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Culture of *Pangasianodon hypophthalmus* into India: Impacts and Present Scenario

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Abstract: *Pangasianodon* aquaculture is the fastest growing food producing sector of the world. Recent national production of *Pangasianodon hypophthalmus* in India accounts for 0.7 million tonnes at present. Being influenced by trade and markets, *P. hypophthalmus* has been introduced to many countries including India. There has been a steady increase in the production of *P. hypophthalmus* by small and marginal farmers of the country. However, concern has arisen about the long term sustainability due to diseases and its negative impacts on socio-economic aspects and biodiversity. Unregulated culture of *P. hypophthalmus* has been causing concern to environmental safety and warranting a very cautious and regulated approach to its culture. The standards, protocols and guidelines have been developed to address the issues of sustainability of *Pangasianodon* catfish production.

Key words: *Pangasianodon hypophthalmus*, aquaculture, diseases, food safety, sustainability

INTRODUCTION

One of the fastest growing types of aquaculture of the world is Pangasianodon farming. *Pangasianodon hypophthalmus* commonly known as Iridescent Shark, sutchi catfish in Thailand or Pla Sawai, Patin in Malaysia, tra or basa catfish in Vietnam belongs to the family Pangasiidae. There are nine species of catfish in Vietnam but only two, tra catfish *P. hypophthalmus* and basa catfish *P. bocourti* are cultured. *Pangasianodon* catfish culture started since 1960 but it geared up only in 1996 when the technology for seed production was developed. By 2006, the annual production of *Pangasianodon* reached 800,000 tons in Vietnam and this escalated to 1.0 to 1.2 million tones in 2007 (Van Sang *et al*., 2007). During the year 2008, 1.1 million tons of *Pangasianodon* fish were produced in Vietnam, which was goal, the country had set for 2010 (Nguyen, 2008). The growth in *Pangasianodon* aquaculture is driven, in large part, by the dramatic increased demand for tra and basa in the market. *Pangasianodon* is sold to more than 130 countries globally, mainly in the form of white filets (Phan *et al*., 2009). The major markets for this fish are the European Union, Russia, Southeast Asia and the United States. Vietnam, the top producer and exporter of *Pangasianodon* catfish is presented in Fig. 1. The United States used to be the major market for tra and basa but that has changed over the past few years, as the United States' share of exported *Pangasianodon* has decreased

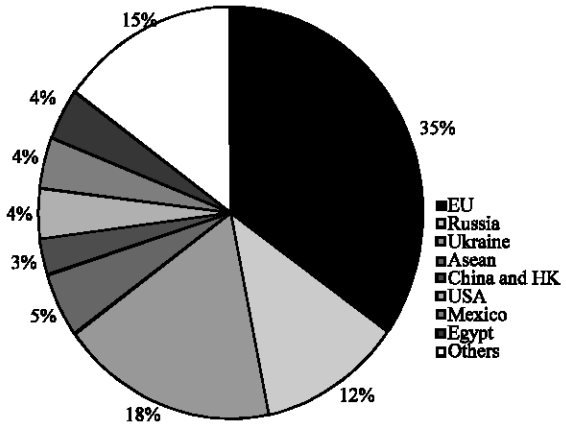

Fig. 1: Export resume of *Pangasianodon* in major markets

from 80 to 4%. European Union countries now dominate the export market, with a share of 35% (Nguyen, 2008).

