Training
On
Pen Culture of Fish and Prawn

December 11-15, 2000

Bull No. 105 *December 2000*

Central Inland Capture Fisheries Research Institute
(Indian Council of Agricultural Research)
Barrackpore - 743 101 West Bengal

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FOREWORD

Inland fishery has made significant strides in the last 5 decades, demonstrating unique resilience in becoming a significant contributor to the Indian economy. The country is endowed with diverse inland water resources. Vast areas of these water resources are available in the form of wetlands. It has thrown enormous challenges before the scientists, planners and policy makers for proper utilization of these water bodies for boosting fish production vis-a-vis upliftment of the status of resource-poor fishermen. The potential value of these wetlands for the production of fishes through aquaculture has now been well recognized. It is regrettable to note, though the resource provides an excellent area for fish and prawn production, no serious effort has been made to utilize the existing potential of the wetlands. This Institute has developed the technology of Pen culture for production of fish and prawn from wetlands and it has demonstrated the same to Fishermen Cooperative Societies.

The Directorate of Extension, Ministry of Agriculture, Govt. of India has identified the technology for transferring the same to the ultimate users and thus sponsored a training course entitled "Pen culture of fish and prawn" at this Institute during December 11-15, 2000 for the extension functionaries of West Bengal. This compendium contains the lectures scripts delivered by the relevant expert Scientists of the Institute during the said training.

M. Sinha
Director

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Training on Pen culture of fish and prawn
December 11-15,2000. CIFRI, Barrackpore

WETLAND FISHERIES RESOURCES, MANAGEMENT PERSPECTIVES AND SCOPE OF PEN CULTURE IN WEST BENGAL

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Wetlands are amongst the most valuable natural ecosystems as they are vital to the very existence of man and human civilization on the Earth. Nonetheless, Wetlands continue to be a nebulous concept, evading a universally acceptable definition. Ramsar convention defined "*wetlands as areas of marsh, fen, peatland or water, whether natural or artificial permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres*", not a precise definition indeed.

It is generally understood that wetlands occupy the transitional zone between permanently wet and generally dry environments. They share characteristics of both the environments, yet cannot be classified exclusively as either aquatic or terrestrial. Wetlands play a pivotal role in supporting plant and animal life, maintaining the quality of the environment on earth. There is an important link between wetlands and the welfare of people in terms of health, safety, food security navigation, agriculture, post-harvest activities, fishing and a host of other activities. This relationship is particularly relevant in case of developing world, where many communities depend on wetlands for the maintenance of traditional subsistence activities, including livestock herding, hunting, fishing and farming. This dependence is much less in the economically developed countries where the problems related to higher population density and poverty are fewer. Conversely, in the resource-poor developing countries, the wetlands are regarded as a source for a number of life supporting economic activities. Therefore, conservation measures need to be tailor-made to suit the requirements, lest it may be harsh on a number of local communities whose lives are linked to the wetlands. Moreover, there is a traditional wisdom in conserving the natural resources, which are followed through generations to keep the developmental activities sustainable and ecofriendly.

A redeeming feature of the traditional wetland based economic activities is its low technology nature, which makes them sustainable and environment-friendly. However, recent years have witnessed higher pressure on the wetland resources due to population pressure and technological size. This trend needs to be checked and reversed in order to protect the wetlands in India.

India is endowed with vast areas of natural and artificial wetlands comprising oxbow lakes, swamps, *bheries*, mangroves, reservoirs etc., which are spread along the riverine and estuarine stretches. Apart from bearing rich fish production potential, these water bodies are biologically sensitive areas, playing a pivotal role in the recruitment of populations to riverine, estuarine and marine waters. The shrimps which support a lucrative overseas trade complete their life cycle through the mangrove system. Similarly, the riverine wetlands like *beels, manuns, chaurs*, etc., are the nursery for many economically important riverne fish species. Vast areas of estuarine wetlands in the form of bheries exist in West Bengal which receive tidal waters and support fishery of high magnitude. In addition to the prawn seed from the estuaries, stocking of prawn and fish seed in the bheries has been found to be remunerative.

Riverine wetlands

The wetlands associated with the floodplain of riverine systems specially those of the Ganga and Brahmaputra, cover an extensive area of more than 200,000 ha.

TABLE 1

Distribution of floodplain lakes in India

State	*River basin*	*Area (ha)*
Arunachal Pradesh	**Kameng, Subansiri, Siang, Diband, Lohit, Dihing & Tirap.**	**2,500**
Assam	**Brahmaputra & Barak**	**100,000**
Bihar	**Gandak & Kosi (Ganga)**	**40,000**
Manipur	**Iral, Imphal & Thoubal**	**16,500**
Meghalaya	**Someswari & Jinjiram**	**213**
Tripura	**Gumti**	**500**
West Bengal	**Hooghly & Matlah (Ganga)**	**42,500**
Total		**202,213**

(Source : Sugunan, 1995)

In West Bengal, floodplain lakes, locally known as *beels*, covering an area of 42,500 ha., constitute one of the important fishery resources. Managed as community resources, nearly half of the *beels* are located in the districts of 24 Parganas, Murshidabad, Hooghly and Nadia. According to the available estimates, fish yield from these waterbodies is only 100 kg/ha. These *beels* are extremely rich in nutrients, as reflected by rich organic carbon and high levels of available nitrogen and phosphorous in the soil. But the nutrients are usually locked up in the form of large aquatic plants, especially water hyacinth, which are not readily available as food for fishes.

Many of the closed *beels*, having severed their connections with the river course are in a transient phase of their evolution into swamps. Such waterbodies, apart from attracting migratory and resident avifauna, exhibit a rich faunistic diversity in the form of molluscs, insects and other weed-associated fauna, air-breathing fishes and a variety of small sized fishes. Development of fisheries in weed infested floodplain lakes involves eradication of unwanted weeds and introduction of fast growing fish species. Studies conducted in Kulia *beel* in Nadia District revealed that removal of floating weeds generated blooms of plankton which favoured stocking of catla (*Catla catla*) in addition to Indian major carps.

Floodplain lakes, by virtue of their productive potential, constitute one of the prime inland fishery resources capable of yielding c. 0.2 million tonnes of fish per year. The management strategy for this vital sector is based on a categorywise approach. Optimum exploitation norms for lakes with riverine connection revolve around the concept of keeping the deeper central portions as exclusively capture fisheries and renovation of margins and pockets for culture fisheries. Capture fisheries would entail monitoring of recruitment and subsequent growth of the natural populations. In closed lakes, stocking is the mainstay of management. In weed-choked lakes, clearance of weeds and a detritivore-oriented stocking schedule would enhance the yield rate considerably. A production rate up to 1,000 kg/ha/yr is attainable from floodplain lakes when subjected to scientific management.

These lakes also provide ideal conditions for pen and cage culture operations. Pen culture involving major carps has indicated a production possibility up to 4 t/ha. in six month from a *maun* in Gandak basin while production rates varying from 0.19 to 4.8 kg/m^2 cage area have been obtained in 90 days from a weed choked Assam *beel* by rearing the air-breathing fishes *Clarias batrachus* and *Heteropneustes fossilis*.

Recent research efforts in *beel* fisheries consist of a new approach by exploiting the activity coefficient and energy conversation within the system. Studies conducted in some beels of West Bengal have shown that energy transfer manipulation. It was possible to harvest fish biomass up to 53.520 cal/yr when stocking at the tertiary level can be increased from 0.266% to 0.41% by ecological biomass was around 10,980 cal m/yr.

Estuarine wetlands

The delta West Bengal is ecologically well suited for development of commercial production of brackish water fishes and prawns. The Hooghly estuary as well as other estuarine inlets and tidal streams along with their distributaries have rendered a good part of low lying Sunderbans into saline swamps which over the years have been reclaimed into productive impoundments called *bheri* through creation of embankments. According to one estimate, the deltaic zone of West Bengal has an estimated 4 Lac ha of swampy area considered as suitable for brackish water aquaculture. However, this figure needs to be suitably supported by proper micro level survey giving due ecological consideration *vis-à-vis* conservation of forests, mangroves and nursery areas of fish and prawn. As against the present cultivated area of 42,000 ha under bheries, it is quite possible to reclaim another 4,05,000 ha of new saline marshy areas into commercial production of brackish water fishes and prawn (Table 2).

