine facility should be isolated and separated from the main production and marketing facility

It is one of the most important pre-requisites while setting up a quarantine facility. It is because of the reason that there are high probabilities that fish which will be kept in quarantine facility is infected. In case, quarantine facility is located close to production facility, there will be high possibility of disease transfer from quarantine facility to production facility. The guiding factors that are to be considered while developing a quarantine facility are:

Guiding factors for BMP-1

2.1 The fish holding systems in the quarantine area should be smaller and less extensive than main facility.

2.2 The quarantine tanks should have viewing facility that is adequate to observe fishes for behaviour and signs of pathology, easier to monitor, capture and treat the fish and also remove mortalities.

2.3 The system should be able to comfortably accommodate the largest fish size and numbers you expect to receive. The habitat and hiding places in the tank should be simple in the construction and easy to clean and disinfect and not have any parts that could injure the fish.

2.4 Only properly trained and authorized people should be permitted to enter the area.

2.5 The restricted nature of this area is emphasized by appropriate and well-placed signage.

3. BMP-2: Precise monitoring and maintaining of the water quality at the quarantine facility is of prime importance

Water quality at quarantine facility is very important. A sudden change of water quality during the quarantine process may lead to undesired results.

Guiding factors for BMP-2

3.1 Water quality parameters should be both optimum and stable. New fish are always much stressed and it is essential that they be placed in a stable environment while they undergo quarantine and acclimation.

3.2 Each quarantine tank should have its own set of equipment (nets, totes, bowls, siphons) and disinfectant baths. It will be desirable to install ultraviolet lights and/or an ozonizer in the incoming water supply line from over head tanks so to sterilize the water coming to quarantine tanks.

3.3 Each tank should have a separate filtration system. A poorly designed or complicated quarantine systems that are difficult to access are generally not well maintained.

4. BMP-3: The fish should be quarantined only for a specific period by following an "All-in-All-out" methodology

The quarantine period should be time-specific. A period of less duration is considered ineffective whereas a longer period is undesirable as well as uneconomical.

Guiding factors for BMP-3

4.1 The duration of quarantining may vary from species to species. Ideally, tropical fish should be quarantined at 22-25^{0}C and cold water fishes at no less than 12-15^{0}C. At lower temperatures, it is best to double the quarantine period.

4.2 The period of quarantine could be 21 days for Goldfish, 14 days for gouramys & cichlids and 7 days for other freshwater fin fish. If the fish are brought for breeding purposes the quarantine period may last for 15-30 days depending on the species.

4.3 Lights should be kept off for the first 12 to 24 hours.

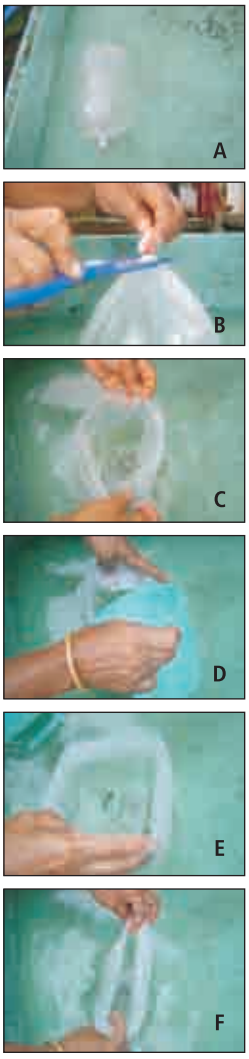
4.4 No new stock of fish should be added to the quarantine tank while an old stock is already being quarantined. Only "All-in-All out" methodology should be adopted. If new fish are added to the quarantine system before the quarantine period is completed, the quarantine period resets to day 0 for that system.

4.5 Fish from each supplier should be quarantined in separate systems and not mixed together. In the event that a group of quarantined fish develop disease, this separation will allow you to accurately identify the source of the diseased fish.

4.6 At the completion of the quarantine period, all fish in a quarantine system are moved out and the tank and support system housing those fish are disinfected before another new lot of fish is moved into quarantine.

Process of acclimatization

1. Turn off aquarium lights
2. Dim the lights in the room where the new arrivals will be opened. Never open the bag in bright light - severe stress or trauma may result from sudden exposure to bright light
3. Float the sealed plastic bag in the tank for 15 minutes (Fig. A). Never open the bag at this time. This step allows the water in the bag to adjust slowly to the temperature of the tank while maintaining a high level of dissolved oxygen.
4. After floating the sealed bag for 15 minutes, cut open the bag just under knot or rubber band (Fig. B) and roll the top edge of the bag down one inch to create an air pocket within the lip of the bag. This will enable the bag to float on the surface of the water (Fig. C). For heavy pieces bags that will submerge, place the bag in a plastic bowl or specimen container
5. Add 1/4 cup of tank water to the plastic bag (Fig. D).
6. Repeat step 5 every ten minutes until the arrived bag is full.
7. Lift the plastic bag from the tank and discard half the water from the bag (Fig. E).
8. Float the shipping bag in the aquarium again and proceed to add 1/4 cup of tank water to the arrived bag every four minutes until the bag is full.
9. Use a very soft hand net to gently catch the fish from the bag and release them into your tank (Fig. F)
10. Remove the filled plastic bag from the tank and discard the water. Never release water from the newly arrived plastic bag directly into your tank.



5. BMP-4: A practice of regular & frequent monitoring and record keeping on behaviour, feeding and health of the fish should be followed

A fish is subjected to quarantine in order to revive it from any stress and also to confirm that it is not the source of any disease. Many a times, a fish may appear healthy initially but may show sign of disease after few days. Therefore, a regular monitoring and record keeping of behavioural changes, feed acceptance and fish health is very important. Record keeping is important because it allows the facility manager to ensure that the fish are being observed regularly, the system is being properly maintained, and that disease problems are tracked and reported in a timely manner. (Refer chapter-12).

Guiding factors for BMP-4

5.1 A work sheet shall be developed for various parameters viz; swimming behavior, feed acceptance, water quality, fish mortalities (if any) etc. and shall be kept along with the quarantine tank.

5.2 The values/remarks on these parameters shall be recorded daily by a trained staff.

5.3 The format once developed shall remain in use for a long period of time without any change.

5.4 The period interval and time of recording data should be same throughout the total period of quarantine.

6. BMP-5: The standard prophylactic treatments should be carried out to reduce the stress and consequent incidence of diseases

A well known theory related to health management is "Prevention is better than cure". It is very well applicable during the process of quarantine. The application of various prophylactic treatments acts as preventive measures. Some of the commonly used prophylactic treatments for fish include dip, bath or prolonged immersion in common salt, formalin, potassium permanganate, acriflavin and hydrogen peroxide.

Guiding factors for BMP-5

6.1 Common salt: Only un-iodised and preferably rock salt shall be used. Freshwater fishes entering quarantine should be given a saltwater dip (Sodium chloride crystals 5gm/litre) if feasible, two more saltwater baths at 3- to 5-day intervals.

6.2 Formalin: Dissolve 1 ml formaldehyde in 10 liter of water and give an immersion treatment for about 1 hr. Formaldehyde could be easily obtained from a supplier of laboratory chemicals. Do not use a solution of formaldehyde which appears milky

6.3 Potassium Permanganate ($KMnO_4$): Dissolve 4 gm $KMnO_4$ in 1000 liter of water and give immersion treatment for 1-3 hrs. In case of prolonged treatment for 24 hrs quantity of $KMnO_4$ is reduced to 2.5 g per 1000 liters.

6.4 Acriflavine: Dissolve 500 mg of acriflavine in 1 liter of water and keep it as a stock solution. Stock solution could be diluted and used as per requirement.

7. BMP-6: Appropriate sanitation procedures should be strictly followed for eliminating entry of pathogens

It may also happen sometime that the fish was disease free when it was brought to quarantine facility but it was subjected to pathogens there only. It could be because of non-adherence of sanitation procedure and maintenance of hygiene in the premises.

Guiding factors for BMP-6

7.1 All tanks should be kept free of fish waste and uneaten food.

7.2 Ensure that all dead and moribund (sick) fish are removed promptly.

7.3 Equipment should be cleaned and placed in a disinfection solution for the appropriate amount of time after each use.

7.4 It is important to use an appropriate disinfectant, at the proper concentration, and allow the recommended contact time with all equipment and tank surfaces to assure efficacy (Table-1).

7.5 Buckets of disinfectants should be placed by each quarantine tank and each tank should have its own set of nets, bowls and siphons. After fish leaves the quarantine system, all tanks should be sanitized and if possible, allowed to air dry.

Table-1: Common disinfectants for use at Ornamental Fish production facility

Disinfectant	Dosage	Duration	Comments
Sodium Hypochlorite thiosulfate (Household bleach at 5.25%)	200mg/l (approx. 35 ml [2.5 tbsp] per gallon of water)	1 hour	Not recommended for nets or metal Maybe neutralized with sodium Toxic to fish
Quaternary Ammonium compounds	2000mg/l	1 minute	Toxic to fish
Calcium Hypochlorite	100-200mg/l	20 seconds	Toxic to fish

8. Important suggestions

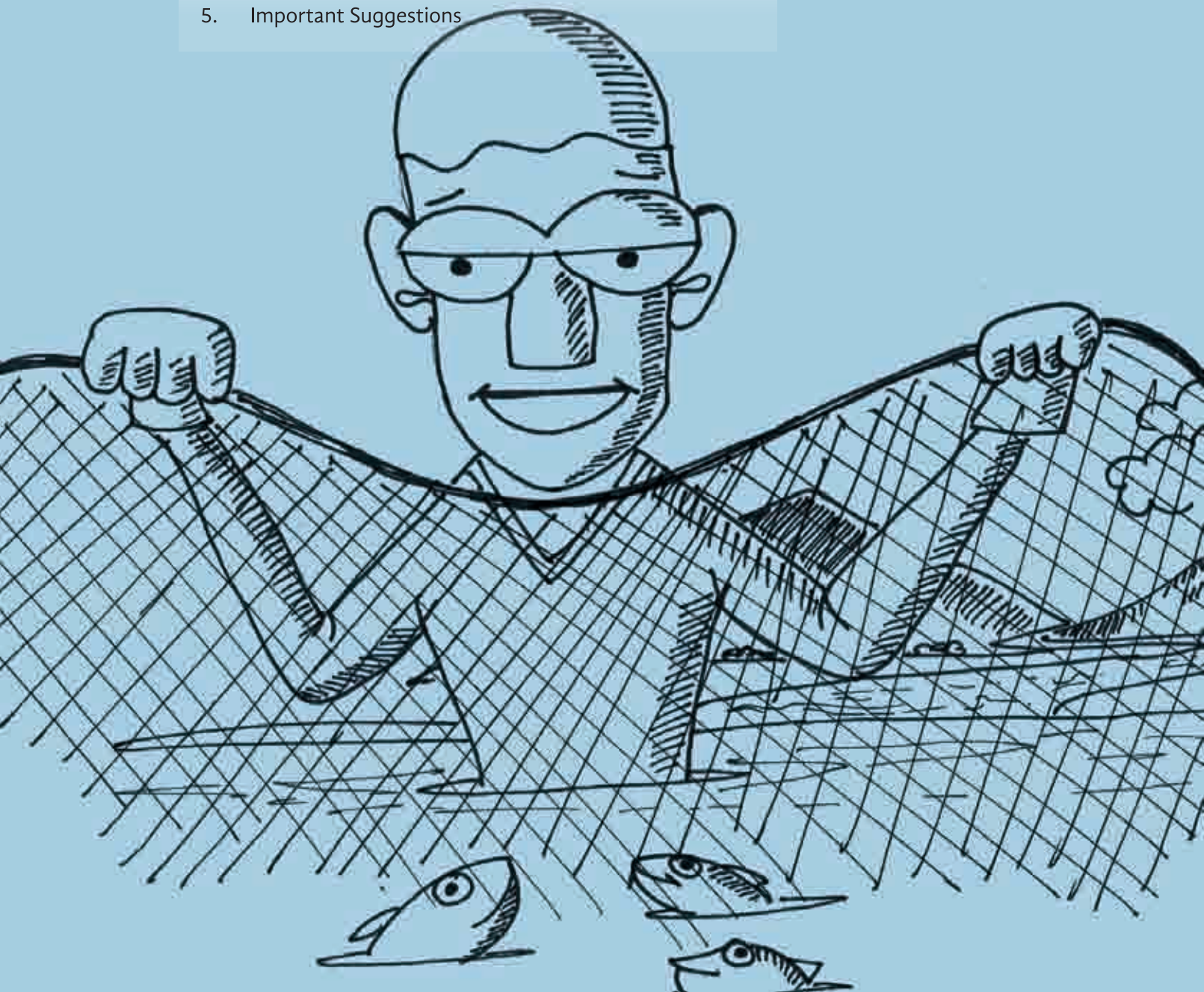
- It is always better to have a quarantine facility at your hatchery/trade place.
- Quarantine area should be isolated and separate from your main facility.
- Acclimatize the fish properly, which is the foremost requirement of quarantine.
- Water quality parameters should be not only optimal but stable.
- Quarantine tanks should have viewing facility that is adequate to observe fish.
- Each quarantine tank should have its own sets of equipments/filter system.
- Standard prophylactic treatments should be carried out to reduce the stress and consequent incidence of diseases.
- Bottom of the tanks should be bare, without sand, plants or anything.
- Only authorized persons should be allowed to enter the quarantine area.