Over the last ten years, the Asian catfish *Pangasianodon hypophthalmus* has emerged as a new aquaculture whitefish product on the world market. While the market for *Pangasianodon* has expanded globally the production of *Pangasianodon* has remained exclusively in Eastern Asia and centered principally in Vietnam. *P. hypophthalmus* has proven particularly adaptable for intensive production in several countries (Mukai, 2011). Being influenced by the international markets, large number of farmers in India got fascinated to culture

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Table 1: Introduction of *Pangasianodon hypophthalmus* in different Asian countries and its ecological impact

Year/Period	From	To	Purpose	Ecological Impacts
Unknown	Unknown	Guam	Pond and cage aquaculture	Not established in wild
Unknown	Unknown	Singapore	Pond aquaculture	Established in wild. Some bad ecological impacts are reported
1969	Thailand	Taiwan	Pond aquaculture	No records available
1972	Thailand	China	Pond and cage aquaculture	Established in wild but no adverse ecological impact is reported
1978	Thailand	Philippines	Pond and cage aquaculture	Established in wild but no adverse ecological impact is reported
1982	Thailand	Mynamar	Pond and cage aquaculture	Established in wild but no adverse ecological impact is reported
1990	Thailand	Bangladesh	Pond and cage aquaculture	Established in wild. Adverse ecological impacts are reported
Unknown	Bangladesh	India	Pond aquaculture	Available in wild and adverse ecological impacts are mild

P. hypophthalmus. Information on culture, feed, reproduction, market and disease aspects of this fish has been generated based on our field studies particularly in the states of Andhra Pradesh and West Bengal. The impacts of culture of this new species have also been assessed based on the protocols developed in the laboratory and a regulatory guideline has been proposed to address the issues of sustainability.

Introduction of *P. hypophthalmus* in Asia: *P. hypophthalmus* a native of Mekong River in Vietnam has been introduced to many Asian countries such as Singapore, Philippines, Taiwan, Malaysia, China, Myanmar, Bangladesh, Nepal including India. In view of its burgeoning trade, some of these countries have been culturing this fish to boost up aquaculture production (De Silva *et al*., 2006, 2009). Based on the information provided by FAO in the Database on Introduction of Aquatic Species (DIAS) and Fish Base, it has been found that this fish has established in wild in many countries wherever, it was introduced. The historical perspectives, source of introduction and its reported ecological impacts have been synthesized and presented (Table 1). The fish was introduced to India probably in 1997 from Bangladesh where this fish is largely cultured both in monoculture as well as in polyculture (Mukai, 2011).

Aquaculture of *P. hypophthalmus* in India: Farmers are over-whelmingly culturing *P. hypophthalmus* using improved management methods and improvised, supplementary feeds available commercially. Because of its remarkable growth rate (almost one kg in 90 days), this fish is being cultured in many states particularly the Andhra Pradesh, West Bengal, Kerala and Orissa. The Pangas catfish *P. hypophthalmus* was first introduced into India in the year 1997 in the state of West Bengal from Bangladesh. Initially its farming was carried in limited area in the state of West Bengal later on this was cultured on large scale in the state of Andhra Pradesh. Since 2004, its farming has increased due to the commercial importance and it is estimated that *P. hypophthalmus* is being farmed in an area of about 40,000 ha with a projected production of to 820,000 to 1500,000 tons. Because of farming community in other states also took up its culture, *P. hypophthalmus* culture in a larger extent paved way for demand for its seed and for establishment of more number of commercial scale hatcheries.

Culture of *Pangasianodon* catfish is largely restricted to land-based pond aquaculture systems in India. It is also being adopted for cage aquaculture because it responds well to supplied diets. It is tolerant to high stocking densities and easily reproduces artificially. However, growth and yield characteristics of the fish in cages still remain unexplored. It is understood that the density of 150 fish m^{-3} produced the best results among the densities tested in experimental cage culture in Bangladesh (Islam *et al*., 2006). Information from grow-out farms reveals that the fish is cultivated both under monoculture as well as polyculture with Indian major carps and Chinese carps. However, monoculture of *P. hypophthalmus* fetches better performance and profit to farmers. Andhra Pardesh is the major producing state for *P. hypophthalmus* where most of the farms are located in Krishna and West Godavari districts of Andhra Pradesh. The farm area is ranging from 4 ha to 40 ha. It has been found that there is a shift of culture practice from carps to *Pangasianodon* catfish in considerable areas in Andhra Pradesh. Due to closure of shrimp ponds on account of disease, farmers had to suffer heavy losses and they also adopted *P. hypophthalmus* farming alternatively in the same areas which were disease affected. It is estimated that presently over 700,000 tonnes of Pangas catfish is produced in the country per annum (Fig. 2).