TABLE 2

Brackishwater area (ha) and their utilization in India

State	Estimated brackishwater area	Area under culture
Gujarat	376.0	1.8
Maharashtra	80.0	0.1
Goa	18.5	6.5
Karnataka	8.0	1.8
Kerala	242.0	8.0
Pondicherry	0.8	NA
Tamilnadu	56.0	0.1
Andhra Pradesh	150.0	1.6
Orissa	80.0	2.6
West Bengal	405.0	42.0
Total	1,416.3	64.5

(Modified from Alagarswamy, 1991)

The eastern fringe areas of Calcutta are characterised by a number of *bheries* which support a good fish and prawn culture activities. Culcutta *bheries*, also known as city wetlands, are the remnants of past network of swampy wetlands that spread over an area of 250 km^2 between 22° 24′ - 22° 36′ N and 88° 23′ - 88° 32′ E as a part of the floodplain of river Bidyadhari, a tidal creek associated with Matlah system. With the rapid growth of the city eastwards construction of a series of channels to drain the city storm waters, these floodplain have lost their flood capacity and at present they are virtually a sink for Calcutta city sewage. Fishermen and farmers have turned these wetlands into valuable resources by utilising the nutrients for growing agricultural and fish crops.

The current yield rates of West Bengal *bheries* vary from 770 - 1,360 kg/ha, of which nearly one-third is shrimp. It is possible to enhance the production rate through proper management to 2,000 kg/ha, with one third as prawn component. Ecology of *bheries* reveals a very high productivity in the high saline *bheries*, which are very rich in phosphate and other inorganic nutrients, while the medium and low saline *bheries* are rich in nitrate and other inorganic nutrients in soil. The *bheries*, in general, are extremely rich in phytobenthos (dominated by blue green algae) which are crucial for high rate of production. In addition, many *bheries* are also marked by floating filamentous algae. The rather low production achieved in *bheries* in West Bengal is largely attributable to the fact that the aquaculture practices followed by farmers leave much to be desired.

Culture of *Penaeus mondon* (tiger shrimp), *P. indicus* and the locally available mullets in the right proportion at optimum stocking density supported by supplementary feedings is likely to enhance production to 2,000 kg/ha of which 1,000 kg would be in terms of *P. monodon* or *P. indicus*. West Bengal is well endowed with uncommon abundance of *P. mondon* seed to achieve this target. This can be further supplemented by hatchery produced seed. By using the sewage enriched tidal water in low saline *bheries* in Basanti/Barasat Sub-Division, the productivity of the *bheries* could be further enhanced through proper regulation if intake of sewage water besides proper desilting of *bheries* and feeder channels at periodic intervals. In the absence of such management measure the productivity will diminish.

There is scope for substantial addition to existing *bheri* areas by reclamation in the lower Sunderban areas after a proper survey of deltaic regions. This would mean increase in fish/prawn production. Paddy-cum-Fish culture is already practiced in low and medium saline wetlands. The monocrop of paddy cultivation is practiced during kharif season. In addition, the farmers in Bashirhat and Barasat Sub-Division are also taking up summer cultivation of

brackishwater fish and prawns in paddy plots by taking in tidal water during February-March. There is hardly any indication that this practice has reduced productivity of paddy cultivation in any manner.

Mangroves are biologically sensitive ecosystems which play a vital role in breeding and nursery phase of many riverine and marine organisms of commercial value. Nearly, 85% of the Indian mangrove are restricted to the Sunderbans in West Bengal and Bay Islands. The Indian share of Sunderbans cover an area of 4,264 km^2 of which 3,106 km^2 has already been lost due to reclamation leaving only 1,158 km^2. Mangrove are unique examples of open ecosystems with respect to both energy and matter. The flora of the Sunderbans is reported to comprise 30 of 53 true mangal species of the world, apart from 44 sp. of mangrove associates, 10 sp. of obligatory mangroves, 11 sp. of beach flora, 33 sp. of weed flora, 9 sp. of non-littoral fauna and 5 introduced species. Mangrove vegetation provides shelter, food and spawning environment to innumerable species of finfish and shellfish. Several of the creeks are ideal sites for fish and prawn seed collection sustaining aquaculture in the region and providing livelihood to thousands of fishermen. The Sunderbans fishery comprise 18 prawn sp., 34 crab sp. and 120 fish sp. besides 4 sp. of turtles. The ecosystem is also shared by 6 frog and toad sp., 13 snake sp. and 4 sp. of lizards, crocodiles and water monitor.

Management perspectives

Since the floodplain wetlands are rich in plant nutrients and are biologically diverse ecosystems, they generally possess high potential for *in-situ* fish production. However, their fish production potential vary widely depending on ecological condition, recruitment from the main river, management measures followed etc. The following management options have been evolved for sustainable fisheries of the floodplain lakes as a result of research on their ecology and fishery management.

Capture fisheries of open floodplain lakes

The open floodplain lakes which retain their connection with the main rivers are characterised by habitat variables akin to lotic waters for most parts of the year. They have flowing water regime supporting low plankton and benthos biomass and high indices of community diversity. With slow eutrophication process and low level of macrophyte infestation rate, they provide a better environment for the ichthyodenizens. Fish production in them is governed by inherent natural productivity and the extent of autostocking from the mainstream. The open lakes may be treated as a continuum of the main river and for developing a good capture fishery. They also serve as feeding and

breeding grounds of commercially important riverine fishes and, therefore, are important for the fishery of the parent river as well.

Fishery management measures, followed in such lakes essentially centre round habitat conservation and fishing management. Some of these measures are :

i) Conservation of the habitat
ii) Ensuring proper recruitment by allowing free migration of brooders and juvenile fishes.
iii) Regulation of fishing pressure based on fish stock assessment.
iii) Devising and implementing regulations on mesh size, closed fishing seasons/grounds and so on.

Culture-based fisheries of closed floodplain lakes

The closed floodplain lakes are those which are totally cut off from the parent river or connected only for a very brief period during the flood season. They remain more akin to lentic ecosystems for most parts of the year. Since the volume of water exchange with the main river is low, they tend to accumulate silt and plant nutrients received from their catchment areas year after year. As a result, they are tend to be eutrophic with high biomass in respect of plankton, benthos, macrophyte, weed-associated fauna, etc., often associated with low index of community diversity. Many of them are heavily infested with macrophytes, with poor plankton production where most of the energy transformation takes place through the heterotrophic / detritus food chain. In the absence of recruitment from rivers and heavy macrophyte infestation, fish production in them is often much lower than their productive potential. Many weed-choked lakes are dominated by air-breathers and small-sized fishes resulting in low yields.

Many of the fishery management measures followed in open lakes for conservation and sustainable use of fish stocks are equally applicable to the closed ones where capture fishery norms are practiced. Besides, fish production rates in closed lakes can be further raised by practicing culture-based fishery is based on stocking and recapture of fast growing fish species similar to that followed in small reservoirs. Since floodplain lakes are usually shallower and richer in plant nutrients / fish food organisms than most reservoirs, they allow a higher stocking density to raise the fish yield. Chances of losing fish stock are low in closed floodplain lakes, unlike reservoirs where substantial stock loss takes place through irrigation canals / spillways. Stocking higher proportion of detritivores for effective utilization of energy accumulated at the detritus can give better results. Determining optimal stocking density, stocking size, minimum size at capture and selection of suitable candidate species are some of

the crucial management options for achieving optimal fish production from culture based fisheries.

Intergration of culture and capture fisheries

Marginal areas of both open and closed floodplain lakes can be cordoned off for pen culture while leaving the remaining area for capture/culture-based fisheries. The pens can be managed more effectively by way of eradication of unwanted fishes, control of macrophytes supplementary feeding, and so on. Since, they are managed along culture fishery lines/norms, stocking density as well as fish production rates from them are quite high.

Scope for pen culture in beels of West Bengal

Beels of West Bengal are extremely rich in nutrients, as reflected by rich organic carbon and high levels of available nitrogen and phosphorus in the soil and water phase. In many cases, the nutrients are locked up in the form of large aquatic plants, especially the water hyacinth, which are not available as food for fishes. Many of the *beels* , having their connections with the river courses, are in a transient phase of evolution into swamps. Such water bodies exhibit high level of weed infestation, rich faunistic diversity of molluscs, insects and other weed associated fauna, apart from harbouring good populations of air-breathing and a variety of small sized fishes. Although these water bodies provide an exclusive habitat for many prized fish species of Bengal, yield from capture fisheries is often very low due to many reasons mainly the limitations in using appropriate gear. The submerged weeds often come in the way of using many common fishing nets. The practice of total deweeding and conversation of *beels* into carp culture systems is not advisable as it is fraught with the danger of severe loss in biodiversity.