Chapter 10

Collection of indigenous freshwater ornamental fish from wild

B. K. Mahapatra

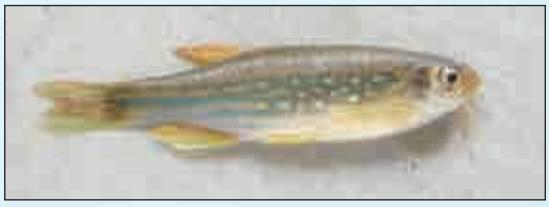
Inside...



Rivers & streams of N-E India and Western Ghats are known as "Biodiversity Hot spots" for wild freshwater ornamental fish

1. An overview

India is known in the international ornamental fish trade for its wild caught varieties which constitute about 85% of total export of Rs.567 lakh (2014-15). There is very less demand of these fish in the domestic trade. Most of these wild ornamental fish are caught from natural rivers and streams of north-east and southern regions (Western Ghats) of India. There are about 250 potential wild ornamental fish available in North-East Region of which 155 species (Table-1) are regularly traded to overseas which mainly includes *Channa barca*, *Channa aurantimaculata*, *Puntius shalynius*, *Danio dangila*. Similarly, a number of native ornamental fish are also reported from southern India especially from the Western-Ghats (Table-2) of which most important are *Sahyadria denisonii*, *Puntius filamentosus*, *Pristolepis marginata*, *Pristolepis fasciata.*, etc.



Danio dangila

Botia dario

The local fishermen were earlier catching both edible and selective varieties of ornamental fish using artisanal fishing methods consisting of small beach seines, dip nets, and a variety of small trap nets. The high demand and price of native ornamental fish led to unselective continuous harvesting which ultimately resulted in depletion of their natural stocks. Besides this,

indiscriminate fishing for food fish using unscrupulous collection techniques (use of dynamites, pesticides, copper sulphate & bleaching powder) also threatened sustainability of ornamental fish. As a result, some of the species are already listed as endangered while many are listed as vulnerable (Table-3). It was mainly because of these threats to ornamental fish biodiversity of N-E and Western Ghats that Marine Products Export Development Authority, Cochin framed "Green Certification": a certificate given to a product to ensure its environmental & socio-economic sustainability and a procedure by which a third party gives written or equivalent assurance that the operation confirms to the relevant standard in relation to social issues, environmental impacts on animal (fish) welfare. The requirement of Green Certificate was to be made mandatory for wild collection of ornamental fish and voluntary for production units. However, it has not yet come into force. Simultaneously, the other side of the story is that most of these wild varieties of ornamental fish do breed in mass during their respective breeding seasons and if not collected there would be mass mortality when water level will decline and be confined to small pockets or rivulets. Hence, there is need of harvesting also but judiciously. In view of this a set of "Best Management Practices" are suggested for judicious collection of wild ornamental fish for the benefit of all stakeholders so that it remains sustainable and eco-friendly.

Injudicious & indiscriminate harvesting is threatening the sustainability of resources

2. BMP-1:Identify reserved zones and fishing zones with restrictions on fishing methods, number of fishermen, etc.

The major cause of threat to the resources of wild ornamental fish is because of non-existence of any fishing policy and regulations either by department of wildlife & forest or state fisheries department. These departments shall develop certain regulatory measures and ensure strict enforcement of regulations.

Fish harvesting should be banned in breeding zones

Guiding factors for BMP-1

2.1 Identification of Breeding grounds

The harvesting of wild ornamental fish is being done since very long and a lot of published information is already available on the subject. The concerned departments shall try to document all the available information and if not available specifically, it could be generated through fresh studies so to identify natural breeding grounds of all the commercially important fish. All these natural breeding grounds could be declared as sanctuaries and demarcated from fishing grounds where fishing shall be permissible. The declaration of breeding grounds shall be known to all the stakeholders through all types of media as well as through display boards.

2.2 Creating public awareness

A large number of public awareness programmes shall be organized and all the stakeholders including general public shall be made aware of the issues including disadvantages of injudicious wild fish harvesting.

2.3 Estimation of resource potential

It will be also useful to estimate the total potential of all the major water resources where these fish are found. It shall include species-wise size of existing population, number of new entrants to the population every year and numbers removed from the population either due to fishing or natural mortality.

2.4 Determine the period of harvesting

There is practice of imposing "Closed Season" in most of the states when fishing is not allowed in any of the natural water bodies but this closed season is specifically with reference to edible fish and mainly limited to monsoon periods. The breeding season of several varieties of ornamental fish is different form monsoon. Hence, there is need of redefining the period of "Closed Season" with specific reference to ornamental fish.

2.5 Registration of fishermen

The fishing of ornamental fish shall be permitted only by certified fishermen registered either with wildlife or state fisheries department. The registration certificate shall be given only to trained fishermen and awarded only at completion of a training programme to be organized by concerned agencies. The objective of the training programme will be mainly awareness on sustainable fishing methods and other related aspects.

3. BMP-2: The wild ornamental fish should be collected in an eco-friendly manner

Traditional methods of wild ornamental fish collection are eco-friendly

It is not the collection of wild ornamental fish which is causing problem but it is the method of harvesting which is not eco-friendly and causing the trouble. The traditional methods of yester years were eco-friendly and only desired varieties were being handpicked and removed from the system whereas presently large numbers of unwanted varieties are also removed from the system and cause of concern.

Guiding factors for BMP-2

3.1 Obtain permission from competent authority

Fish collectors should register with the competent authorities and take required permission to catch the species of interest.

3.2 Do not use any types of chemicals for capturing fish

In order to collect large quantity of food fish with less effort, fishermen have started using several types of pesticides viz; chlorinated hydrocarbons, organophosphates &carbomates and other chemicals viz; copper sulphates, bleaching powder etc. The use of all these chemicals is harmful to entire

ecosystem. Many a times the use of these chemicals at higher concentration is resulting in mass mortality of aquatic fauna.

3.3 Harvest only selected fish using traditional gear

The use of traditional gear is more beneficial and useful for sustainable population of ornamental fish in natural water bodies. The traditional gear are selective in nature and targeted fish can be handpicked.

Gear used for collection of wild ornamental fish

The local fishermen collect wild ornamental fish by using two categories of gear i.e. active gear and passive gear. The gear selection depends on the type of water body and target fish.

A. Active gear: The active gear are those that moved through the water by human power. The commonly used active gear are seine nets, encircling net, drag nets, scoop nets and dip nets.

B. Passive gear: The gear that are usually set and left stationary for a period of time in a water body. The passive gear includes gill nets and locally improvised traps such as Ghuni, Atol, Mogra, Roh etc.

a. **Seine nets** are used for catching fast moving ornamental fish like Mola, Punti, Chanda etc.

b. **Scoope nets** are used to sweep up woody debris to collect fish like *Badis, Glossogobius*, etc.

c. **Thela Jal are** triangular shaped and used for catching *Scatophagus argus* and small danionin species.

d. **Chat Jal** is made by mosquito net mainly used in the big size water body for catching all type of fish.

e. **Chekke** which is made of bamboo is used in streams and swampy areas to collect the small ornamental fish.

f. **Pata** which is made by fixing of splitted bamboo screen or nylon net is a long and continuous structure set across the river or passage of fish.

g. **Ghuni** is specially used for traping of Kholse, *Colisa fasciatus*, *C. lalia*, Pankal, *Mastacembelus pancalus*, dwarf chameleon fish, *Badis badis* etc.

h. **Roh** is used in terraced paddy fields for catching small indigenous ornamental fish including Danios, Puntius etc. .

Dingora, Cherha, Polo, Juluki, Jhupri etc. are other popular gear used for catching small indigenous fish.

Chekke

Chekke in operation

Roh

Ghuni

Mogra

3.4 Understand the habitat of fish and decide a harvesting method:

Large fish tend to inhabit open water spaces whereas small fish typically hide under cover or in shallow water habitats where the avenues for escape are limited and vulnerable to capture. On the other hand, small fish hidden in root wads are often difficult to draw out. Hence, the harvesting method could be decided accordingly.

3.5 Do not harvest fish from breeding grounds:

Fish collectors should decide it on their own not to harvest fish from breeding grounds and during the breeding season. The fish shall be collected only during the collapsing phase and not during the growing phase.

Traditional types of fish collection container

4. BMP-3: The fish holding and acclimatization facility of the collector and exporter should be proper to avoid stress and mortality

The total quantity of wild ornamental fish that are sold and exported is much less than the actual collection. Most of it faces mortality at different stages of transportation from place of collection to packaging of consignment for export. There is need to improve holding facilities at all the different stages including packaging and transportation.

Guiding factor for BMP-3

5.1 Facilities at the primary holding site:

It is at collection site only that the habitat of fish is suddenly changed from open water to confined water which results in sudden stress to fish and at times difficult to recover. Therefore, the fish collector should first set up proper holding facilities at site within the same water body so that there is no change in water quality. A hapa installed in deep section where there is mild flow of water will be a preferable site.

Fish holding facilities at the collection site

5.2 Transportation from primary holding site to secondary holding site:

It is the most crucial stage in the entire process of wild ornamental fish marketing. An improper method of fish transportation may result in high mortality either during the transportation else in the holding tanks at marketing site. Fish could be transported either in open tanks or in oxygen packing but density should be less than the normal packing. There should not be much change in water quality. It will be more beneficial to use the water from same water body from where fish were collected if it is clean and not turbid.

5.3 Develop proper facilities at secondary holding site:

The holding facility at marketing site should include a number of Cement/FRP tanks and glass tanks with provisions of water exchange and filtration. All the tanks should be properly disinfected before every stocking and suitable hideout may be provided in the tank as per the habitat of fish. In case ground water is being used, it should be aerated for a minimum period of 24 hours before use.

5.4 Quarantine and prophylactic treatment:

The fish shall be properly quarantined and introduced to prophylactic treatment using standard protocols as described in Chapter-9 (quarantine) and Chapter-7 (prophylactic treatment). The minimum conditioning period should be for 14 days. Initially, don't feed the fish. They have to be weaned/ acclimatized slowly to the commercial diets.