The state of West Bengal is the hub of seed production of *P. hypophthalmus* in the country. Over 500 crores of seed of *P. hypophthalmus* is being produced every year and bulk of it is being transported to Andhra Pradesh and a part to Orissa, Tamil Nadu, Maharashtra, Kerala, Karnataka, Bihar, Rajasthan and Uttar Pradesh. The seed production of *P. hypophthalmus* is not only for the purpose of aquaculture but it is also used as

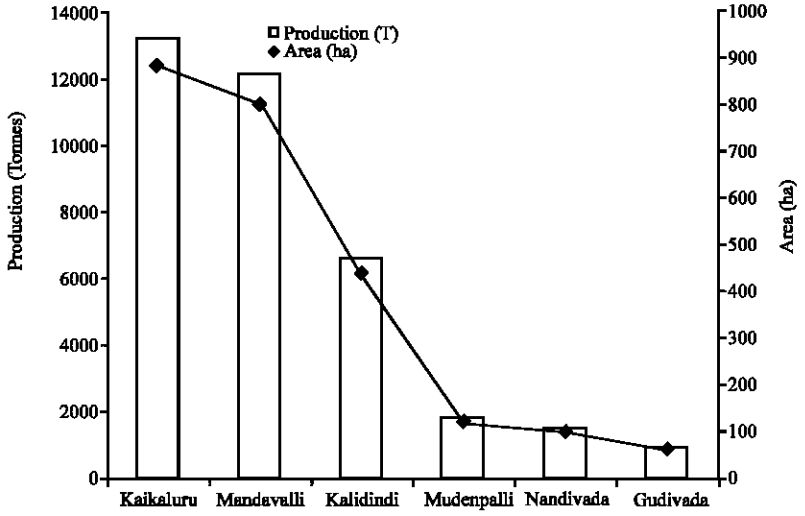

Fig. 2: Culture production of *Pangasianodan hypophthalmus* in Krishna district of Andhra Pradesh

aquarium fish. Different varieties (striped and albino) of *P. hypophthalmus* is produced for aquaculture and aquarium trade. The culture production of *P. hypophthalmus* is 15 to 20 t/ha/year which is higher than carp production (8-10 t/ha/year) in the same areas.

P. hypophthalmus when young they are carnivorous and cannibalistic; feeding at the bottom on offal, snail, gastropods, insects, etc and turn to omnivorous feeding habit, readily accepting artificial feeds under confined culture. The species reaches sexual maturity by 3 years of age and can grow up to a size of 4-6 kg. Females are larger than males. In nature, fishes are seasonal spawners and breed during warmer months. The fish can be artificially bred in hatcheries by hormone injection. Eggs are dry stripped from females and mixed with milt from the males.

Hatching occurs in 22 to 24 h at 26-30°C. Hatching percentages are variable and may range from 20 to 80% depending on egg quality and fertilization rate. Larvae are free-swimming and begin feeding on Artemia or similar live food 24 h post-hatch. Predation can be significant if adequate food is not provided. Fry grow rapidly and can be weaned to powdered feed after about 10 days. Production of fingerlings may be accomplished by stocking in nursery ponds with established zooplankton populations. Grading of the juveniles is recommended to remove larger individuals. Fingerlings can reach 4-6 cm in 40-50 days post-hatch. The stoking has further been intensified in monoculture and it is 30,000 fingerlings/acer (7.4 m^{-2}) in nursery ponds under intensive culture, each pond produces 50 tones ha^{-1} of 1 kg fish. The culture cycle of 8 to 6 months is of year around. In commercial culture of *Pangasianodon* farmers are using both pelleted and extruded feeds. The Feed Conversion Ratio (FCR) of these feeds can be improved to a range of 1:1 to 1:2 while common FCRs reported by farmers are in the range from 1:1 to 1:3. The floating feed is the modern way of feeding in contrast with the traditional way using farm made feeds comprising remains agricultural ingredients. The feed composition ranges from 25 to 28% crude protein for grow out pond.