Pen culture can be resorted to in weed-infested *beels* to cordon off some marginal areas to culture desired species of fish and prawn. Pens offer opportunities to practice fish husbandry within *beel* by maintaining a captive stock. Pens also have an added advantage of allowing continuous water circulation with the *beel* water which facilitates better dilution of metabolites. This allows higher stocking densities, compared to other stagnant water culture systems. If used judiciously, it can augment the fish/prawn yield from the *beels* substantially.

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MANAGEMENT PRACTICES FOR PRODUCTION OF PRAWNS AND FISH IN PENS

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The word *Pen* literally means small artificial enclosure for animals and here it is relating to fishes and prawns for aquaculture. In aquaculture pens are required for raising juveniles to replenish fish stocks in large water bodies like reservoirs and lakes and when culture operations are taken in the some restricted area of open water systems. The pen culture operations are thus requirement specific and involve varying management practices. In reservoirs or lakes pens serve as nursery space while the same type of enclosures are used for culturing shell and fin fishes in large water bodies.

Indo-Gangetic states like Bihar and West Bengal have immense wetland potentials. These water bodies though potentially rich are not yielding to the desired levels and need involvement of scientific management for their optimum exploitation. Pen culture can be adopted largely for economical exploitation of shallow marginal areas of the wetland resources. The management measures for pen culture operation are presented below :

Management of pens

Pens as already mentioned have different uses and accordingly their management also varies as per the demands.

Nursery pens

The nursery pens differ in many respects from the earthen dug-out nursery ponds. Firstly the pen is a temporary structure / enclosure inside large water body and the water in pen is auto exchangeable. Secondly, shifting of such artificial enclosure is possible and can be done as and when required and also in the event of its protection against man made and natural hazards.

Construction

Nursery pens of desired size and shape are to be installed in areas of large water bodies which are exposed to comparatively low wind action and the contour is with gradual slope. One side of the pen should face the bank and the long arm of the rectangular shaped pen must be parallel to the bank side. When ever possible the narrow fringed areas also can be enclosed with split bamboo screen to make pens for nursery use.

Management

By virtue of the objectives, these artificial enclosures are installed temporarily in shallow areas during pre-monsoon period and stocked with advanced fry of fishes for growing to fingerlings size. The rearing period is restricted for 3 to 4 months and after that pens are dismantled. The recovered pen materials can be repaired and preserved for reuse in the future years.

Fortification

Depending on sediment nutrient levels, the programme of artificial fortification may be taken up. In case it is required, the fortification is recommended through the application of organic manure which besides gradual mineralisation and continuously enriching the water, occasionally severs as food for the bottom dwelling species. Rate of manure application requires to be fixed on the basis of nutrient deffiency of the bed soil.

Stocking

The built in nursery pens of reservoirs or water lands must be stocked with mixed population of the selected species and if possible in the ratio fixed as per the stocking schedule. However, the stocking density in nursery pens must not be very high since the stocked population must attend desirable size within the rearing period and be released following the lime schedule.

Feeding

Supplementary feeding if necessary may be done with conventional mixture of RB : MOC (1 : 1) @ 4-5% of the body weight in early hours when the wind action is comparatively less. The feed mixture may be broadcast in favour of the wind direction.

Harvesting

Harvesting of nursery pen is not required like that of nursery pond since the fish stock grown in the enclosure is ultimately to be released into the parent water body. As such dismantling of pen may allow safe escapement of the fish stock leaving no chance of handling injuries and subsequent moralities. However, the stock must be sampled prior to release to keep records of length and weight range for the individual species.

Culture pens

Pens for culture purposes are different from the nursery pens in respect of area, height and screen mesh size. Depending on the initial and harvesting size of the species, the pen diminution and mesh size are decided. In general, the culture pens are of 0.1 to 0.2 ha area, 1.5 m to 2.0 m height and 5.0 mm mesh size. The pens remain in operation during the culture period and thereafter dismantled, removed, repaired and preserved for future use. By this process the pen materials can be used for 3 to 4 times with little repair and least cost involvement. Moreover, the site for pen installation need be changed from time to time considering the prolonged stagnation effect on natural flora and fauna of the parent water body.

Construction

Utilising the locally available cheap materials, the pens of desired size need be constructed in suitable location of the water body. In Bihar, West Bengal and Assam bamboo can be the best material for pens which besides being cheap and easily available are durable too. Moreover, repairing of split bamboo screens to be taken by an unskilled person. The supportive poles to errect the screens must be strong enough to withstand the intense wind action and also pressure from huge mass of floating macrophytes like water hyacinth. Sufficient free height be allowed for preventing the escapement of the stock as well as entry of unwanted ones. The nylon net fitted on screen wall needs removal at middle of culture period for facilitating easy exchange of water and also entry of natural food for the stocked species. The pens may be installed in cluster of 2-4 instead of series and sufficient space need be left between such clusters considering the ill effects of metabolite dispersion and also to facilitate the necessity of water exchange for the pen environment and good health of the stocked population.

Fortification

The concept of pen culture is largely based on utilisation of the natural food in the large water bodies for growing prawn and fish under special care in controlled area following scientific technology. Thus, whatsoever fortification reqired be done has to be need-based since excess of organic fertiliser may proved to be detrimental for the pen environment and also for the culture species particularly when it is bottom dwellers like prawn.

Stocking species selection

The success of pen culture largely depends on the selection of species in consideration of the time available for culture and productivity of the water body to be installed with the pens. In West Bengal, 6 to 8 months beyond the rainy season are suitable for pen culture. The species capable of growing to marketable size within the said period are selected for the purpose. Ofcourse, the economics of the culture operations need be thought of at the time of species selection and obviously those having more price and consumer preference may be given priority. Culture of giant fresh water prawn, *Macrobrachium rosenbergii* has been popularised due to its high price and also availability of viable technology. This prawn species can grow to 40-50 gm average size in 4 to 5 months which is marketed with profitable price. However, major carp fingerlings (50 -100 gm) can also be grown to 300 - 500 gm average size in 6 to 8 months.

Prawn production in pens

The giant prawn, *M. rosenbergii* happens to be fastest growing and largest fresh water prawn species available in the country. The juveniles of the species are available in many of the major river systems like Hooghly, Mahanadi, Cauveri, Godavari etc. However, technology for artificial fecundation of the species has been developed and subsequently popularised and as a result, dependence on natural collection for the seeds of the species has been reduced and hatchery grown seed are used for culture purpose. Stocking of prawn juveniles in pens may be taken up in the month of November after the pens are cleaned of unwanted species of fishes, prawns and other organisms like crabs, molluscs, insects ect.

Stocking

Juveniles of 2.5 to 5.0 g average size are ideal for stocking in pens. However, the production from pens is always better when the stocking size is bigger. This is perhaps because of higher tolerance power and more survivability of the bigger juveniles in compared to the smaller ones. Pre-stocking conditioning results better survival of the stocked juveniles and need be followed while stocking the pens. One time stocking is advisable since periodical or in-batch stocking facilitate cannibalism amongst the prawns. Morning hours are the best time for stocking of prawn juveniles in pens when the temperature is low and also the pen ecosystem is stable. Various stocking densities are recommended depending on the pen environment and productivity and also the initial size of prawn juveniles. However, for better production bigger size juveniles (5.0 g) @ 20,000 - 25,000/ha may be stocked.

Feeding

Prawns need protein rich food for faster growth and higher survival. The natural food becomes inadequate to sustain high density of prawns. Hence in commercial pen culture, the prawns must be fed with protein rich (40%) artificial feed for higher rate of production. The following points be considered for selection/preparation of supplementary feed for prawn.

i) It must contain higher protein (40%)
ii) Should be in the form of pellets.
iii) The pellets should not disintegrte before 6 hours.
iv) The ingredients used must not include the food articles utilised for human consumption.
v) Conversion ration must be very high (1 : 2 - 1 : 3)

Because of nocturnal habit, the prawns feed mostly during dark phase of the night and accordingly feeding schedule must include a time in evening with application of higher quantum (60 -70%) of the required feed and rest may be provided in morning hours of the day. While feeding, few important points need be considered are;

i) The feed should be applied at selected points in trays.
ii) Examining the left over in the trays, feed for the next time may be adjusted
iii) Prawn guts may be examined in open eyes placing them against sun.
iv) Feed if not consumed for consecutive days may be discontinued and thus, its acceptability may be ascertained.

In view of the extensive adoption of the culture technology and adequate margin of profit out of the activities, it is imperative to search out local resource

for seed and feed so that the cost of production can be reduced and also dependence for tough materials may be avoided by the farmers. Accordingly the high cost supplementary feeds can be gradually replaced by the locally available animal protein and at the same time it will be cheaper too. Molluscan meat (smashed) has been tried at this Institute as alternative food source and proved to be an ideal substitute of the pelletised feed.