5. Important Suggestions

- The breeding grounds of all important wild ornamental fish species should be identified and declared as sanctuaries. These sanctuaries should be known to all stakeholders.
- The institutional support shall be extended to identify breeding & fishing grounds, estimate production & fishing potential, determine the period of harvesting etc. and also to regulate the entire process of collection and marketing.
- Only registered fishermen who have undergone specialized skill development training shall be permitted to collect fish.
- Fish collectors should not use any type of pesticides or chemicals for harvesting of fish and use only traditional gears.
- Only required fish should be removed from the water bodies and unwanted fish shall be released back.
- Fish should not be harvested from breeding grounds but only from fishing zones during the collapsing phase.
- Fish collectors should plan of proper facilities both at primary and secondary holding facilities.
- The fish shall be properly quarantined and introduced to prophylactic treatments using standard protocols.
- A large number of public awareness programmes shall be organized and all the stakeholders including general public shall be made aware of the issues including disadvantages of injudicious wild fish harvesting.

Table-1: Native Freshwater Ornamental Fish of North-East India

S. No.	Species	Trade name	Period of availability
1	*Aborichthy Skempi* (Chaudhuri)	Sildewinder loach	*W*
2	*Acanthocobitis botia* (Hamilton)	*Leopard loach*	W
3	*Acantopsis choirorhynchos* (Bleeker)	Banana loach	W
4	*Ailia coila* (Hamilton)	*Gangetic ailia*	M
5	*Ailia punctate* (Day)	Jamunaailia	M
6	*Amblycep Smangois* (Hamilton)	Indian torrent catfish	W
7	*Amblypharyngodon mola* (Hamilton)	Brass fish	S, M
8	*Anabas testudineus* (Bloch)	*Climbing perch*	M, W
9	*Anabas oligolepis* (Bleeker)	Gangetic koi	M, W
10	*Anguilla bengalensis* (Gray& Hardwicke)	Indian long fin eel	S
11	*Aorichthys aor* (Hamilton)	Shovel mouth catfish	S, M, W
12	*Aorichthys seenghala* (Sykes)	Giant river catfish	S, M, W
13	*Aplocheilus panchax* (Hamilton)	Red / Blue panchax	S, M, W
14	*Apocryptes bato* (Hamilton)	Scary dragon	S, M, W
15	*Aspidoparia morar* (Hamilton)	Aspidoparia	S, M, W
16	*Badis badis badis* (Hamilton)	Dwarf chameleon fish	M,W
17	*Badis badis burmanicus* (Hamilton)	Red chameleon fish	M,W
18	*Bagarius bagarius* (Hamilton)	Painted giant catfish	S, M, W
19	*Balitora brucei* (Gray)	Balitora loach	W
20	*Barilius barila* (Hamilton)	Bared trout	W
21	*Barilius barna* (Hamilton)	Silver hill trout	W
22	*Barilius bendelisis* (Hamilton)	Hamilton's trout	W
23	*Barilius bola* (Hamilton)	Goliath hill trout	W
24	*Barilius dogarsinghi* (Hora)	Manipuri trout	W
25	*Barilius gatensis* (Valenciennes)	Metallic hill trout	W
26	*Barilius guttatus* (Day)	Burmese trout	W
27	*Barilius radiolatus* (Gunther)	*Gunther's baril*	S, EM, M, PM
28	*Barilius shacra* (Hamilton)	Stripped hill trout	W
29	*Barilius tileo* (Hamilton)	Spotted hill trout	W
30	*Barilius vagra* (Hamilton)	Half banded hill trout	W
31	*Batasio batasio* (Hamilton)	Translucent shark	S, EM, M, W
32	*Batasio tengana* (Hamilton)	Assamese batasio	S, EM, W

S. No.	Species	Trade name	Period of availability
33	*Botia berdmorei* (Blyth)	Blyth's loach	W
34	*Botia dario* (Hamilton)	Rani loach	W
35	*Botia histrionica* (Blyth)	Burmese loach	W
36	*Botia lohachata* (Chaudhuri)	Y-loach / Tiger loach	W
37	*Botia rostrata* (Gunther)	Twin Banded loach	W
38	*Brachydanio rerio* (Hamilton)	Zebra danio	S, EM, M, PM
39	*Chaca chaca* (Hamilton)	Devil catfish	M, W
40	*Chagunius chagunio* (Hamilton)	Shovel mouth carp	AS
41	*Chanda nama* (Hamilton)	Indian glass fish	AS
42	*Chandramara chandramara* (Hamilton)	Golden heads trander catfish	M, W
43	*Channa barca* (Hamilton)	Violet snakehead	S
44	*Channa marulius* (Hamilton)	Peacock snakehead	S, EM
45	*Channa gachua* (Hamilton)	Asiatic snakehead	S, EM
46	*Channa punctatus* (Bloch)	Checkered snakehead	S, EM
47	*Channa stewartii* (Playfair)	Assamese snakehead	S, EM, M, PM
48	*Channa striatus* (Bloch)	Striped snakehead	S, EM, W
49	*Chaudhuria khajuriai* (Talwar et.al.)	Garo eel	S
50	*Chela cachius* (Hamilton)	Neon / Silver hatchet	AS
51	*Chela laubuca* (Hamilton)	Indian glassy hatchet	AS
52	*Chitala chitala* (Hamilton)	Hump back knife fish	AS
53	*Cirrhinus reba* (Hamilton)	Reba carp	AS
54	*Clarias batrachus* (Linnaeus)	Walking catfish	S, EW
55	*Clupisoma montana* (Hora)	Kochagarua	AS
56	*Colisa fasciatus* (Schneider)	Giant gourami	EM
57	*Colisa labiosus* (Day)	Thick lipped gouramy	EM
58	*Colisa lalia* (Hamilton)	Dwarf gourami	EM
59	*Colisa sota* (Hamilton)	Sunset / Honey gourami	EM
60	*Conta conta* (Hamilton)	Thread tail catfish	M, W
61	*Crossocheilus burmanicus* (Hora)	Burmese latia	AS
62	*Ctenops nobilis* (McClelland)	Nobel gourami	EM
63	*Danio aequipinnatus* (McClelland)	Giant danio	S, EM, M, PM

S. No.	Species	Trade name	Period of availability
64	*Danio dangila* (Hamilton)	Moustached danio	S, EM, M, PM
65	*Danio devario*(Hamilton)	Silver/ Turquoise danio	S, EM, M, PM
66	*Danio naganensis* (Chaudhuri)	Naga danio	S, EM, M, PM
67	*Danio regina* (Fowler)	Focoler's danio	S, EM, M, PM
68	*Erethestis pussiles* (Mull. &Tros.)	Gangetic erethistes	AS
69	*Esomus danricus*(Hamilton)	Indian flying barb	S, EM, M, PM
70	*Eutropiichthys vacha* (Hamilton)	Batchuavacha	S, EM, M
71	*Gagata cenia* (Hamilton)	Clown catfish	M, W
72	*Gagata sexualis* (Tilak)	Keel gagata	S, EM, M, PM
73	*Garra annandalei* (Hora)	Annandeleigarra	S, EM, W
74	*Garra gotylagotyla* (Gray)	Stone fish	S, EM, W
75	*Garra gravelyi* (Annandalei)	Burmese garra	S, EM, W
76	*Garra kempi* (Hora)	Kemp garra	S, EM, W
77	*Garra lamta* (Hamilton)	Lamtagarra	S, EM, W
78	*Garra lissorhynchus* (McClelland)	Khasi garra	S, EM, W
79	*Garra mcClellandi* (Jerdon)	Cauvery garra	S, EM, W
80	*Garra naganensis* (Hora)	Naga garra	S, EM, W
81	*Garra nasuta* (McClelland)	Khasi garra	S, EM, W
82	*Garra rupecula* (McClelland)	Mishmi garra	S, EM, W
83	*Glossogobius giuris* (Hamilton)	Sleeper goby	EM, W
84	*Glyptothorax cavia* (Hamilton)	Banded torrent catfish	EM, M, W
85	*Glyptothorax striatus* (McClelland)	Copper catfish	EM, M, W
86	*Hara hara* (Hamilton)	Butterfly catfish	EM, M, W
87	*Hara jerdoni* (Day)	Dwarf anchor catfish	EM, M, W
88	*Heteropneustes fossilis* (Bloch)	Scorpion fish	S, EW
89	*Labeo angra* (Hamilton)	Angralabeo	AS
90	*Labeo bata* (Hamilton)	Black tip tail shark	AS
91	*Labeo boga* (Hamilton)	*Red-gilled violet shark*	AS
92	*Labeo dero* (Hamilton)	Hilly labeo	AS
93	*Labeo calbasu* (Hamilton)	Black shark	AS
94	*Labeo gonius* (Hamilton)	Miniscale shark	AS
95	*Labeo nandina* (Hamilton)	Pencil gold	S, EM
96	*Laguvia ribeiroi* (Hora)	Ribero's catfish	EM, M, W
97	*Laguvia shawi* (Hora)	Cheetah catfish	EM, M, W
98	*Lepidocephalus annandalei* (Chaudhuri)	*Tail spot loach*	W

S. No.	Species	Trade name	Period of availability
99	*Lepidocephalus berdmorei* (Blyth)	Burmese loach	W
100	*Lepidocephalus guntea* (Hamilton)	Panther loach	W
101	*Lepidocephalus irrorata* (Hora)	*Loktal loach*	W
102	*Macrognathus aral* (Bloch & Schneider)	Peacock eel	S
103	*Macrognathus pancalus* Hamilton	Striped spiny green Eel	S
104	*Mastacembelus armatus* (Lacepede)	Tire-track eel	S
105	*Mystus tengara*(Hamilton)	*Guinea catfish*	M, W
106	*Mystus vittatus*(Bloch)	Pyjama striped catfish	M, W
107	*Nandus nandus* (Hamilton)	Leaf fish	S, EM
108	*Neolissocheilus hexagonolepis* (McClelland)	Chocolate mahseer	W
109	*Notopterus notopterus* (Pallas)	Black knife fish	W
110	*Ompok bimaculatus* (Bloch)	Butter catfish	M, W
111	*Ompok pabda* (Hamilton)	Gulper catfish	M, W
112	*Olyralongi caudata* (McClelland)	Long fighting catfish	M, W
113	*Oreichthys casuatis* (Hamilton)	*Hi fin barb*	S, EM, M, PM
114	*Osteobrama cotio cotio* (Hamilton)	Diamond barb	S, EM, M, PM
115	*Pangasius pangasius* (Hamilton)	Indian tiger shark	S, EM, M, PM
116	*Pseudambassis baculis* (Hamilton)	Black spot glass fish	EM,M,W
117	*Pseudambassis ranga* (Hamilton)	Indian/Jewel glass fish	EM,M,W
118	*Pseudotrophius atherinoides* (Bloch)	*Striped glass catfish*	EM, M, W
119	*Psilorhynchus balitora* (Hamilton)	Banded torrent	S, EM, PM
120	*Psilorhynchus sucatio* (Hamilton)	Checkered torrent	S, EM, PM
121	*Puntius chola* (Hamilton)	Bitter carp	S, EM, M, PM
122	*Puntius clavatus* (McClelland)	Stedman barb	S, EM, M, PM
123	*Puntius conchonius* (Hamilton)	Indian rosy barb	S, EM, M, PM
124	*Puntius filamentosus*(Valenciennes)	Filament barb	S, EM, M, PM
125	*Puntius fraseri* (Hora & Misra)	Fraseri barb	S, EM, M, PM
126	*Puntius gelius* (Hamilton)	Golden Dwarf barb	S, EM, M, PM
127	*Puntius guganio* (Hamilton)	White streaked barb	S, EM, M, PM
128	*Puntius phutunio* (Hamilton)	Dwarf barb	S, EM, M, PM
129	*Puntius sarana orphoides* (Valenciennes)	Olive barb	S, EM, M, PM
130	*Puntius sarana sarana* (Hamilton)	Olive barb	S, EM, M, PM
131	*Puntius shalynius* (Yazdani&Talukdar)	Shalini barb	S, EM, M, PM