Freshly harvested fish, whole and ungutted are chilled with ice and packed in insulated boxes and transported by land, mainly to West Bengal and North Eastern states where demand for fish is highest. However, the packed fish is transported throughout India for sale. Fish is sold at INR 32 kg^{-1} (USD 0.71) whole sale. The retail prices are INR 55 kg^{-1} (USD 1.20), to cater for the INR 18 kg^{-1} (USD 0.40) for transport costs.

Food safety and sustainability: The large-scale production of *Pangasianodon* catfish is being carried out in private as well as government sector without considering the ecological and genetical consequence of the fish (Barua *et al*., 2004). Many issues on quality and the nature of farming system have been raised (Holland, 2007; Naubacher, 2007). The fish hatchery owners do not recruit brood fish for breeding from original sources in a regular interval and they always try to use same broods and their off-springs as brood stock year after year. So inbreeding depression such as abnormality in growth, reduced fecundity and low disease resistance and loss of genetic variability are inevitable.

It is estimated that 83% of catfish farmers use chemicals/drugs due to poor water quality. The issue of food safety and quality is now raised and containment is needed. Part of the chemicals/drugs applied for catfish

farms are discharged in to river water, which may cause problem for wild species, water quality and thus health of people in the surrounding area. *Pangasianodon* catfish produced in the freshwater basins of Vietnam, available on the Italian market as frozen or thawed fillets have been found to process low residue levels of mercury, organochlorine pesticides and polychlorinated biphenyls (Orban *et al*., 2008). In Vietnam, the relationship between government and industry is an area of attention and crucial for setting realistic performance quality standards, negotiating regulatory issues and implementing improved inspection, audit and risk assessment systems (Nguyen, 2008).

Mass culture of *P. hypophthalmus* to get higher production is threatened by various types of diseases particularly caused by, *Aeromonas, Columnaris, Edwardsiella* and *Vibrio*. Heavy mortalities have been noticed and the fish exhibited off-feeding, circular motions, edging and other morbid conditions . All sizes of fish ranging from 5 g to 1.5 kg were found disease affected causing heavy losses to farmers. Exophthalmia, haemorrhagic conditions on the body, hole on the head region, necrosis on tail region and bulging of caudal peduncle are some of the common disease conditions. In many ponds mortality lasted for 15-17 day after appearance of the disease symptoms which multiplied many time within 3-4 days. Occurrences of red disease in Pangas catfish from grow out farms was found to be Haemorrhagic Septicemia. In few specimens even swelling of liver was observed. Microscopic examinations of gill by squash preparation of infected fish reveal presence of Trichodina parasitic infection of moderate degree. The water quality and soil characteristics of the diseased farms indicated that there prevailed high level of carbon dioxide (25-60 ppm), Chemical Oxygen Demand (COD) (2.9 to 4.9 ppm), ammonia (unionized) (0.1-0.5 mg L^{-1}) and nitrite (0.03-0.2 ppm) associated with low dissolved oxygen (2.9-4.5 mg L^{-1}) (Singh *et al*., 2009).

Management of health on *Pangasianodon* catfish farms mainly involves chemical treatments often with antibiotics. In general, farmers used antibiotics (Oxytetracycline, Entrofloxacine, Furazolidon) at the rate of 10 g kg^{-1} feed for red disease while others used iodine based water sanitizers (Virudine, Microbites, Iodophore, Micodine etc.). Use of probiotics (Nitrosomonas, Nitrobacter, Redwin, Bactowin etc.) was also in practice for improving the water quality and preventing the disease occurrence.