Environmental management

Prawns being highly sensitive to environmental stresses, need proper care for protection against eco-physico-chemical and biological alterations. The other point of consideration is bottom dwelling habit of prawns which put them in danger easily since the environmental problems in aquatic systems mostly originate from the bottom. In pen culture, regular monitoring of water quality is an essential requisite. It has been observed that the prawns come to the margins in foggy winter morning which is alarming for the farmers. As precautionary measure, the water should immediately be oxygenated till the prawns go back to the water. Similarly in extreme Summer when the water temperature touches 36^0C and above, the prawns come under stress and often succumb to the situation. Under such undesirable condition pumping of cold water from deeper part of the parent body would come to the rescue of the prawns and save the stock from the partial or complete loss. However, it is also necessary to provide sheds for the prawns during Summer hot for the safety of the prawns in pens.

Health monitoring

So far many a diseases are reported in prawns and it is obvious that infestation of any of the disease will be intensified when the hosts i. e. the prawns will remain in high density. Regular monitoring of prawn health helps in controlling disease infestation in pens. The infested prawns whenever encountered should be segregated and disposed or destroyed . However, periodical application of lime and KMo_4 as prophylactic measure keeps the environment healthy for the prawns and thus, protect them from disease infestation. If any sign of epidemic is observed it is better to harvest the entire stock or to be destroyed if necessary.

Harvesting

Harvesting of prawn is difficult task in compared to that of fish. Repeated netting with drag net followed by cast netting and simultaneous hand picking can be the best method of harvesting prawns effectively. But such netting operation need be continued for 3 to 4 days with 1 to 2 days intervals in between. It is reported that light trapping facilitates harvesting of prawn in ponds/pens.

In this method, bright lights are placed at some points near the margin of a side and pellets are kept in lighted area. The prawns being attracted to lights move towards the margin, sit on feed pellets and are caught in drag net operated from the back i. e. from the opposite side.

Marketing

Marketing plays vital role in economical success of aquaculture. Disposal of products like prawn at right time and right price must be looked into since the commodity is highly perishable and also highly priced. For such, preservation or other methods of processing of the commodity must be followed so that it is not degraded qualitatively prior to marketing. Facilities in these regards must be developed at the nearest of all the possible areas of large scale prawn farming. Cooperative efforts of the entrepreneurs and Government agencies would help in infrastructural development which in turn will promote aquacultural activities to enhance production and finally will help to boost foreign exchange earning for the country.

Economics

The economics has been drawn taking an unit of pen area for prawn culture as 0.1 ha.

AREA OF CULTURE ---- **0.1 ha**.

EXPNDITURE

		Amount in Rs.
A) **Non - recurring**		
	Cost of pen materials	8,000.00
	Labour charge	4,000.00
	Painting	1,500.00
		13,500.00
B) Recurring		
	Cost of seed (@Rs.2.50/Pc)	5,000.00
	Cost of feed (S.F.+ Local)	3,000.00
	Cost of Diesel	1,500.00
	Miscellaneous	1,000.00
		9,500.00
	TOTAL OF A + B	**23,000.00**

INCOME

Selling of prawns @ Rs. 300.00/kg (@ 700kg/ha)	21,000.00

PROFIT

		Expenditure	Income	Balance
1st year	1st Crop	Rs.23,000.00	Rs.21,000.00	
	2nd Crop	Rs.9,500.00	Rs.21,000.00	Rs.10,000.00
2nd year	1st Crop			
	2nd Crop	Rs.25,000.00*	Rs.42,000.00	Rs.17.000.00
3rd year	1st year			
	2nd year	Rs. 28,000.00*	Rs.45,000.00	Rs. 17,000.00

- Inclusive of repair and paining changes.

N.B. : 1. Netting X Watch and ward by the farmers involved.
2. The pen materials will be used for 3 -4 year with repair and painting.

Fish production in pens

Fish is cultured in pens to boost up production and also for raising stocking materials for the large water bodies like reservoirs and lakes. Nursery rearing of fish in pens has already been discussed and the culture of marketable size of fish in pens will be dealt now.

For fish culture in pens, the construction and fortification remain the same as stated in earlier pages. Difference starts with selection, density and ratio of the species. In general, for this purpose the trends adopted in aquaculture practices are followed with little variations fulfilling the local needs. It has been observed that selection of appropriate species combination, stocking size and densities play important role in overall production of fish from the pens.

Harvesting of fish can be easily done with drag nets and the harvested fishes are disposed to the local markets or the wholesalers. Since, fishes have local demand these can be quickly disposed and require less attention for preservation. However, in case of bulk harvesting, facilities for preservation of the products are must and accordingly the infrastuctural development is a necessity.

Economics

For fish culture the unit of pen area has been considered as 0.2 ha.

AREA OF CULTURE - **0.2 ha**

EXPENDITURE

A) Non-recurring	Amount in Rs
Cost of penmaterials	Rs. 1,000.00
Labour charge	Rs. 6,000.00
Paining	Rs.2,500.00
	Rs.18,500.00

C) Recurring	
Cost of seed @ Rs. 2.00/Pc	Rs. 2,000.00
Cost of feed	Rs. 3,000.00
Miscellaneous expenditure	Rs. 2,000.00
	Rs. 7,000.00
	TOTAL OF A+B 25,000.00

INCOME

Selling of fish @ Rs.40/kg (@ 3500 kg/ha)	Rs.28,000.00

PROFIT

	Expenditure	Income	Balance
1st year	Rs.25,500.00	Rs.28,000.00	Rs. 2,500.00
2nd year	Rs.10,000.00	Rs.28,000.00	Rs. 18,000.00
3rd year	Rs. 12,500.00	Rs. 30,000.00	Rs. 17,500.00

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Training on Pen culture of fish and prawn
December 11-15,2000. CIFRI, Barrackpore

MATERIALS AND CONSTRUCTION OF PENS

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Introduction

The use of cages and pens to rear fish in inland waters is an increasingly popular method of fish culture, involving relatively low initial costs, simple technology and management methods. The pen culture is practiced on a commercial basis only in the Philippines, Indonesia and China. Some experimental pen culture has been carried out in many countries. Pen culture originated in Japan in the early 1920s. Pens are still constructed in much the same way as they always were, except that nylon or polyethylene mesh nets have replaced the traditional split bamboo fences. The nets are attached to posts set every few meters, and the bottom of the net is pinned to the substrate with long wooden pegs. Buttressing may be used to strengthen the structures in exposed areas. This system is suitable only in places where there are no biological intruders like crabs which can destroy the nets. In such places the bamboo screens alone can be used. Pen materials and method of construction remains same irrespective of the organisms stocked in pens.

PEN MATERIALS

Essential materials

- pen wall or screen
- wooden/bamboo poles to support the pen walls and hold them in position. casuarina poles also can be used according to the availability and cost effectiveness.
- foot rope (coir minimum 4.5 mm thick)/high density polyethylene (HDPE)
  rope
- head rope (coir minimum 3 mm thick)/HDPE rope
- horizontal bars, (Bamboo/casuarina) to tie the head line.
- HDPE twine/coir (0.75-1 mm thick) for tying, lacing etc.

The pen structure consists of main support, framework spanning over the supports, horizontal and inclined bracing, stays and fish retaining net linings.

Frame

Bamboo is the most commonly available frame material particularly in the states like **Assam, West Bengal** and **Bihar,** where it is cheaper. Bamboo is found to be most suitable for *beels, mauns,* or shallow impoundment. The bamboo for making frame should be of 6" to 8" in diameter and 30' or more in length. Depending on availability, logs can be used as a replacement of bamboo poles. Galvanised iron pipe frame also can be used with iron net, for durability and rigidity of the structure. However, the cost effectiveness of these materials is to be worked out before selecting them for pen construction. Casuarina posts also can be used where it is cheap.

Screen

Pen screens may be of varying sizes according to the requirements. Split bamboo or canes with smooth surface with sufficient length are preferred as screen material. Iron mesh also can be used, though very costly. Considering their durability, synthetic nets are the most suitable pen materials if the chances of damage by various biotic agents and logs could be controlled. They are very popular in countries like the Philippines, Thailand, Indonesia, etc. Coir ropes or synthetic threads are the best weaving materials. The mesh size of the screen is decided on the basis of initial size of the stocking material. In Tamil Nadu nylon was used as screen material.