S. No.	Species	Trade name	Period of availability
132	*Puntius sophore* (Hamilton)	Soft-fin barb	S, EM, M, PM
133	*Puntius terio* (Hamilton)	Terry barb / One spot barb	S, EM, M, PM
134	*Puntius ticto* (Hamilton)	Fire-fin barb/Two-spot barb	S, EM, M, PM
135	*Rasbora daniconius* (Hamilton)	Stripped rasbora	AS
136	*Rasbora rasbora* (Hamilton)	Yellow-tail black tip	AS
137	*Rhinomugil corsula* (Hamilton)	Corsula	EM, M
138	*Rita rita* (Hamilton)	White catfish	M, W
139	*Rineloricaria lanceolata*	Whiptail catfish	M, W
140	*Salmostoma bacaila* (Hamilton)	Razor belly	EM, M
141	*Schistura beavani* (Gunther)	Banded loach	W
142	*Schistura denisonidayi* (Hora)	Ring loach	W
143	*Schistura multifasciatus* (Day)	Many banded loach	W
144	*Schistura savona* (Hamilton)	Half banded loach	W
145	*Schistura scaturigina* (McClelland)	Victory loach	W
146	*Schistura sikmaiensis* (Hora)	*Orange loach*	W
147	*Sicamugil cascasia* (Hamilton)	*Yellow tail mullet*	S, EM, W
148	*Somileptes gongota* (Hamilton)	Jaguar loach	W
149	*Strongylura strongylura* (Van Hasselt)	Spot tail needle fish	M
150	*Tetradon cutcutia* (Hamilton)	Emerald puffer	M, W
151	*Tor chelynoides* (McClelland)	Black mahseer	M, W
152	*Tor putitora* (Hamilton)	Yellow-finned mahseer	M, W
153	*Tor tor* (Hamilton)	Red finned mahseer	M, W
154	*Wallago attu* (Schneider)	Fresh water shark	M
155	*Xenentodon cancila* (Hamilton)	Silver needle fish	M

AS: All Season; **W**: Winter; **S**: Summer; **M**: Monsoon; **EM**: Early Monsoon; **PM**: Post Monsoon

Table-2: Native Freshwater Ornamental Fish of Western Ghats, India

S. No.	Species	Trade name	Period of availability
1.	*Aplocheilus lineatus* (Valenciennes)	Golden Wonder Killifish	S, M, W
2.	*Barilius bakeri* (Day)	Blue dotted hill trout	W
3.	*Barilius gatensis* (Valenciennes)	Metallic hill trout	W
4.	*Chela dadiburjori* (Menon)	Dadio	AS
5.	*Chela fasciata* (Silas)		AS
6.	*Dwakinsia filamentosus* (Valenciennes)	Blackspot barb	EM, M, PM
7.	*Dwakinsia arulius* (Jerdon)	Arulius barb	EM, M, PM
8.	*Dwakinsia assimilis* (Jerdon)		EM, M, PM
9.	*Dwakinsia exclamation* (Pethiyagoda&Kottelat)		EM, M, PM
10.	*Dwakinsia tambraparni* (Silas)		EM, M, PM
11.	*Haludaria fasciata* (Jerdon)	Melon barb	
12.	*Haludaria melanampyx* (Day)		
13.	*Horabagrus brachysoma* (Günther)	Günther's cat fish	
14.	*Horabagrus nigricollaris* (Pethiyagoda&Kottelat)		
15.	*Horadandia atukorali* (Deraniyagala)		
16.	*Lepidocephalus thermalis* (Valenciennes)	Common spiny loach	
17.	*Macropodus cupanus* (Cuvier)	Spiketail paradise fish	
18.	*Nandus nandus* (Hamilton)	Gangetic leaf fish	S, EM
19.	*Nemacheilus traiangularis*		
20.	*Pethia conchonius* (Hamilton)	Indian rosy barb	S, EM, M, PM
21.	*Pethia gelius* (Hamilton)	Golden Dwarf barb	S, EM, M, PM
22.	*Pethia narayani* (Hora)	Narayan barb	S, EM, M, PM
23.	*Pethia nigripinnis* (Knight et.al.)		S, EM, M, PM
24.	*Pethia pookodensis* (Mercy & Jacob)		S, EM, M, PM
25.	*Pristolepis marginata* (Jerdon)	Malabar leaffish	
26.	*Pristolepis fasciata* (Bleeker)	Malayan leaffish	
27.	*Puntius ambassis* (Day)		S, EM, M, PM
28.	*Puntius bimaculatus* (Bleeker)	Redside barb	S, EM, M, PM
29.	*Puntius chola* (Hamilton)	Green swamp barb	S, EM, M, PM
30.	*Puntius dorsalis* (Jerdon)	Long snouted barb	S, EM, M, PM
31.	*Puntius fraseri* (Hora &Misra)	Dharna barb	S, EM, M, PM
32.	*Puntius melanostigma* (Day)		S, EM, M, PM
33.	*Puntius mahecola* (Valenciennes)		S, EM, M, PM
34.	*Puntius sarana* (Hamilton)	Olive barb	S, EM, M, PM
35.	*Puntius ticto* (Hamilton)		S, EM, M, PM
36.	*Puntius vittatus* (Day)	Kooli /Greenstripe barb	S, EM, M, PM
37.	*Sahyadria denisonii* (Day, 1865)	Denison barb	EM, M, PM
38.	*Sahyadria chalakudiensis* (Menon et.al.)		EM, M, PM
39.	*Schistura guentheri* (Day)		W
40.	*Tetraodon travancoricus*	Malabar pufferfish	M

AS: All Season; **W**: Winter; **S**: Summer; **M**: Monsoon; **EM**: Early Monsoon; **PM**: Post Monsoon

Table-3 Conservation status of some of the Native Freshwater Ornamental Fish of India

S. No.	Species	Conservation status						
		CR	EN	VU	LRnt	LRlc	DD	NE
1	*Aborichthys kempi* (Chaudhuri)	-	-	●	-	-	-	-
2	*Acanthocobitis botia* (Hamilton)	-	-	-	○	-	-	-
3	*Acantopsis choirorhynchos* (Bleeker)	-	-	-	-	-	-	●
4	*Ailia punctata* (Day)	-	-	●	-	-	-	-
5	*Amblycep Smangois* (Hamilton)	-	-	-	○	-	-	-
6	*Amblypharyngodon mola* (Hamilton)	-	-	-	-	●	-	-
7	*Anabas testudineus* (Bloch)	-	-	●	-	-	-	-
8	*Anabas oligolepis* (Bleeker)	-	-	-	-	-	-	●
9	*Anguilla bengalensis* (Gray& Hardwicke)	-	●	-	-	-	-	-
10	*Aorichthys aor* (Hamilton)	-	-	-	-	-	-	●
11	*Aorichthys seenghala* (Sykes)	-	-	-	-	-	-	●
12	*Aplocheilus panchax* (Hamilton)	-	-	-	-	-	●	-
13	*Apocryptes bato* (Hamilton)	-	-	-	-	-	-	●
14	*Aspidoperia morar* (Hamilton)	-	-	-	○	-	-	-
15	*Badis badis badis* (Hamilton)	-	-	-	-	-	-	●
16	*Badis badis burmanicus*	-	-	-	-	-	-	●
17	*Bagarius bagarius* (Hamilton)	-	-	●	-	-	-	-
18	*Barilius barila* (Hamilton)	-	-	●	-	-	-	-
19	*Barilius barna* (Hamilton)	-	-	-	○	-	-	-
20	*Barilius bendelisis* (Hamilton)	-	-	-	○	-	-	-
21	*Barilius bola* (Hamilton)	-	-	-	-	-	-	●
22	*Barilius dogarsinghi* (Hora)	-	+	-	-	-	-	-
23	*Barilius gatensis* (Valenciennes)	-	-	-	-	-	-	●
24	*Barilius guttatus* (Day)	-	-	-	-	-	-	●
25	*Barilius radiolatus* (Gunther)	-	-	-	-	-	-	●
26	*Barilius shacra* (Hamilton)	-	-	-	○	-	-	-
27	*Barilius tileo* (Hamilton)	-	-	-	○	-	-	-
28	*Barilius vagra* (Hamilton)	-	-	●	-	-	-	-
29	*Batasio batasio* (Hamilton)	-	-	-	-	-	-	●
30	*Batasio tengana* (Hamilton)	-	-	-	-	-	-	●
31	*Botia berdmorei* (Blyth)	-	●	-	-	-	-	-
32	*Botia dario* (Hamilton)	-	-	-	-	-	-	●
33	*Botia histrionica* Blyth	-	-	●	-	-	-	-
34	*Botia lohachata* (Chaudhuri)	-	●	-	-	-	-	-
35	*Botia rostrata* (Gunther)	-	-	-	-	-	-	●
36	*Brachydanio rerio* (Hamilton)	-	-	-	○	-	-	-
37	*Chaca chaca* (Hamilton)	-	●	-	-	-	-	-
38	*Chagunius chagunio* (Hamilton)	-	-	-	-	-	-	●
39	*Chanda nama* (Hamilton)	-	-	-	-	-	-	●
40	*Chandramara chandramara* (Hamilton)	-	-	-	-	-	-	●

S. No.	Species	Conservation status						
		CR	EN	VU	LRnt	LRlc	DD	NE
41	*Channa barca* (Hamilton)	-	-	-	-	-	-	-
42	*Channa marulius* (Hamilton)	-	-	-	-	-	-	-
43	*Channa punctatus* (Bloch)	-	-	-	-	-	-	-
44	*Channa stewartii* (Playfair)	-	-	-	-	-	-	-
45	*Channa striatus* (Bloch)	-	-	-	-	-	-	-
46	*Chaudhuria khajuriai* (Talwar, Yazdani&Kundu)-	-	-	-	-	-	-	-
47	*Chela cachius* (Hamilton)	-	-	-	-	-	-	-
48	*Chela laubuca* (Hamilton)	-	-	-	-	-	-	-
49	*Chitala chitala* (Hamilton)	-	-	-	-	-	-	-
50	*Cirrhinus reba* (Hamilton)	-	-	-	-	-	-	-
51	*Clarias batrachus* (Linnaeus)	-	-	-	-	-	-	-
52	*Clupisoma garua* (Hamilton)	-	-	-	-	-	-	-
53	*Clupisoma montana* (Hora)	-	-	-	-	-	-	-
54	*Colisa fasciatus* (Schneider)	-	-	-	-	-	-	-
55	*Colisa labiosus* (Day)	-	-	-	-	-	-	-
56	*Colisa lalia* (Hamilton)	-	-	-	-	-	-	-
57	*Colisa sota* (Hamilton)	-	-	-	-	-	-	-
58	*Conta conta* (Hamilton)	-	-	-	-	-	-	-
59	*Crossocheilus burmanicus* (Hora)	-	-	-	-	-	-	-
60	*Ctenops nobilis* (McClelland)	-	-	-	-	-	-	-
61	*Danio aequipinnatus* (McClelland)	-	-	-	-	-	-	-
62	*Danio dangila* (Hamilton)	-	-	-	-	-	-	-
63	*Danio devario* (Hamilton)	-	-	-	-	-	-	-
64	*Danio naganensis* (Choudhuri)	-	-	-	-	-	-	-
65	*Danio regina* (Fowler)7	-	-	-	-	-	-	-
66	*Dwakinsia filamentosus* (Valenciennes)	-	-	-	-	-	-	-
67	*Dwakinsia arulius* (Jerdon)	-	-	-	-	-	-	-
68	*Dwakinsia assimilis* (Jerdon)	-	-	-	-	-	-	-
69	*Dwakinsia exclamation* (Pethiyagoda & Kottelat)	-	-	-	-	-	-	-
70	*Dwakinsia tambraparni* (Silas)	-	-	-	-	-	-	-
71	*Erethestispussiles* (Mull. &Tros.)	-	-	-	-	-	-	+
72	*Esomus danricus* (Hamilton)	-	-	-	-	+	-	-
73	*Eutropiichthys vacha* (Hamilton)	-	+	-	-	-	-	-
74	*Gagata cenia* (Hamilton)	-	-	-	-	-	-	+
75	*Gagata sexualis* (Tilak)	-	-	-	+	-	-	-
76	*Garra annandalei* (Hora)	-	-	-	-	-	-	+
77	*Garra gotylagotyla* (Gray)	-	-	+	-	-	-	-
78	*Garra gravelyi* (Annandalei)	-	-	-	-	-	-	+
79	*Garra kempi* (Hora)	-	-	+	-	-	-	-
80	*Garra lamta* (Hamilton)	-	-	-	-	-	-	+
81	*Garra lissorhynchus* (McClelland)	-	-	+	-	-	-	-
82	*Garra mcClellandi* (Jerdon)	-	-	-	-	-	-	+
83	*Garra naganensis* (Hora)	-	-	+	-	-	-	-
84	*Garra nasuta* (McClelland)	-	-	-	-	-	-	+