Current intensive culture system is putting a lot of stress on *Pangasianodon* catfish and subsequently the fish has become susceptible to disease and parasites. Most of the *Pangasianodon* farms are suffering from parasitic diseases in general, however, bacterial diseases are also reported. Consequently, the yield and quality of the fish have decreased due to disease outbreaks. Vietnamese *Pangasianodon* sp. (Ferguson *et al*., 2001), bacillary necrosis of Pangasianodon, newly recognized disease was recently observed in farms was typified by multifocal irregular white lesions of varying sizes on several organs including liver, spleen and kidney. Histopathologically, the lesions were confirmed to be acute to sub-acute. Associated with these lesions were several species of parasites but common to all affected fish were variable numbers of large bacilli, usually seen at the margins of lesions. Aqua-culturists used a wide range of chemicals and antibiotics to manage the disease outbreaks.

Impacts of *Pangasianodon hypophthalmus* culture into india

Biodiversity: The locations of culture and hatchery sites of *P. hypophthalmus* in India were found close to open waters and hence there exist every chance of escape. The escapee *P. hypophthalmus* are now available from wetlands and other natural aquatic water bodies of West Bengal as well as Kolleru lake area of Andhra Pradesh; Kerala and Uttar Pradesh. The culture activity is spreading fast in the country and now it is not only restricted to Andhra Pradesh and West Bengal rather it has extended to other coastal areas including fishery hotspots of Western Ghats and also in north-eastern parts of the country. The fish has potential to mature and breed naturally in wild and hence escapee fish may colonize and form feral population in different agro-climatic conditions impacting the ecosystem and in turn affecting the biodiversity. In India, the breeding of local *P. pangasianodon* has a similar spawning period which can be overlapped by *P. hypophthalmus* in case of its establishing in wild. An experimental trial for cross breeding between *P. pangasius* with *P. hypophthalmus* has already been successfully attempted in Bangladesh (Khan and Mollah, 2004; Hossain *et al*., 2009). The husbandry techniques are now improving and hatcheries have begun selection for traits favorable to aquaculture or aquarium purpose for *P. hypophthalmus*. Hence, escapee fish may become a concern in future (Van Sang *et al*., 2007).

Environmental issue: Irrational use of antibiotic and chemicals in *P. hypophthalmus* farms in India is of great environmental concern. Frequent outbreaks of bacterial diseases have put considerable pressure on farms to use a variety of antibiotics and chemicals and also at hatcheries. In fact, the contamination with banned

chemicals and antibiotics which is in practice might occur at any stage throughout the production chain. It is therefore, necessary to have a nationwide campaign to improve sanitation and ensuring quarantine warranty, environmental purity and food safety.

Issues of fish health: Gill fluke infection is commonly seen in all *P. hypophthalmus* farms with infection rates varying from 60 to 90% of fish. The highest mortality due to gill fluke is manifested during the first week after stocking. The visible infection in spawn and early fry at the hatcheries is low except for gas bubble disease which is probably due to high ammonia level and eutrophic conditions. Farmers pay attention only to the direct economical loss from diseases other than that from gill fluke infection. In fact, gill fluke has been understood to contribute significantly to the loss due to secondary bacterial infection which was followed by the initial infections with the parasite.

Pangasianodon catfish diseases have been considered as the major problem in its culture. Due to the open culture of *P. hypophthalmus,* risk of disease and parasite transfer to wild stocks would be possible. Recently, the bacteria *Edwardsiella ictaluri,* a disease native to North America and reported from ictalurid catfish, was identified in farmed *P. hypophthalmus* cultured in the Mekong River Delta. This is the first instance of this disease being observed in pangasiids. *Edwardsiella ictaluri* has been isolated from *P. hypophthalmus* in Vietnam, which has not been reported from the co-habitant *P. bocourti* (Crumlish *et al*., 2002). A previous report of bacillary muscle necrosis reported from Vietnam (Ferguson *et al*., 2001) has now been identified as being attributable to *E. ictaluri* (Crumlish *et al*., 2002). It remains unclear as to whether the bacteria are introduced or local but previously unknown, however transmission of pest could be an issue in the future. A report from New Zealand on risk assessment of Vietnamese *P. hypophthalmus* has highlighted the possible transfer of *Edwardsiela ictahuri* in the aquaculture areas in Vietnam which is a concern of OIE listed disease (Reed, 2008).