Net lining

Provision of lining the frame with net is necessary to protect unwanted entry and exist of organisms. Nylon nets are used for this purpose. The nets should be cleaned periodically for facilitating water exchange and aeration inside the pen area. Where the screen is made of polyethylene webbing, net lining is not used.

Pen wall (screen) quality requirement

The pen walls must retain small-size-shrimp seed and fish in water especially in open salt water environments (mariculture) long enough to enable the shirmp grow to exportable size. The primary target group for the technology will be small-scale farmers with limited means. The pen wall material must, therefore, be :

- with mesh small enough to retain shirmp and fish seeds, but big enough to allow free flow of water without easily permitting silt deposits or algal growth,
- resistant to salt water and sun,
- strong enough to withstand the stretching tension and wind and wave actions,
- resistant to crab cuts,
- cheap and easily available,
- easy to handle and transport,
- such that pen construction and installation on soft or firm bottoms, pen repair and maintenance and pen removal are easy.

Selection of pen wall/screen material

Split bamboo or palmyrah leaf stalk, synthetic netting and rust resistant wire or plastic mesh were considered as probable screen materials for pen. Nylon and HDPE webbing are also cheap . In one project of BOBP at Killai backwaters of Tamil Nadu, the screen material was of 14 mm mesh and knotless nylon webbing of about 0.75 twine size.

Quantity of various materials required

At Killai (Tamil Nadu) the following quantities of various materials were used for an isolated 0.5 ha pen area. In this project casuarina poles were used.

	Description of the materials required	Approximate quantity required
1	Knotless nylon webbing, 10-14 mm mesh, 0.75 twine thickness	40-50 kg
2	Casuarina post, 9-10 cm dia. at base end, 3.5 m long	2 tonnes
3	Casuarina horizontal bar, 4-5 cm dia. at base, 3 m long	100 nos.
4	Foot rope, HDPE, 4-5 mm dia.	400 m
5	Coir rope, 2-3 mm dia.	6 kg
6	HDPE twine, 1 mm thickness (for tying loop to posts)	1 kg
7	Reinforcement webbing of HDPE, 16-18 mm mesh, 40 mesh depth, 0.75 -1 mm twine thickness	21 kg
8	Metal furrower to make furrows for inserting pen webbing into firm ground	1 no.

Pen construction

Pen construction was simple. The webbing was cut into pieces of appropriate width and a 4-5 mm thick HDPE foot rope tied to the bottom line of the webbing. A loop was worked out in the foot rope initially at 5 m intervals but later the loop-to-loop distance was reduced to 3.25 m. The broader ends of the posts were chiseled to a sharp point and half a metre above the pointed end a shallow groove was cut. The pen was then ready for installation.

Pen installation

The pen wall, the foot rope and the poles were taken to the site in boats. Posts were fixed at four predetermined corners. One end loop in the bottom line of the pen wall was tied to the groove of a strong post and driven one metre in, so that the bottom line went half a metre into the mud. The next loop, 3.25 mm apart, was then tied to another post and driven into the mud in the same way and so on. Care was taken not to stretch the bottom line too much. While the loop-to-loop distance was 3.25 m, in actual installation the post-to-post distance was kept at about 2.5 m. This made installation easy.

The foot rope in between any two posts did not go straight into the mud, there was a hump in the middle. By stepping on the foot rope, it was pressed down to the desired depth. This needed much patience.

In areas where the bottom was sandy and firm the pen wall could not be sunk. So a deep furrow was made with a suitable furrower. The foot rope was then fixed into it with the feet. Depending on the depth, the workers had to dip into the water to do the job. Since the possibility of *eels* and other species burrowing in sandy bottoms was low, the insertion of the foot rope in such bottoms was mainly to keep the pen wall fixed to the bottom, so that it did not come up loose because of wind, wave and current action. About 30 cm insertion into sandy bottom was enough.

The webbing wall in between two posts of one or more sides of the pen had some loose portions which could be lowered to allow a boat or a floating cage to get into the pen for feeding, releasing fry, sampling, etc. The loose part could again be raised and tied to the horizontal bar. The pens were installed side by side with common walls, saving extra material and cost.

Conclusion

Occasional setbacks caused by unexpected flood and cyclone are inevitable. Frequent crab cuts will be a major problem where nylon netting's are used for screens. But HDPE webbing of 0.75-1.25 mm thick twine is highly effective protective layer against crab cuts. The mesh webbing of 8 mm was proved very effective than bigger mesh sizes in many cases without much disturbance from pests. However, bamboo screens are the most suitable for pen construction in *beels*.

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Training on Pen-culture on fish and prawn
December 11-15, 2000, CIFRI, Barrackpore

ROLE OF BIOTIC FACTORS INCLUCIVE OF STOCKING MATERIALS IN PEN CULTURE

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Introduction

Increasing demand of animal protein in general and fish protein in particular has assumed a focal point of animated discussion on a global scale. However, this demand is more intense in thickly populated developing countries like India so as to match the galloping percentage of mal-nourished human population in the face of alarming rate of population growth. The question is as to how world order can cope with the situation, when demands and threat perceptions are on the rise simultaneously? The ground realities suggest that most of the natural resources are over taxed and have come under acute pressure to satisfy a range of demands, especially in third world countries with relatively higher rate of population growth. The increasing need for food in such countries, therefore, has forced the local populace to over exploit the biotic resources. Accordingly, the very sustainability of living resources is under severe threat in recent time. It is in this context that most of the important natural fisheries either have already been over exploited or in the process of being over exploited. The existing trend of world fishery is nowhere more glaring than the inland waters, especially the rivers and their continuums. These ecosystems are fished heavily without any exception.

The paradox is that in spite of growing awareness for fish and shrimp protein the fisheries remain as the least valued of various uses of water, and at many a time on the allocation of water it does not figure even. The resultant impact is that the natural fishery is on a declining spree. In the backdrop of this development more innovative methods of fish rearing has gained ground. Rearing of fish is not essential only for quantitative increase, but it is also essential for improving the quality of the product. Reared fish are intended either to augment food supply or for restocking open waters to replenish the exhausted stock. The pen-culture is recent addition to this aspect of fisheries, wherein a portion of the same systems is being utilized as culture space. In such an operation the cost of constructing culture facilities is much cheaper, relatively. The pen-culture has added advantages of being user friendly, less labour incentive and cost effective. Besides it is suitable for serving the twin objectives of producing table size fish or materials for stocking in larger sheet of waters like reservoirs.

It is well known that the productivity of fish or prawn farming in pens is the end product of interaction between so many environmental and biotic factors. It is imperative, therefore, to have in depth understanding of the whole range of related aspects for getting optimum results. An attempt has been made in this paper to touch some of the aspects pertaining to the role of biotic factors in pen culture of fish and prawns in brief.

Natural productivity of a Pen area

Production and productivity is a function of the capacity of a system to produce desirable biotic species i.e. maximum production and adequate maintenance of cultivated species under normal condition. The natural production of fish or prawn in pens, therefore, is the outcome of inter-relationship between the quantum and quality of fish / prawn food organisms and their interaction with the environmental variables. The dilemma, however, lies in the fact that till date nothing much has been done to understand the role of secondary productivity in fish or prawn production. Most of the contemporary studies on productivity estimation are devoted to primary productivity. It is necessary that we must come out from this traditional mode and divert our attention for understanding the role of biotic factors in their totality, rather than depending to heavily on primary production based estimation of fish or prawn productivity.

The natural productivity of pen enclosures is dependent on the texture and quantum of biotic communities present and can be arrived at by using the empirical method:

$$K = A/10 \; X \; B \; X \; k$$

Where, K = Productivity of the pen area expressed in kilos; A = Area of the enclosure; B = Biogenic capacity and k = *coefficient* of productivity.

The productivity *coefficient* K is composed of four secondary *coefficients* designated as k_1 (Temperature), k_2 (water chemistry, alkalinity or acidity), k_3 (Fish species), k_4 (Age of the fish)). The K value thus, be calculated as $K = (k_1 \; X \; k_2 \; X \; k_3 \; X \; k_4)$. The values of K range between 1.0 to 16 depending upon the geographical region, water chemistry, culture candidates and the period of rearing. Some values of K are given in Table 1 for ready reference.

1. k_1 = Average annual temperature ^0C	2. k_2 = Acidity or Alkalinity of water
k_1 (10 ^0C) = 1.0 k_2 (16 ^0C) = 2.0 k_3 (22 ^0C) = 3.0 k_4 (25 ^0C) = 3.5	k_2 (Acid waters) = 1.0 k_2 (Acid waters) = 1.5
3. k_3 = Fish or Prawn species	**4. k_4 = Age of Fish/Prawn**
k_3 (Cold water species) = 1.0 k_3 (Warm water species) = 2.0	k_4 (Over six months) = 1.0 k_4 (Under six months) = 1.5

After Huet, 1964

The production in the pen enclosures, however, would differ from the natural production due to supplementary feeding or enhancement in biota on account of fertilization. In case of a fertilized pen area one can expect 0 to 100 percent more as compared to the natural production.