S. No.	Species	Conservation status						
		CR	EN	VU	LRnt	LRlc	DD	NE
85	*Garra rupecula* (McClelland)	-	-	●	-	-	-	-
86	*Glossogobius giuris* (Hamilton)	-	-	-	○	-	-	-
87	*Glyptothoraxcavia* (Hamilton)	-	●	-	-	-	-	-
88	*Glyptothorax striatus* (McClelland)	-	-	●	-	-	-	-
89	*Haludaria fasciata* (Jerdon, 1849)	-	-	-	-	●	-	-
90	*Haludaria melanampyx* (Day, 1865)	-	-	-	-	-	-	●
91	*Horabagrus brachysoma* (Gunther, 1864)	-	-	●	-	-	-	-
92	*Horabagrus nigricollaris* (Pethiyagoda &Kottelat, 1994)-		●	-	-	-	-	-
93	*Hara hara* (Hamilton)	-	-	-	-	-	-	●
94	*Hara jerdeni* (Day)	-	-	-	-	-	-	●
95	*Heteroneustes fossilis* (Bloch)	-	-	●	-	-	-	-
96	*Labeo angra* (Hamilton)	-	-	-	○	-	-	-
97	*Labeo bata* (Hamilton)	-	-	-	○	-	-	-
98	*Labeo boga* (Hamilton)	-	-	-	○	-	-	-
99	*Labeo calbasu* (Hamilton)	-	-	-	○	-	-	-
100	*Labeo dero* (Hamilton)	-	-	●	-	-	-	-
101	*Labeo gonius* (Hamilton)	-	-	-	○	-	-	-
102	*Labeo nandina* (Hamilton)	-	-	-	-	-	-	●
103	*Laguvia ribeiroi* (Hora)	-	-	-	○	-	-	-
104	*Laguvia shawi* (Hora)	-	●	-	-	-	-	-
105	*Lepidocephalus annandalei* (Chaudhuri)	-	-	-	○	-	-	-
106	*Lepidocephalus berdmorei* (Blyth)	-	●	-	-	-	-	-
107	*Lepidocephalus guntea* (Hamilton)	-	-	-	-	-	-	●
108	*Lepidocephalus irrorata* (Hora)	-	-	●	-	-	-	-
109	*Macrognathus aral* (Bloch & Schneider)	-	-	-	○	-	-	-
110	*Macrognathus pancalus* (Hamilton)	-	-	-	○	-	-	-
111	*Mastocembelus armatus* (Lacepede)	-	-	-	-	-	-	●
112	*Mystus tengara* (Hamilton)	-	-	-	-	-	-	●
113	*Mystus vittatus* (Bloch)	-	-	●	-	-	-	-
114	*Nandus nandus* (Hamilton)	-	-	-	○	-	-	-
115	*Neolissocheilus hexagonolepis* (McClelland)	-	-	-	-	-	-	●
116	*Notopterus notopterus* (Pallas)	-	-	-	○	-	-	-
117	*Olyralongi caudata* (McClelland)	-	-	-	-	-	-	●
118	*Ompok bimaculatus* (Bloch)	●	-	-	-	-	-	-
119	*Ompok pabda* (Hamilton)	-	●	-	-	-	-	-
120	*Oreichthys casuatis* (Hamilton)	-	-	-	-	-	-	●
121	*Osteobrama cotio cotio* (Hamilton)	-	-	-	○	-	-	-
122	*Pangasius pangasius* (Hamilton)	●	-	-	-	-	-	-
123	*Pethia nigripinnis* (Knight *et.al.*)	-	-	-	-	-	-	●
124	*Pseudambasis baculis* (Hamilton)	-	-	-	-	-	-	●
125	*Pseudambasis ranga* (Hamilton)	-	-	-	-	-	-	●
126	*Pseudeutropius atherinoides* (Bloch)	-	-	-	-	-	-	●
127	*Psilorhynchus balitora* (Hamilton)	-	-	-	-	-	-	●
128	*Psilorhynchus sucatio* (Hamilton)	-	●	-	-	-	-	-

S. No.	Species	Conservation status						
		CR	EN	VU	LRnt	LRlc	DD	NE
129	*Puntius chola* (Hamilton)	-	-	●	-	-	-	-
130	*Puntius clavatus* (McClelland)	-	●	-	-	-	-	-
131	*Puntius conchonius* (Hamilton)	-	-	●	-	-	-	-
132	*Puntius filamentosus* (Valenciennes)	-	-	-	-	-	-	●
133	*Puntius fraseri* (Hora and Misra)	-	-	-	-	-	-	●
134	*Puntius gelius* (Hamilton)	-	-	-	-	-	-	●
135	*Puntius guganio* (Hamilton)	-	-	-	●	-	-	-
136	*Puntius phutunio* (Hamilton)	-	-	-	-	●	-	-
137	*Puntius sarana orphoides* (Valenciennes)	-	-	-	-	-	-	●
138	*Puntius sarana sarana* (Hamilton)	-	-	●	-	-	-	-
139	*Puntius shalynius* (Yazdani&Talukdar)	-	-	●	-	-	-	-
140	*Puntius sophore* (Hamilton)	-	-	-	●	-	-	-
141	*Puntius terio* (Hamilton)	-	-	-	●	-	-	-
142	*Puntius ticto*(Hamilton)	-	-	-	●	-	-	-
143	*Puntius vittatus* (Day)	-	-	-	-	●	-	-
144	*Rasbora daniconius* (Hamilton)	-	-	-	-	-	-	●
145	*Rasbora rasbora* (Hamilton)	-	-	-	-	-	-	●
146	*Rhinomugil corsula* (Hamilton)	-	-	●	-	-	-	-
147	*Rita rita* (Hamilton)	-	-	-	●	-	-	-
148	*Sahyadria denisonii* (Day,1865)	-	●	-	-	-	-	-
149	*Sahyadria chalakudiensis* (Menon *et.al.*)	-	●	-	-	-	-	-
150	*Salmostoma bacaila* (Hamilton)	-	-	-	-	●	-	-
151	*Schistura beavani* (Gunther)	-	-	-	-	-	-	●
152	*Schistura denisoni dayi* (Hora)	-	-	-	-	-	-	●
153	*Schistura guentheri* (Day, 1867)	-	-	-	-	●	-	-
154	*Schistura multifasciatus* (Day)	-	-	●	-	-	-	-
155	*Schistura savona* (Hamilton)	-	-	-	-	-	-	●
156	*Schistura scaturigina* (McClelland)	-	-	-	-	-	-	●
157	*Schistura sikmainensis* (Hora)	-	-	-	-	-	-	●
158	*Sicamugil cascasia* (Hamilton)	-	-	●	-	-	-	-
159	*Sisorrhabdophis* (Hamilton)	-	●	-	-	-	-	-
160	*Somileptes gongota* (Hamilton)	-	-	-	●	-	-	-
161	*Strongylura strongylura* (Van Hasselt)	-	-	-	-	-	-	●
162	*Tetradon cutcutia* (Hamilton)	-	-	-	●	-	-	-
163	*Tetraodon travancoricus*	-	-	●	-	-	-	-
164	*Tor chelynoides* (McClelland)	-	-	-	-	-	-	●
165	*Tor putitora* (Hamilton)	-	●	-	-	-	-	-
166	*Tor tor* (Hamilton)	-	●	-	-	-	-	-
167	*Wallago attu* (Schneider)	-	-	-	●	-	-	-
168	*Xenentodon cancila* (Hamilton)	-	-	-	●	-	-	-

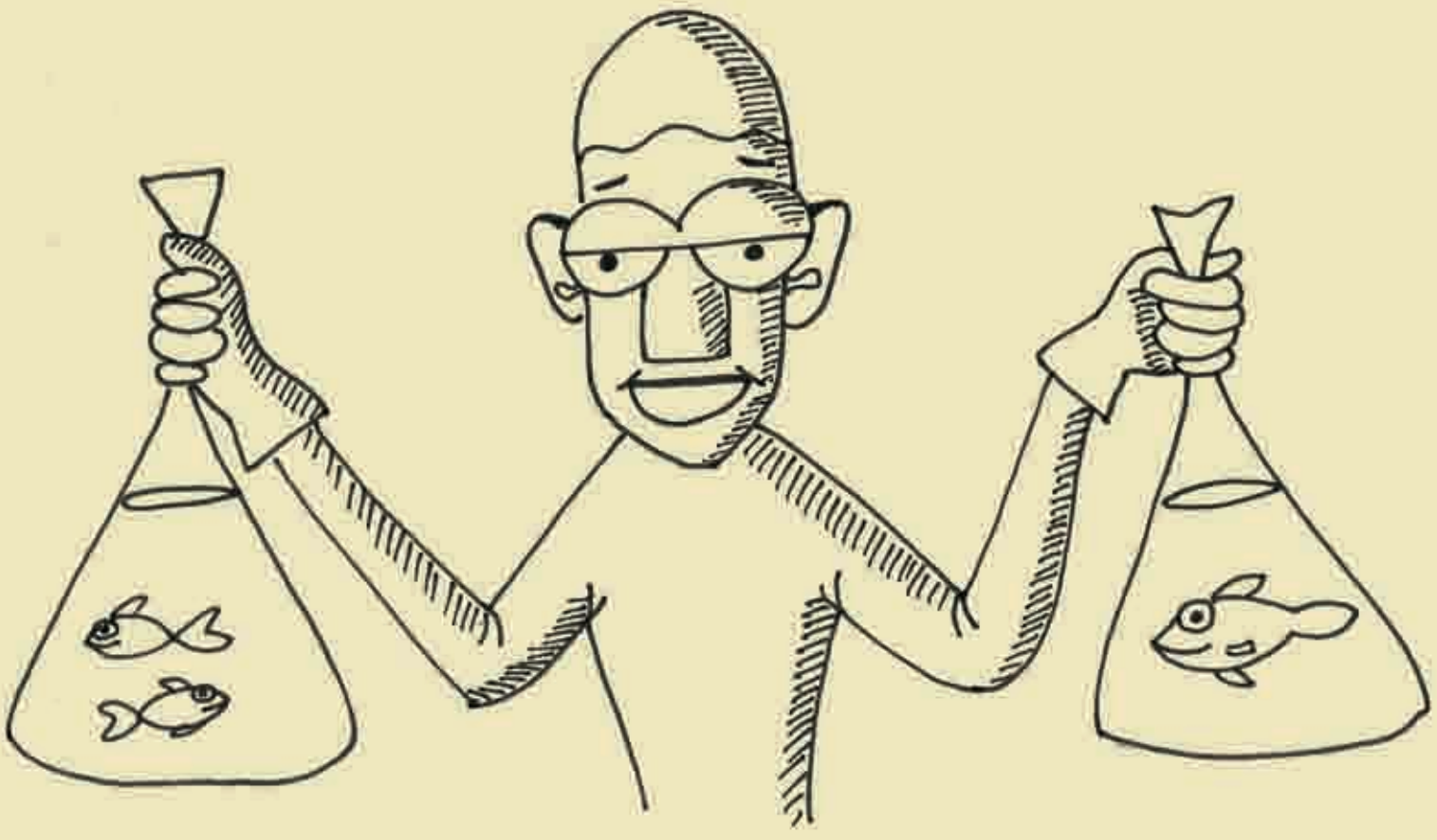
● CR= Critically endangered; ● EN= Endangered; ● VU = Vulnerable; ● LRnt= Near threatened;
● LRlc= Least concern; ● DD = Data Deficient; ● NE = Not evaluated

Chapter 11

Conditioning and packaging of ornamental fish for transportation

Hanson K. Mathew, T.V.Anna Mercy and B.K.Mahapatra

Inside...