It is pertinent to mention that infection of *P. hypophthalmus* does not result in clinically apparent disease. Therefore, septicaemic fish are quite likely to be harvested for human consumption. There remains the possibility that some fish could be carrier of *E. ictaluri* without displaying clinical signs. In India, the septicaemic fish infections were observed at some of the *P. hypophthalmus* farms (Singh *et al*., 2009). If such infected fish is harvested and processed for consumption, it will have a serious concern with human health. Further, there is no treatment of the effluent water from culture ponds and lacking knowledge of farmers, dead fish and/or diseased fish from aquaculture and aquarium facilities are released directly to public canals and rivers. Hence, there is prevailing threat of disease risks associated with culture of *P. hypophthalmus.*

Socio-economic issues: Being a relatively new and fast developing sector; it has impacted on the socio-economic milieu to a great extent but a quantitative assessment of these aspects are still be made (Singh and Lakra, 2011). Easy management of culture operations in recent years attracted farmers to culture Pangas catfish culture. *P. hypophthalmus* is now available at low cost of Rs 30-40 kg^{-1}. The carp production is declining due to the fact that farmers are cultivating *P. hypophthalmus* in carp as well as shrimp aquaculture farms. It is important to point out that demand for carps is still high and it costs Rs. 50-70 kg^{-1} in bulk. Farmers are producing *P. hypophthalmus* at lower investment but the cost of production is escalating considering the cost of feed, antibiotics and other chemicals. This situation is impacting marginal farmers, consumers, culture environment and socio-economic conditions.

CONCLUSION

Efforts should be made to improve *Pangasianodon* culture through the adoption of Better Management Practices (BMPs) as has been done in shrimp farming (Umesh, 2007; Umesh *et al*., 2009). A number of immediate management measures would be useful at striving to achieve BMPs. Since conventional feed do not perform significantly; improvement in feed quality is urgently warranted, if current *Pangasianodon* farming is to sustain. There is need for suitable adoptive measures. The recent explosion of *Pangasianodon* farming in South East Asia is causing concern over environmental and social management. It is thus necessary to find out how a new global set of standards can be formed to preempt any negative consequences of this boom. In order to achieve this goal a multi-stakeholder process called the *Pangasianodon* Aquaculture Dialogue (PAD) is looking up to create a measurable, performance-based set of standards for the industry. Recently the first draft standards accreditation and certification has been released for *Pangasianodon* (Starr, 2008; www.worldwildlife.org/aquadialogues).

On the basis of various field generated data and other information, the following scenario has emerged for *P. hypophthalmus* culture in India:

- The culture of *P. hypophthalmus* is prevalent in the states of West Bengal and Andhra Pradesh
- Spread of *P. hypophthalmus* farms in fishery sensitive and biodiversity rich areas such as Western and Eastern Ghats can harm indigenous fish diversity, has strongly opened outlets for escape *P. hypophthalmus* which may enter the natural waters and compete with wild fish affecting the ecosystem balance
- *P. hypophthalmus* is a riverine fish and it has a great potential to mature and breed in rivers
- Use of fishmeal, trash fishes in *P. hypophthalmus* feed will deplete resources on which other local fish depend as food
- *Pangasianodon hypophthalmus* is prone to diseases such as hemorrhagic septicemia, bacillary diseases, *Flavobacterium columnarae, Trichodina* and can impact farmed and wild stocks
- Inappropriate use of antibiotics and chemicals practiced in *P. hypophthalmus* culture can have adverse impacts on the environment and human health

Consequently, the culture of *P. hypophthalmus* in India warrants a very cautious and regulated approach. Therefore, following guidelines has been prepared for safe and sustainable aquaculture of *P. hypophthalmus*.