What is Biogenic capacity?

The aquaculture, as we all know, is nothing but transfer of energy from one level to another in an ascending order and being regulated by the quantum and quality of biota or shellfish/finfish organisms present at various strata of the system. Obviously, more the required biota in a grazing chain leading to better feeding efficiency, higher production of fish/prawn.

The *Biogenic capacity, therefore, denotes the nutritive value of a culture system,* which varies from water to water. This capacity is expressed in a scale of I to X, which is called '*the scale of biogenic capacity*'. The waters of pen enclosures could, thus, be differentiated as 'I' (The weakest) and 'X' (The greatest) in terms of nutritive values. Accordingly the the pen waters can be placed under five categories such as:

- *Poor water with biogenic capacity between I & III*
    - Phenerogamic vegetations practically absent or rarely present
- *Average water with biogenic capacity between IV & VI*
    - Phanerogamic vegetations tend to grow thinly along the margins and combined with emergent or semi-submerged plants. Plankton dominates the pelagic water
- *Rich water with bogenic capacity between VII & X*
    - Phanerogamic vegetations in plenty even in the middle of waters, but not as weeds generally dominated by submerged vegetations, balanced population of plankton flora and fauna.

- *Sterile waters given a value of 'O'*
    - Almost negligible biotic production, either phenorogamic or planktonic, due to certain stress factors
- *Water with the richest nutritive value 'X'*
    - Nutrient enriched Eutrophic waters with complex biotope such as wetlands. Algal blooms prominently figure with a tendency to convert in to weed infested water bodies, if left un-cared. In such water bodies the success of culture operation revolves round the effective and efficient management of macrophytes, either removed or brought into grazing chains by introducing efficient weed grazers such as grass carp.

Proper understanding of biogenic capacity of a pen site, therefore, assumes significance for better planning of culture operation, which is sustainable and commercially viable. The appreciation of biogenic capacity, though important, but it is more a matter of judgment than measure. Simulation of a lot many positive and negative factors is imperative to arrive at definite conclusion and accordingly experience is a factor to reckon with.

Relationship between the biogenic capacity and the quality of fish food organisms

The value and richness of natural food present in a given culture space depend on the quantum and texture of biota and their feeding effectiveness for the fish species to be stocked. It is obvious that specific type of food in reasonable quantity has a definite bearing in shaping the growth performance of a particular fish/prawn species. Adequate the nutritive organisms in a set of natural fish food, suitable for a particular stocked fish/prawn species, better and quick the growth performance. It is necessary, therefore, not to generalize the pen-culture operations for all type of culturable candidates. For instance, the biogenic capacities for carp culture or the shrimp farming can not be the same being different in food requirement. Hence, it is prudent to define the objectives forehand, in clear-cut terms, to obtain optimum results from a pen-culture operation. To be more precise the selection of aquatic resource for each set of culture group must be in tune with the requirement of biogenic capacity or the preference for food and habitats. The operations of pen-culture in wetlands, for instance, have shown high degree of suitability both for carp and shrimp farming, but this is not true in case of reservoirs. The reservoirs generally poor in terms of nutrients and accordingly the growth and abundance of nutritive natural food is relatively poor too. The shrimp farming or table size carp farming in such water bodies may not be

lucrative in view of slow growth rate. However, reservoirs could effectively be used for the rearing of stocking materials for the same system, especially during post-monsoon months when biogenic capacity of the water increases due to greater proliferation of nutritive biota due to input of allochthonous nutrients through the monsoon runoff.

The basic element of the biogenic capacity

The quantity of natural food, the nutritive organisms (aquatic plants and animals) necessary for a fish/prawn species, is known to regulate the degree of the biogenic capacity and therefore, this factor can be considered as the basic element. The animal component of the grazing chain depends upon the abundance and texture of organisms of plant origin either living or dead (detritus). The living plants include macroscopic as well as microscopic organisms (phytoplankton and biological cover or periphyton) - Fig 1. The macroscopic vegetation serves as the anchor for biological cover besides providing shelters for nutritive fauna. Growth of macrophytes, submerged and semi-submerged, in reasonable quantity (in patches) may be beneficial in pen-culture operation, as it provides browsing sites for species with nibbling habits while feeding (*Labeo rohita* or shrimps).

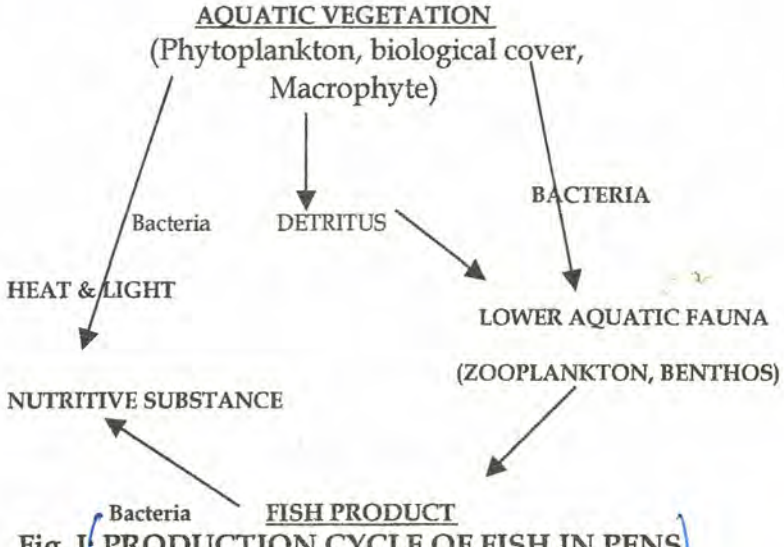

Fig. 1: PRODUCTION CYCLE OF FISH IN PENS

Role of aquatic weeds in Pen area

Looking into the successes of Pen-culture in floodplain wetlands in recent years, generally infested with aquatic vegetation, the role of phenerogames on the ecology of such water bodies needs greater elucidation. Macrophytes being the part of an aquatic system, however, can't be branded as undesirable, if present in reasonable quantity (> 20% of the surface area). However, problems crop-up when they assume the status of weeds, as this is

not desirable in any culture system including pen-culture. The fact remains that in case of excessive proliferation of weeds in a pen area the circulation of nutrients necessary for adequate growth of required nutritive organisms for the culture candidates are affected adversely. In fact the circulation path of nutrients shortened (*Soil - Weeds – Soil*) depriving the pelagic organisms from getting sufficient nutrients for proper growth (Fig II).