Conditioning and packaging of ornamental fish for transportation

1. An Overview

Ornamental fish which is either caught from wild sources or produced at a production facility is transported to different places either for reselling or marketing to hobbyists. The transportation distance may range from a few kilometres to thousand kilometres depending whether it is to be transported locally, interstate or overseas. Fish could be transported in open tanks if transported locally but need to be packed in Low Density Polyethylene (LDPE) bags for long distance transport. These bags are subsequently packed in corrugated board boxes in case of interstate transport and polystyrene boxes in case of overseas transport. However, the packaging of fish is not that simple as it appears. There are many factors that are to be considered in advance which involve conditioning of fish prior to packaging, duration of transport, number of fish to be packed, species to be packed, size of the packaging box, location of destination, means of transport, etc. A wrong decision or practice results in increased cost, heavy mortalities and loss of goodwill of the supplier. A proper planning about conditioning, packaging and transportation system not only maximizes the number of fish to be transported with smaller quantity of water but also ensure bio-security an issue of serious concern in case of export consignments. A set of "Best Management Practices" is suggested to help the fish producers to improve the efficiency of ornamental fish packaging practices.

2. BMP-1 : Harvest and handle your fish carefully irrespective of whether it is pond reared or tank reared

An ornamental fish producer will be either rearing fish in ponds or tanks. However, to improve the efficiency of conditioning all the pond reared fish are to be shifted to tanks. The harvesting of fish from ponds and its shifting to tanks needs to be done carefully so that neither there is any damage to scales or fins nor to other body parts of the fish.

Guiding factor for BMP-1

2.1 Preparing the fish for conditioning (Nutritional prophylaxis)

Fish are stocked at high density under intensive system during the process of conditioning. It puts the fish under stress due to several physiological changes owing to change in water chemistry. In order to reduce the stress & improve resistance to diseases, fish are fed vitamin C supplemented diets (8-10%) for two weeks in advance prior to harvesting.

2.2 Ensure the plan of action before harvesting

Before starting to harvest fish from ponds, there must be a plan of action so that the harvesting event is conducted in a quick and efficient manner. Additional factors, such as the number of fish needed to fill an order, the number of workers available, the amount of time available for harvesting, and the weather, should be taken into account. A careful consideration and preparation before and during harvest results in a high quality product. Pre-arrangements shall be made to keep all the tanks ready with water and aeration before the start of netting. The number of tanks required should also be decided depending on the number of fish to be harvested.

2.3 Decide a proper harvesting method

It is the producer's responsibility to choose the best harvesting technique- whether trap or seine - for the fish species being raised and for the quantities required. Care should always be taken to reduce or eliminate the amount of stress placed on the fish regardless of the method chosen. The harvesting method will be different for different species. For example, angel fish could be collected by reducing water depth in pond to 1 -2 feet. Most of the angel fish will group themselves in different corners that can be collected by nets. About 90% fish could be collected in two or three trials.

2.4 Mesh size & quality of netting material

The netting material should be soft and mesh size of the net shall be as per the requirement. Smaller fish up to 2" length could be collected by using monofilament nets of 1/20" mesh size where as larger fish up to 4-5" could be collected through knotless nylon nets of ¼" mesh.

2.5 Handling & shifting of fish to tanks

One of the most important factors in moving fish from a pond to the holding facility is the source of water used in the transport container. Water taken directly from the pond or aerated well water or a half-pond / half-aerated well water mixture can be used to transport the harvested fish. A fish should remain completely intact while being shifted from one facility to the other. The best method of handling any fish is that it should be least touched by hand and should remain in water only.

3. BMP-2: A proper conditioning of fish prior to packing is the key to the success of entire packing and transport process

Conditioning refers to clearing the fish of all the gut contents and acclimatization to the tank environment. It is during the conditioning processes that fish are graded according to the size and damaged fishes are removed.

Guiding factors to BMP-2

3.1 Removal of dead or damaged fish

Once all the fish are shifted to tank from pond, dead fish, if any, should be removed and disposed off safely. Any damaged or injured fish should also be removed and shifted to quarantine tanks.

3.2 Grading as per size

Ornamental fish will attract better price if these are of the same size. Hence, fish are graded according to the size. Grading could be done manually or by auto grading systems that uses screens of different mesh sizes.

3.3 Water exchange

The water of the conditioning tanks is treated with common salt @ 3 gm/litre and about 70% water is exchanged daily. Fish are kept in conditioning tank for 1-2 days and now could be termed as "Tank Fish". Fish should be visually examined very carefully for any external parasites, or any sign of distress like erratic swimming, clamped-fins, abnormal opercular movement etc.

3.4 Shifting in glass tanks

Fish are thereafter counted and shifted to glass tanks which are also provided with aeration and water re-circulation facility. Since grading and counting consumes a lot of time, it should be done well in advance. The water is treated with methylene blue (@ 0.0035 ppm) and common salt (@ 0.1 ppt). Fish are kept there for a minimum of 1 to 2 days as per the packing schedule.

4. BMP-3: Fish should be starved before packaging to allow higher packing densities

Fish may vomit or defecate in the bags when not purged. It will also contaminate the water in the packing bag leading to bacterial blooms. Starving also slows the metabolic rate of the fish. It helps in reducing oxygen requirements of the fish, reduces ammonia and carbon dioxide output and allows higher packing densities.

Guiding factors for BMP-3

4.1 Period of starving

Most species require a starving period of 1 day prior to transport but larger fish and herbivorous fish may need 2 or more days for sufficient starving. Mollies may require still longer period for starving.

4.2 Stage of starving

Starving cannot be done in ponds or tanks where there are natural foods available. It is generally not possible to achieve good purging in production ponds and it is recommended that this be undertaken in glass tanks only.

5. BMP-4: Selection of proper packaging material will ensure safe arrival of consignment at destination

Fish which is packed in LDPE bags and kept either in corrugated or polystyrene boxes reaches its destination either through road, rail or air or a mix of all. Sometimes these boxes are not kept properly in the ware-house/cargo of the railway station/airport and also not handled properly. Hence, it is needed that packaging bags and boxes are convenient to handle and don't get damaged during transport. A water leakage from any bag is also a matter of serious concern.

Guiding factors for BMP-4

5.1 Thickness and shape of packaging bags

Proper thickness of LDPE packaging bags is very important. A LDPE bag of 250 micron thickness is more desirable. Many a times some supplier will select bags of less thickness but it is unsafe. The shape of packaging bag is also important. In domestic market packaging bags that are sealed straight at corners are commonly used whereas in international trade curved sealing is preferred. The use of bags with straight corners is not good for smaller size of fish as these will conglomerate at these corners. Therefore the corners could be tied with a rubber band.

5.2 Size of packaging bags

Size of packaging bags is also very important as the number of fish packed depends on the size of bag. The number of fish that could be packed in a bag is directly proportional to size. In domestic trade, the most commonly used bag sizes are 5" x 12", 12" x 20" and 18"x 24" whereas in international trade the bags of 3" x 9" to 13" to 26" are used.

5.3 Size and material of packaging box

The poly bags are packed in a box for safe handling of fish. The boxes of large sizes are not preferred as poly bags are arranged in a layer only and not stacked one upon other. Secondly, it is difficult to handle large size boxes. In domestic trade corrugated boxes of 3-5 ply are used whereas in international trade boxes of polystyrene are used. The most common sizes of polystyrene boxes used by exporters of Southeast Asian countries are 60 (L) cm x 42 (W) cm x 30 (H) cm and 49 (L) cm x 38 (W) cm x 38 (H)

5.4 Advantage of poly-styrene boxes

The poly-styrene boxes provide insulation against temperature and also reduce the risk of water leakage from box. The minimum wall thickness of boxes should be 2.5 mm but should be thicker if temperature of the destination country is very low. The guidelines of the International Air Transport Association (IATA) should be followed to decide the maximum weight that can be shipped in a box of specific size.

6. BMP-5: Optimize the packing density according to the duration of transport and size of the fish

The number of fish that are to be packed in a bag needs to be perfectly calculated. It depends on the size of fish as well as duration of transport. The quantity of water, quality of oxygen and process of packaging are other important factors for consideration

Guiding factors for BMP-5

6.1 Determining of stocking density

The stocking density of fish is determined considering many factors specified in Table-1 and the number of fish that could be packed in a bag of a specific size is stated in Table-2 for approximate travel duration of 48 hrs. In general practice, about 200 g (25 fishes of 3" length) total biomass of gold fish or 30 g (100 fishes of 1.25" length) of guppies could be packed in one litre of water under standard conditions.

6.2 Ratio of water and oxygen

It is to be ensured that there is enough reserve of dissolve oxygen in the bag when it reaches at destination. Fish are packed in plastic bags filled with 1/3 water and 2/3 oxygen. However, it is to be ensured that only pure oxygen is used not air. Secondly, it shall be ensured that all the air is removed from the bag before filling-in with oxygen. Other points to be remembered are that

Table-1: Factors affecting packing density of fish

Factor	Comment
Species tolerance to stress	Species tolerance varies, some are notoriously difficult to ship and need extra care or lower packing density
Size of fish	As the size increases the packing density decreases. This is because production of carbon dioxide and ammonia increases
Transit time	The longer the transit time (this should include from the time of packing to the time of unpacking) the lower the packing density. This is because the longer the fish are in bags, the more metabolites will accumulate
Temperature	Fish are 'cold-blooded' and lower temperatures (within a species tolerance range) reduce metabolite production and increase possible transit times. Higher temperatures increase metabolite production and can also stimulate bacterial production in packing water
Health and Stress status of fish prior to packing	Health status of fish prior to shipping is vital for successful shipping. Fish that are already stressed or of poor health will need to be packed at lower density or better not packed at all
Chemical and other additives	Packing water can be modified to include salts, anaesthetics, ammonia-binding agents too.

bags should be properly inflated and reasonably tight but should not be overfilled as during a flight the bags decompresses a bit and expand leading to burst or leak in flight.

6.3 Removal of ammonia

Ammonia is highly toxic to fish in its un-iodised form. It accumulates in packaging bags due to excretion of fish and bacterial action on the excreta. A level of 0.05 ppm could be harmful for the fish. It could be controlled by adding granules/rings of zeolite @15-20 g/litre of water.

6.4 Slowing down of metabolic activities

The success of transportation could be further enhanced by adding certain additives in packing bags. The most commonly used additives are Eugenol (5 mg/l), Quinaldine (5 mg/l) and MS-222 (20 mg/l). However, it should be ensured that dosages are proper and the use of sedatives is permitted by the importing country.