- Certification of the hatcheries that are already producing *P. hypophthalmus* seed
- ICAR Institutions can import limited numbers of genetically pure broodstock of *P. hypophthalmus* for development of brood stock banks
- Suitable guidelines for hatchery establishment and standard operating procedures need to be developed for the accreditation of the hatcheries
- Farmers who intend to take up *Pangasianodon hypophthalmus* culture shall apply to the State Fisheries Department in the prescribed Performa
- The *Pangasianodon hypophthalmus* farm should not be located adjacent to rivers, flood prone areas. Seepage channel around the culture pond is suggested to avoid infiltration of pond water into adjacent paddy/other crops
- In case of cage culture large size fingerlings (more than 100 g) should be stocked in cages especially designed to prevent escapes. Inlets and outlets of culture ponds should be provided with screens to prevent escape of fishes from the pond into the natural environment
- Monoculture should be restricted up to semi intensive type with a stocking density of less than 20,000 advanced fingerlings 15-20 g ha^{-1}. Under poly culture, the stocking density of *Pangasianodon hypophthalmus* should not be more than 10,000 ha^{-1}
- Each pond should not be more than 5 ha in area having an average depth of 1.5 m for better monitoring and management
- Grow out culture period for ponds should be 8 to 12 months depending upon stocking density and the targeted size at harvest. Cage culture should be for about 6 months. Generally the marketable size is 1-1.5 kg
- Wet feeds should be totally discouraged in the culture. Use of floating pellets is desirable for better growth, meat quality, health and pond water and soil management and also in order to achieve the FCR of less than 1:1.5. In case of polyculture mash feeds of good quality may also be used through bag feeding in addition to floating pellets
- Under monoculture, manuring of culture pond may not be required; however, agriculture lime should be applied @ 100 kg ha^{-1} depending on the pH of pond soil and water. For polyculture ponds, fertilization using organic/inorganic manures could be followed as per the soil fertility
- Proper feed storage facility should be provided at the farm site with proper ventilation and fumigation. The feed should be stacked on raised wooden platforms without touching the walls to avoid mould. The feed should be used within three months from the date of production
- Banned antibiotics should not be used. Sanitizers such as Bromine, iodine, lime etc., may be used judiciously. Avoid unnecessary usage of other chemicals/drugs. During culture, water exchange should be decided depending on the water quality status. After every two crops pond desiltation and drying should be carried out. The used culture water should not be discharged directly into natural drainages without any treatment such as lime, sod. hypochlorite etc. As far as possible run off from agriculture fields should be avoided to reduce bioaccumulation of pesticides. Health and growth monitoring should be done regularly on monthly basis. Any sign of disease occurrence/incidence should be immediately reported to the State Fisheries Department/Research Organizations
- Registers should be maintained pond wise on day to day management of the farm indicating the details of stocking, source of seed, inputs, sampling details, water quality details, health, growth, etc. The records should be produced at the time of inspection by the concerned fisheries authorities

- Feeding should be suspended one/two days prior to harvest. Harvesting can be carried out in two phases (6-8 months; 10-12 months). Harvesting may be done using drag nets and quick harvesting is suggested
- Harvested fish should be immediately iced and transported for domestic markets/processing plants
- Training programmes and awareness camps on Better Management Practices of *P. hypophthalmus* are proposed to be conducted for achieving sustainability. Exposure visits to the Officials of Govt/Research Organizations/Progressive farmers/ Entrepreneurs to countries where *P. hypophthalmus* culture is popular and successful. Visit could be made to countries like Vietnam, china, Thailand, etc. The training programming for farmers shall be taken up by the concerned State Fisheries Department/ Research Organizations/KVK's
- Culture of *Pangasianodon hypophthalmus* in water bodies namely ponds in fresh waters and brackish water areas especially having low salinity, abandoned shrimp ponds, seasonal tanks, cages in canals, lagoons and reservoirs without prior permission from State Fisheries Department is illegal and such farmers are liable for punishment which includes seizure of stock and demolishing of ponds etc

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