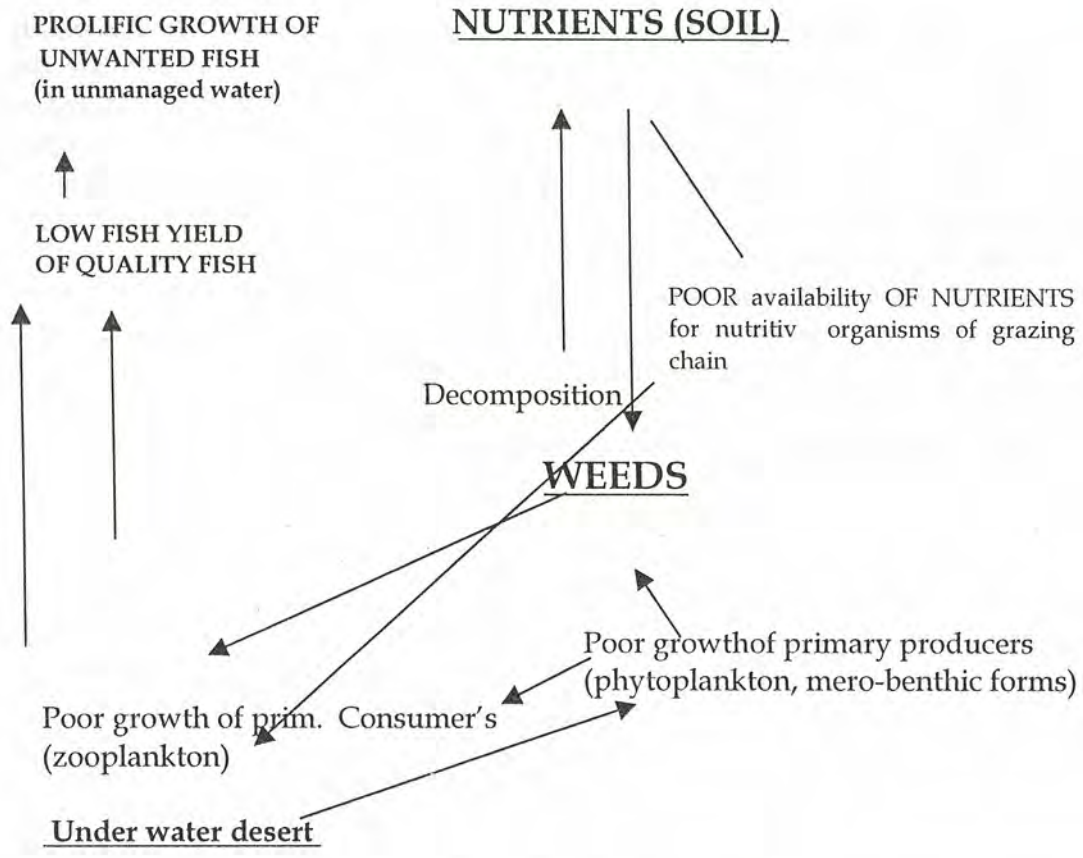

Fig II: Role of Aquatic Weeds in a Water System

Role of Stocking Material in Pens

The success of pen operations depends largely on rational stocking of culture candidates. Accordingly, the selection of culture species and the size of stocking materials have great bearing for optimizing table size fish/prawn or producing stocking materials to be stocked in open waters. Experiments and trials of pen culture conducted under CIFRI, Barrackpore suggest the following:

- Fast growing fish/prawn species compatible with the system and available seeds easily need be selected.
- The stocking of pens must be done with advanced fingerlings > 100 mm in case of producing marketable finfish, while the recommended stocking size for shell fish may be > 10-20 mm.
- In order to exploit the available niche, successfully, a combination of at least three or more varieties of fish seed with different feeding habits or a combination of finfish and shellfish may be attempted to promote synergetic effects between species besides to gain more biomass on commercial scale.
- A stocking density of 5000 fingerlings (finfish) and 25,000-30,000 (shellfish) have found giving good results. Over stocking or under stocking always has negative impact in terms of productivity, hence avoided
- The stocking ratio amongst various species needs to be worked-out based on the ecological profile and the biogenic capacity of the culture water.

Problems of Predators and Scavengers

A number of predatory and scavenging biotic species have been reported to visit or roam around the pen sites such as harmful insects (water beetles, water bugs, dragonfly), crabs, carnivorous fish (*Wallago attu, Channa* spp.), turtles, birds (Kingfisher, Heron), amphibians and reptiles. These animals always pose serious problems in pen-culture operations, if adequate precautionary measures are not being taken. The major problems are:

- Killing or wounding stocked fish species
- Damaging pen structures
- Putting fish under undue stress and reducing feeding intensity and subsequently resistance to diseases
- Carrier of many diseases

Problems of drifting objects & Fouling of Pens

Drifting objects

The pen structures are vulnerable to obstruction of drifting floating biomass such as *Eichhornia crassipes*, especially in weed infested water bodies like wetlands. The drifting plants cover substantial portion of the outer structures of pen and obstruct free exchange of water. In such a situation the culture area may develop a number of problems starting from unhygienic aquatic regime due to stagnation to decrease in oxygen level besides promoting blooming of unwanted algal species, especially blue-greens.

Fouling

Fouling of pen area due to excessive colonization of members of sessile (*Spirogyra, Zegnyma, Stigeoclonium, Chaetophora, Oedogonium* etc.) and epiphytic (diatoms and blue-greens in particular) Algae, on the outer and inner walls of pen structure is of common sight. This is more pronounced in warm tropical waters like India. The algal growth of such nature, no doubt enrich the natural food spectrum of phyto-phagus and omnivorous fish species, but it has tremendous negative impact as obstructs the free water exchange from either side of the pen enclosure. Besides non-existence of free water exchange may also convert the culture area into an isolated piece of stagnant water mass, where the problems related to accumulation and decomposition of wastes such as left-out supplementary feeds could affect the stocked fish species adversely, even to the extent of heavy mortality.

Conclusion

Sustainable Bio-production is dependent on the rational utilization of biotic resources and effective management of production variables. As management of resources hold the key for getting optimum production, the managers must have proper understanding of biota and their interactions, both positive and negative so as to plan culture operation properly. In addition an in-depth knowledge of Biogenic capacity of the culture site is important too, for getting better results through effective planning, more innovations and rational utilization of resources. Producing adequate and balanced food in tune with the growth of human population in thickly populated developing countries is the greatest challenge being faced by the present generation. The task is daunting looking into the increasing 'utility syndrome' of natural resources, but there is no escape from this situation. The question remains, therefore, that we have to have more innovative management norms to gain the maximum from per unit area of any resource. Extension of carp or shrimp farming in pens is an offshoot of the larger management plan being invoked in potential aquatic waters so as the gain the maximum without disturbing the natural fishery of open waters.

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Training on Pen culture of fish and prawn
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ROLE OF ABIOTIC FACTORS IN PEN CULTURE

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Culture of fishes and prawns in pen enclosures has drawn much interest in the recent past especially in the weed choked *beels*. Pen culture has wide scope for utilising all available water resources as well as optimum utilisation of fish food organisms for growth and complete harvest of the stock. The success of pen culture is largely dependent on water and soil quality of the pen. As fish live in water, the water quality of the pen should be monitored periodically for getting optimum sustainable fish yields. For high fish production the physico-chemical parameters should be in the conducive range. If the abiotic factors are not in congenial conditions, the aquatic organisms will be under stress which may lead to poor fish production or fish mortality. For optimum survival and growth of fish in pen culture, following physico-chemical parameters are considered to be more important for water quality management

1) Temperature, 2) Transparency, 3) Dissolved oxygen, 4) pH, 5) Total alkalinity, 6) Free CO_2, 7) Nitrogen, 8) Phosphate,9) Silicate and 10) Hardness.

Temperature

Indian major carps and other fishes in our country grow well in temperature ranging between 20 -30° C. If the water temperature is higher than 35° C in summer, the fishes may be under stress. Some floating weeds (water hyacinth) may be provided in the water body in one corner in such cases to keep the temperature under control. Fish growth is also poor if the water temperature is below 15 ^{0} C due to lower metabolic rate

Transparency

The optimum transparency in the pen ranged between 20 and 60 cm. Very high transparency (more than 1.5 m) indicate poor productivity, while very low transparency due to suspended clay, silt or plankton bloom is also not desirable for fish culture.

Dissolved oxygen

Dissolved oxygen is absolutely essential for growth and survival of fish and fish food organisms. Dissolved oxygen content ranging between 5.0 and 10 mg/1 is considered to be optimum for fish culture. If the oxygen content is low (less than 2.0 ppm) for considerable period aerate the pen by an aerator or reduce the number of fish in the pen to avoid fish kill. At higher temperature (in summer) solubility of oxygen in water is low, so aeration may be more necessary during, summer than that during winter.

pH

pH is the negative log of hydrogen ion activity. pH denote generally acidic or alkaline nature of water. Slightly alkaline water reaction (pH 7.2-8.2) is optimum for fish production Fish will be under stress in both moderately acidic or alkaline water. But fish will die if the water is strongly acidic (pH 4.0 or below) or strongly alkaline(pH 10.5 and above). So, before initiating pen culture pH of the pen need be assessed and remedial measures are require to be taken if necessary.

Total alkalinity

Fish growth and survival is optimum when the total alkalinity of water range between 80 and 160 ppm. Poor alkalinity (0-20ppm) indicates poor fish health and low production. Wetlands situated in North Bengal and Assam are generally poorly productive due to poor total alkalinity. But wetlands situated at Burdwan, 24 Parganas (North), 24 Parganas (South) and Nadia are of higher productivity due to congenial total alkalinity contents. A water body having low alkalinity may be easily modified by liming. Application of lime in the system also increases its hardness content to a desirable level.

Hardness

Total hardness above 20 ppm is considered congenial for fish health. However, hardness content ranging between 80 -150 ppm is highly conducive for fish production.

Free CO_2

Free CO_2 is essential for photosynthesis by phytoplankton and algae. However excess free CO_2 is not congenial for fish health since it may disturb oxygen absorption from the atmosphere. In the pen culture, the free $C0_2$ should be below 20 ppm. The optimum free CO_2 content in a fish pond is 5 to 10 *ppm*.