Table-2: Packing densities in relation to size of fish per bag

Fish length	TRANSPORT TIME*	
(inches)	48 hrs.	72 hrs.
1.5	200	150
2.0	150	100
2.5	100	75
3.0	75	50
4.0	50	35
5.0	20	12
6.0	15	10

*Experience adds to more accuracy

7. BMP-6: A proper process of packaging will ensure safe arrival of fish at destination

Subsequent to preparing of consignment for packaging, a standard set of operating protocols shall be followed to reduce the transport mortalities. It includes preparing the water to be used in packaging, pre-packaging acclimatization and final packaging. The practice of pre-packaging acclimatization is not followed in domestic trade but is better to be followed in case of long distance transportation. However, it is a compulsory component in export trade.

Guiding factors for BMP-6

7.1 Preparing of water for packaging

Water to be used for packaging shall be prepared in advance. The required quantity of clean water is stored in clean tanks and it is treated with common salt (3 gm/l) and methylene blue (2 mg/l) or acriflavine (7 mg/l). The addition of common salt will aid in osmoregulation whereas methylene blue or acriflavine acts as anti-microbial agent.

7.2 Pre-packaging exercise ensures high transportation survival

Once fish are sufficiently starved they can be pre-packed into bags so as to acclimate fish to packing conditions. It allows 'weak' or stressed fish to be identified and removed from consignments prior to shipping. This stage is also important in terms of a final quality check before packing and shipping. Pre-packaging involves oxygen packing of counted numbers of fish in standard poly bags at densities mentioned above. The bags are placed on racks/trolleys in an air-conditioned room at 22-23°C in dark for 4-6 hours in case of tropical fish and at 15-18°C in case of coldwater fish. The details of species, total number of fish and their average size shall be mentioned with the help of a marker pen on the bags.

7.3 Final packaging

A required quantity of pre-treated water is filled up in poly bags as specified above according to the size of bags. It shall be ensured that the temperature of water being filled in bags is same as that of pre-packed bags after acclimatization period. The bag filled up with water is now placed in another bag of same dimensions. Inserting of a news paper in between the two bags provides additional safety against water leakage and also reduces stress to fish due to excess light. Thereafter, fish are transferred to the new bag with the help of a hand net of very soft material. The air inside the bag is expelled and replaced with oxygen. The bag is then sealed by twisting the top of the bag and folded over, with rubber bands or metal clips used to fasten the top of the bag. In domestic trade bags are tied with rubber bands while in international trade tying with metal clips is popular and a fast process. The details of species, total number of fish and average size are again mentioned with the help of a marker pen on the bags.

7.4 Packaging of aggressive fish

All aggressive fish like fighter fish and most of the cichlids, or fish with fragile finnage like veil tail angel, pearl gouramis, bubble eye gold fish or costly fish like arowana or discus are packed individually to prevent them from attacking each other or that the fins remain intact on arrival.

7.5 Box packing of poly-bags

It shall be ensured that poly-bags stocked with fish are properly kept in boxes meant for transportation. The important points to remember are:

a. Bags are kept straight and not stacked upon each other.

b. There is no sharp object inside the box.

c. Once all the poly-bags are kept in the box, these are to be covered with a news paper before closing the box.

d. In case of a very long duration transport ice packs can be placed in the box but not inside the poly-bags.

Important Suggestions

- Transport time should be shortened as much as possible. This can be achieved through proper planning, coordination of the procedure of harvesting, conditioning and counting
- Examine and evaluate the quality of fish prior to packaging. Only healthy and good quality fish with strong stress resistance should be packed to increase their chances of survival.
- Fish should be starved minimum for one day prior to packaging.
- Water quality shall not change from conditioning tank to packing bags.
- Screening of the fish starts from the time the fish are counted to actual packing in polyethylene bags.
- Pre-packing acclimatisation at low temperature (22-25^{0}C) improves the success of transportation.
- As counting of fish is one of the most time consuming tasks, it should be performed in advance.
- Sorting and grading of fish according to size and colour should be done in advance to get a good visual impression about the fish.
- Nutritional prophylaxis should be done before harvesting of fishes.
- Optimise the packing density according to the duration of transport.
- Only fresh poly-bags shall be used for fish packaging by to reassure against leakage.
- Aggressive and sensitive fish shall be packed individually.
- It is important to get feedback from the customers. The fish should speak for us as they are our ambassadors for further marketing.

Chapter 12

Record keeping at ornamental fish production and marketing establishments

V.P. Saini

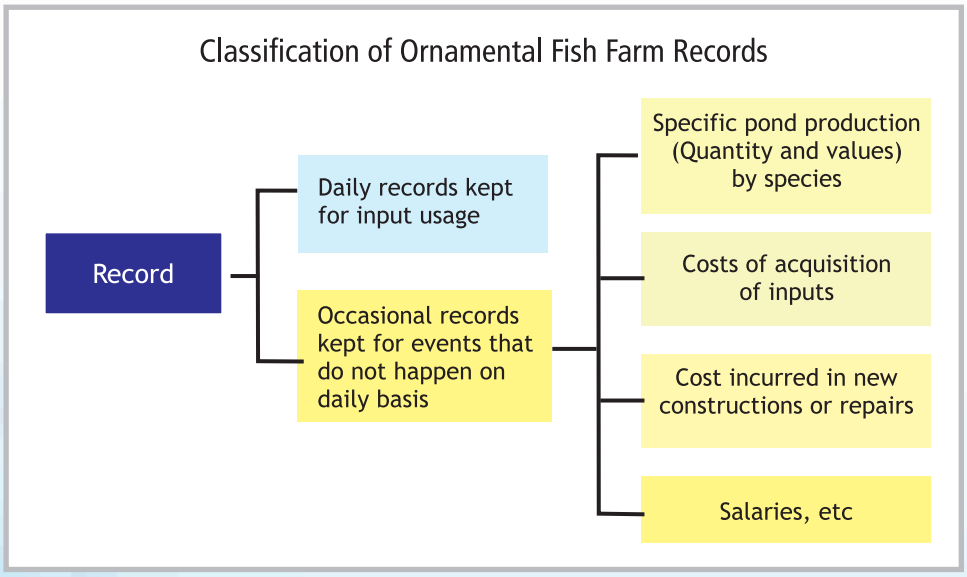
Inside...

1. An overview

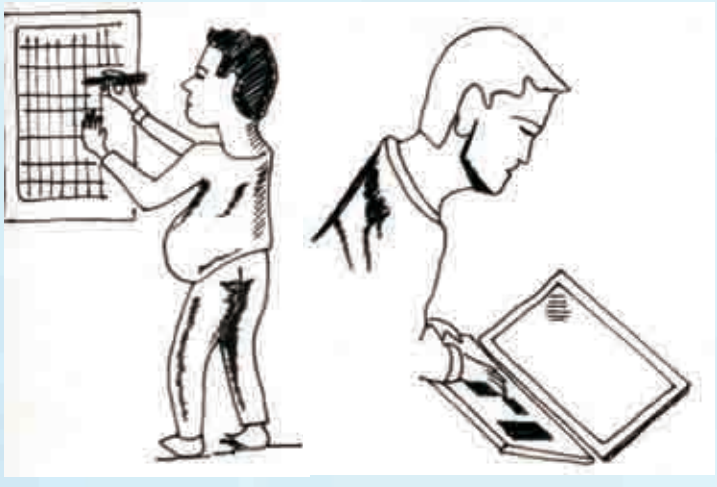
One of the main drawbacks on the economic operation of ornamental fish investment in India is the lack of deliberately kept economic records of production operations. Investors who operate without records are likely to make wrong decisions due to lack of information of what is happening at their farms. The best sources of information needed to advice on proper running of ornamental fish farm are the properly designed and kept farm records. Record is information that has been systematically and carefully collected and appropriately stored for intended use. In order to run any business successfully, carefully thought out, properly collected and kept records are a must. For the purpose of keeping track and decision making in ornamental fish business, comprehensive and well maintained records must be kept. Just as in any other enterprise, properly collected and kept records are also important in ornamental fish farming. The properly maintained records can be used:

Record keeping facilitates smooth functioning and reduces risk for an enterprise

- to determine profitability of various techniques of production
- to compare the efficiency of use of inputs, such as land, labour and capital, with that of alternative production activities
- to help the investor in improving the efficiency of farm's operations
- to preserve institutional memory of the enterprise for future reference.
- to forecast the production
- to determine the amount of inputs required for specific activity
- to determine the financial health of the enterprise



Farm record keeping methods



Farm record keeping methods range from the simple manual record (note book & log book) to sophisticated computer accounting systems. The manual farm record book remains the old stand-by for farm record keeping due to its ease of use while the computer accounting systems vary in complexity and need for technical assistance. Many of the programmes available require some computer knowledge offer enough to fast and accurate management records. There are numerous kinds of farm record keeping systems available in the market. For example, TALLY & QUICKEN computer software are widely used to keep financial records and Microsoft excel for input output records. Review the different options before finalizing on the right system for your operation and decide for one that fits your specific farm operation. It is important to keep farm records as simple as possible but to record all necessary details in order that the performance of the farm operation can be fully evaluated.

2. BMP-1: Keep Identification (ID) records for tracking farm facilities and fish stock

The identification records of farm facilities and fish brood stock are essential for farm manager to track the production, sale, breeding performance of individual fish and to give instructions to farm workers. Giving the fish name/number and keeping a table with the characteristics of the fish and link it to the name can work in many cases. The methods of identification can be subdivided into 2 categories: internal (PIT) and external (fin clipping, paint and dye, fin tagging, etc.).

Guiding factors for BMP-1

2.1 Prepare a detailed layout plan for all the facilities (i.e. ponds, buildings, net houses, etc.) available at farm

2.2 Give a unique ID number to each facility

2.3 The ID number should be printed/displayed on each site

2.4 The method of fish identification employed must cause minimal suffering to fish both during and after the marking process

2.5 Large sized fish can be tagged individually using PIT. However, for marking small sized fish external tagging would be safer

2.6 No matter, which type of tagging/ marking is opted, but it should be reasonably quick & simple to apply and easy to read/identify

Table 1. Log Book Format for Buildings ID Record

S.No	Building/Room/ Hall/Net house	ID No	Area	Use	Year of Construction	Construction cost

Table 2. Log Book Format for Ponds/Tanks ID Record

S.No	Ponds / Tanks	ID No	Size / Area	Year of Construction	Construction cost

Table 3. Log Book Format for Fish (brood stock) ID Record

S.No	Fish species	Source of procurement	Type of ID	ID No.	Special characteristics	Remarks

3. BMP-2: Keep breeding and seed rearing records for timely planning of marketing

The importance of breeding records is to measure the productive efficiency of the fish and to enable selection. For example, many farmers would like the fish which gives higher number of babies. Therefore, an accurate up-to-date breeding record of each individual is necessary (Table 4-5). The most important data in breeding records include: parentage (name or other identification of parents), fecundity, growth rate of offspring, etc.

Guiding factors for BMP- 2

3.1 Species wise, variety wise and sex wise number of brood stock used

3.2 Sex ratio of brood fish should also be recorded

3.3 Details of hormones used (type & dosage)

3.4 Breeding indices (species wise & variety wise fertilization, hatching and survival rates) be recorded carefully

3.5 Details of feeds used in nursery pond – type and quantity

3.6 Water quality in hatching and, nursery tanks/ponds

3.7 Stocking density in the culture system- species & variety wise

3.8 Duration of rearing & harvesting details

3.9 Survival percentage in the nursery system

3.10 Total value of harvested seed, etc. be recorded in log book for each and every cycle of breeding and nursery rearing

Table-4: Log Book Format for Breeding Records

Date	Species (Fish)	Fish ID	Size of Fish	Sex ratio (F:M)	Hormone Used & Dosages	Fertilization (%)	Fecundity (Nos./g BW)	Hatching (%)	Total number of Larvae

Table-5: Log Book Format for Seed Rearing records

Date	Species (Fish)	Type of Rearing facility & ID No	Nos stocked per m^3	Type of Feed used	Feeding Rate	Rearing period	Size at harvest	Survival (%)	Total Fry (Nos)	Rate per Fry	Total Cost of harvested fry

4. BMP-3: Keep production records to monitor the production performance and profitability

These records are useful in measuring the performance of the fish. It contributes greatly to the economic appraisal of the enterprise. It can help farmers take decisions on investments, based on how many fish produced how much on the farm, so how much surplus can the farmer expects? The records can also be used by the whole sector to improve the genetics of the fish in the country, with specific focus on the production. Production records are kept of - fish products like eggs per fish per breeding cycle and phenotypic quality data. Production records are also necessary when farmers start selling the products and want to know of the balance available every day or every week or in a certain period. The intent of these records is to provide management with an accurate list of products sold (Table 6-8).

4. Guiding factors for BMP-3

4.1 Each expense or input item for pond/tank management and ornamental fish rearing should be described in as much detail as possible. e.g. pond management (fertilization, liming, etc.), stocked species and size.

4.2 Each item used, its date of application, its amount, its unit cost, and its total cost should be recorded.

4.3 As each pond is harvested, the following items should be recorded – date of harvest, species harvested, and amount harvested, and price received per unit.

Table-6: Log Book Format for Pond Management Records

S.No	Pond/ Tank ID	Date	Type of Input	Quantity of input	Unit cost	Total cost (Rs)	Remarks

Table-7: Log Book Format for Stocking Records

S.No	Pond/ Tank ID	Date	Species	Source of Stocking	Stocking Rate	Average size	Total Nos	Unit cost	Total Cost

Table-8: Log Book Format for Harvesting Records

S. No	Pond/ Tank ID	Date	Species harvested	Quantity Harvested (Nos)	Recovery/ Survival (%)	Average size at harvest	Unit Price (Rs/fish)	Total Value (Rs)

5. BMP-4: Keep feeding records to save feed cost and availability of feed in store

Feeding records give information about the amount, type and quality of the feed. Feeding records can be used both for day to day management and adjustment of the feed ration (Table-9). It can be used for planning of activities related to feed conservation, etc.

Guiding factors for BMP-4

5.1 Feed costs are the single greatest expense in raising fish

5.2 A careful feeding schedule results in rapid and efficient fish growth

5.3 Carefully observe if there is any amount of feed leftover at the end of day

5.4 In case the fish is not consuming all the feed in reasonable time, the amount of feed should be reduced. It will avoid the wastage of feed and also help in maintaining water quality

Table-9: Log Book Format for Feeding Records

S.No	Pond/ Tank ID	Date	Species (Fish)	Number of Fishes	Type of Feed	Feed Quantity	Balance Feed in Store	Feeding schedule	Unit Cost	Total cost

6. BMP-5: Keep disease and treatment records to prevent diseases outbreak

Disease and treatment records are necessary to keep track of the disease. It can guide to better management practices by leading the attention to repeated events or certain vulnerable groups of fish over time. It provides information about the health status of fish and it can help ensuring important treatments given at the right time. On basis of the disease and treatment records, success of interventions both for prevention and treatment can also be evaluated (Table-10). Disease and treatment records can for example involve: disease occurrence and date, treatments, etc.

Guiding factors for BMP-5

6.1 While precautions should be taken to prevent diseases, close monitoring and data recording are equally important.

6.2 Carry out a simple heath inspection routine every day or weekly. Observe fish behavior, see if the fish is showing abnormal feeding or swimming pattern

6.3 If diseases symptoms are detected, seek assistance from the expert and record all the information in record log book.

Table-10: Log Book Format for Disease and Treatment Records

S.No	Pond/ Tank ID	Date	Species (Fish)	Diseases	Treatment	Cost of Treatment	Mortality (%)	Method of dead fish disposal

7. BMP-6: Keep weather condition and water quality records for improving production performance

It is suggested that a proper record of water quality (temperature, oxygen, ammonia, pH and nitrite levels) be kept (Table-11). It will facilitate to notice the problems well before they become threat to the fish.

Guiding factors for BMP 6

7.1 Each ornamental fish production unit should have some means of evaluating water quality in order to be aware of the health of the fish culture system

7.2 Water quality analysis kits are popular for this purpose because they are relatively inexpensive

7.3 Monitor and record water quality daily that will help you to foresee the problems in advance and thereby avoid problems.

Table-11: Log Book Format for Water Quality Monitoring Records

S.No	Pond/ Tank ID	Date	Weather Parameters			Water Quality Parameters						
			AirTemp (°C)	Rainfall (mm)	Humidity (%)	Temp (°C)	Colour	pH	DO (mg/l)	Hardness (mg/l)	Nitrate (mg/l)	Ammonia (mg/l)

8. BMP-7: Keep financial records to track the financial flow and economics of operations

The records of the costs and earnings related to the ornamental fish farming be kept for cash analysis and enterprise appraisal. In aquaculture, the most necessary records are simple overview over the cash flow that is the total economy of the farm: what comes in? and what do we buy? In addition to this, keeping records of the ornamental fish enterprises is an important part, because it can show whether it gives an income to the family or not. The financial records will also help farmer to see what they invest in it, and what it costs to produce it. Also in relation to the ornamental fish farm, an investment is more than expenditure? an investment hopefully enables and improves the production in the future. Economic records are of paramount important in providing the farmer with information concerning the profitability. Moreover, economic records are required for tax purposes and for the purpose of getting loans & credits (Table 12 -16).

Guiding factors for BMP- 7

8.1 Progress in ornamental fish business operation cannot be determined from year to year without an annual inventory.

8.2 Using the cash method for record keeping (i.e. keeping a record of receipts, expenses, and purchase cost of feed, fish sold during the year, plus depreciation schedules) will suffice to arrive at net income

8.3 Producers should maintain a balance sheet, a statement of owner equity, an income statement and cash flow statement.

Table-12: Log Book Format for Investment and Finances Record

S. No	Particulars	Year(s)										Total
		I	II	III	IV	V	VI	VII	VIII	IX	X	
1	**Investment**											
a	Land											
b	Buildings											
c	Equipment and Material											
d	Ponds/tanks											
e	Others											
	Booked Value											
2	**Depreciation**											
a	Buildings (5%)											
b	Equipment & Material (10%)											
c	Ponds/tanks (5%)											
d	Others (10%)											
	Total Depreciation											
3	**Financing**											
a	Equity											
b	Loans											
c	**Repayment**											
i	Principal											
ii	Interest											

Table-13: Log Book Format for Revenue (Per Month per Species) Records

Species	Sales price	Months												Total
		April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	

Table-14: Log Book Format for Operational Cost (Per months) Records

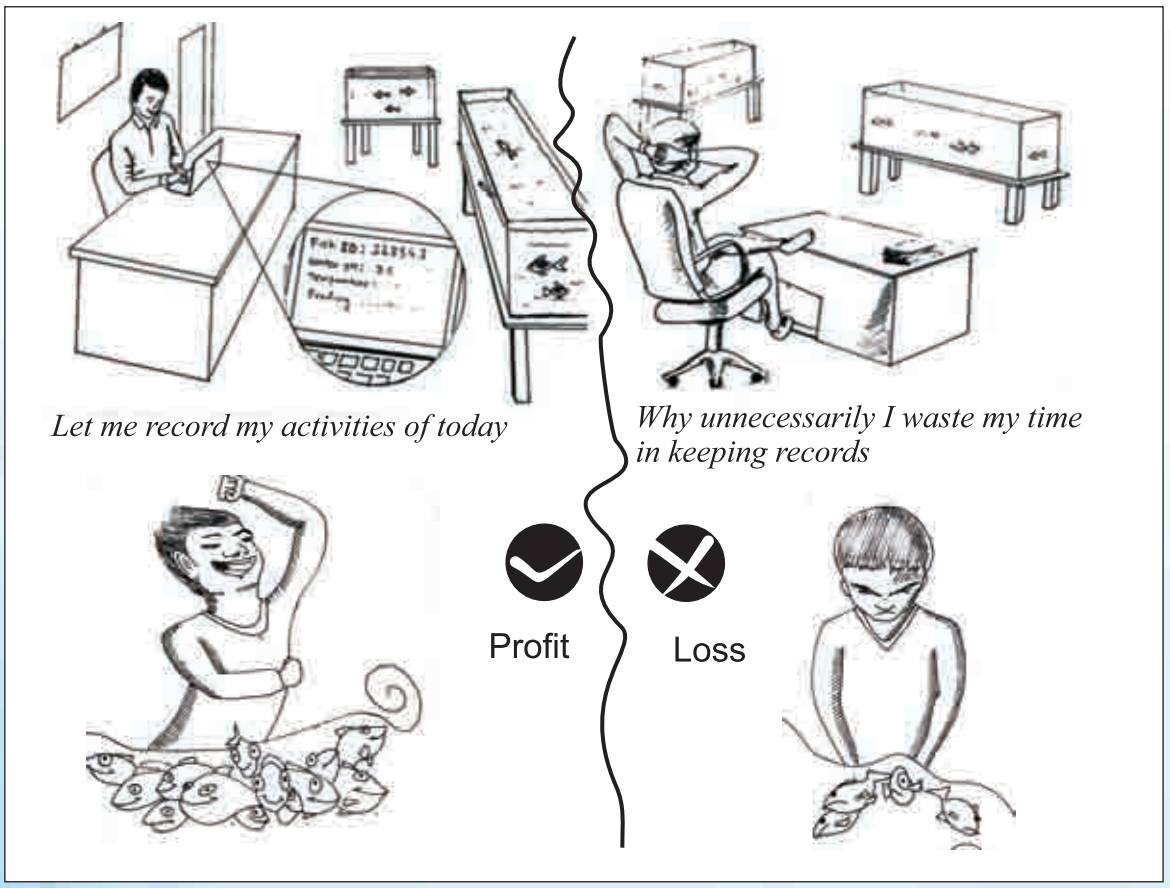
Particulars	Months												Total
	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	
Feed													
Medication													
Brood Stocks													
Electricity													
Water													
Labour / staff													
Others													
Contingency													
Total													

Table-15: Log Book Format for Cash Flow Records

Cash Inflow				Cash Outflow				Profit (Cash Inflow- Cash Outflow)
Date	Source	Amount	Comments	Date	Source	Amount	Comments	
Total								

Table-16: Log Book Format for Financial Balance Records

Income and expenditure			
Expenditure (a)	**Amount**	**Income (b)**	**Amount**
To expenditure on labour, brooder, electricity, water, feed medicine, loan repayment, etc.		By fish sale	
To excess of income over expenditure (c=b-a)		Bank interest	
		Others	
Total			
Balance			
Liabilities	**Amount**	**Assets**	**Amount**
Opening balance		Cash in bank	
Add this year income(c)		Cash in hand	
		FDR	
Total			



9. Important Suggestions

The record keeping is important for efficient farm management. Using financial records and methodology will help you understand how and where your business is going. Record keeping and sound production and financial data interpretation will help you define the weakest links of your farm business operation and enable you to start corrective action plans. Keep the following guidelines in mind when implementing or reviewing your record keeping system.

- Keep it simple! If the record keeping system is unnecessarily complicated, you are more likely to make mistakes
- To identify the facilities and fish stock (brood stock) it is essential to keep the identification records
- Details of all inputs and harvest from each unit should be recorded to estimate the profitability
- To evaluate the breeding efficiency of farm brood stock detailed record of breeding indices (species wise & variety wise fertilization, hatching and survival rates) be recorded carefully
- Record the details of feeds used in nursery pond – type and quantity, water quality in hatching and, nursery tanks/ponds.
- Stocking density in the culture system- species & variety wise, rearing duration & harvesting details with value of harvested seed, etc. be recorded in log book for each and every cycle
- Carry out a simple heath inspection routine every day or weekly, If disease symptoms are detected, seek assistance from the expert and record all information in record log book.
- The records of the costs and earnings related to the ornamental fish farming be kept for cash analysis and enterprise appraisal. The most necessary records are simple overview over the cash flow, that is, the total economy in the farming

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