Nutrient elements

Nitrogen, phosphorus and potassium are three elements which enhance the productivity of any water body. Fish food organisms (phytoplankton, algae etc.) grow profusely if the nutrient elements are present in adequate quantities. In fish culture ponds these elements are generally supplied as fertilizer or manure to get high production of fish. If the wetland where pens are situated are nutrient deficient, then application of inorganic fertilizer or organic manure will improve the productivity of the system. However, the fertilizer or manure should be used in such quantity that there is not much algal growth in the wetland. Excess algal growth in any system is not desirable since they will consume the D.O. during night time causing stress on fish and other organisms. In case of algal growth, stop fertilizer application and maintain the D.0. level always above 2-3 ppm and preferably above 5 ppm *by* aeration. Inorganic nitrogen content in the range of 1.0-2.6 ppm may be optimum for fish production. Phosphorus is a very important nutrient for enhancing aquatic productivity. Indian soil is usually phosphorus deficient. So application of phosphatic fertilizer generally enhances aquatic productivity. Fixation of phosphate is minimum in near neutral soil reaction. Phosphate content ranging between 0.2 and 0.6 *ppm* is optimum for fish production.

Silicate

Silicate is an essential nutrient for growth of diatom, an important fish food organisms. Silicate content above 5 *ppm* is conducive for fish growth.

Soil quality

Bottom soil plays an important role in the growth and survival of fish in pen culture. It provides shelter and food to the bottom microbiota, helps in the mineralisation of organic matter and governs the release and fixation of macro and micro-nutrients in the water phase.

Bells or oxbow lakes originate from change in flow and direction of a river due to silting up of its course. The basic soil on which a *beel* is built exerts its influence upon the productivity of the system for some years. With the advancement of time production and decomposition of plant and animal organisms particularly macrophytes in the water body and their precipitation on the bottom soil modify its properties to a great extent. Thus a productive *beel* may be converted to a poorly productive one when it is infested with submerged and floating macrophytes. In general, the physical and chemical properties of water in a *beel* are more or less a relation of the properties of its bottom soil.

Productivity in pen enclosure is dependent on the availability of nutrients such as nitrogen, phosphorus, organic carbon, potassium, calcium and magnesium. Some micronutrients or trace elements also contribute significantly to pen productivity. The availability of the nutrients is dependent on soil reaction (pH).

pH

A measure of the soil reaction, pH denotes its acid or alkaline character. It is one of the most important factors affecting productivity of a water body. Soil pH is dependent on various factors such as calcium and magnesium carbonate, carbon dioxide, organic matter, clay minerals etc. If the pH is 7 it is neutral, above or below 7 it is alkaline or acidic respectively. It has been observed that pen soils with pH less than 5.5 or above 9.5 are unproductive while soils with near neutral soil reaction (pH 6.5 - 7.5) are very productive. Lime is essentially required when the soil reaction is acidic to bring the pH to a desired level. To a normal fish pond it is applied at 200-400 kg/ha/yr. In strongly acid soil the lime requirement will be much higher depending on soil pH. Fertilizers like ammonium sulphate and urea and organic acids make a heavy demand on the lime content of the soil.

Nitrogen

Nitrogen in *beel* soil is present in organic form but all of it is not available for utilisation. It is only the fraction which is easily utilised by plants is termed as available nitrogen. Fish production is poor when available nitrogen is below 25 mg/100g, medium when 25-50 mg and high when 50-75 mg/100g of soil. Similarly, fish production is optimum when the total nitrogen ranged between 0.1% and 0.25%.

Phosphorus

In agriculture phosphorus is important for root development, flowering and fruiting, crop maturation, disease resistance, crop quality etc. The availability of phosphorus in soil depends on soil pH. In acidic soils it remains fixed as iron, aluminium or manganese phosphate and phosphate deficiency is reflected in the water body. In alkaline soil, phosphorus gets fixed as calcium and magnesium phosphate. Phosphate fixation is minimum in near neutral soil reaction. If available phosphorus is below 3 mg, the water body is unproductive, average when 3-6 mg and productive between 6 and 12 mg/100 gm of soil.

Potassium

In fish culture its importance is not much felt since it is easily available in most water bodies. But *beels* with sandy non adsorptive soils may be potassium deficient and may respond to its fertilisation.

Organic carbon

Organic compounds are very useful due to their high carbohydrate content so necessary for bacterial activity. In a water body fish production is low if the organic carbon is less than 0.5%, medium when it is 0.5-1% and high when 1-2.5%.

Calcium and magnesium

These two elements are present in soil as carbonate and bicarbonate. Presence of calcium carbonate in soil is responsible for its alkaline reaction and reduced solubility of iron, manganese and aluminium. These ions are toxic under acidic conditions. Lime stimulates the general purpose heterotropic soil organisms thereby increasing the activity of organic matter and nitrogen in the

soil. Aminisation, ammonification and sulphur oxidation are more in slightly alkaline conditions. The non symbiotic bacteria and the nodule bacteria are also stimulated in the presence of lime.

Micronutrients

Micronutrients like manganese, copper, iron, molybdenum, zinc, cobalt and boron also have important role in aquatic productivity. In sandy, organic and very alkaline soil micronutrient availability may be a problem. Since the micronutrients are required in very small amounts, a slight excess may be toxic. The availability of trace elements is dependent on soil pH, the optimum pH range being 6.5 to 7.5.

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Training on Pen culture of fish and prawn
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FISH AND PRAWN HEALTH MANAGEMENT IN FLOODPLAIN WETLANDS WITH SPECIAL REFERENCE TO PEN CULTURE

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The floodplain wetlands *viz., mauns, beels, chaurs, jheels, bheries* constitute approximately 1.3 m ha of inland fisheries resource. These water areas have an average yield of 120-300 kg ha^{-1} against the potential yield of 1000-1500 kg ha^{-1}. The ecological status of various *beels* reveal that they are in various stages of eutrophication and choked with submerged or floating vegetation of suboptimal water quality. These are the areas also where pen culture is being done. The health of prawns or fish cultured in *beels* or pens will very much depend upon the habitat quality as the primary factor of importance for disease outbreak. The succeeding pages will elaborate on the water quality parameters of importance in the *beels* and their actual status, the stress being created and the various fish diseases being encountered in these water areas.

Environmental parameters of importance in relation to fish health

Oxygen

Often fishes swim on the surface of water gulping air with mouth wide open. This stressed condition of fish is due to oxygen depletion in water. Three main factors influence the amount of oxygen which a water body can hold.

a) Temperature - water holds less oxygen at higher temperature.
b) Salinity - water holds less oxygen at higher salinities.
c) Atmospheric pressure - Water holds less oxygen at low atmospheric pressure. Other factors which affect the amount of DO in water include phytoplankton blooms, organic loading and respiration of fish and other aquatic vertebrates and invertebrates.

Ammonia

It is commonly the second important parameter after DO. The total ammonia concentration in water consists of two forms.

NH_3 - unionised ammonia
NH_4 - ionised ammonia

The unionised fraction is most toxic to fish. As a general rule, the higher the pH and temperature the higher the percentage of total ammonia *i.e.,* the toxic unionised form. Ammonia in water originates from :

i) decomposing organic matter
ii) excretion of aquatic organisms
iii) death of phytoplankton bloom

Hydrogen sulphide

Very often the muck in the sediments smell like rotten eggs and the bottom dwelling fishes surface and die. This is due to accumulation of H_2S gas which is produced by chemical reduction of organic matter.

Nitrite

Fish gills frequently turn brick red in colour. This is because of excess nitrite in the water which is absorbed by fish and reacts with haemoglobin to form methaemoglobin and this gives brick red colour to the gills.

Suspended solids

It originates from phytoplankton blooms, uneaten food particles and fish fecal matter. Suspended solids are important in reducing the penetration of light thus reducing productivity.

pH

It is an important parameter affecting fish health. The optimum range of pH for most of the freshwater fishes is 6-9. The factors which affect the toxicity of acid to fish are :

i) CO_2 - high CO_2 increases the toxicity of acid

ii) Species size and age - The hatchlings or fry are normally most vulnerable to acids. Rapid changes in pH are very harmful to fish.

CO_2

Free CO_2 is toxic to fish. High concentration of 12-50 mg/l of free CO_2 hinders uptake of DO by fish and thus the effects of high CO_2 are accentuated at low DO concentrations.

Alkalinity

Water with low alkalinity of less than 20 mg/l have low buffering capacity and consequently are very vulnerable to fluctuations in pH due to rainfal or phytoplankton bloom.

Environmental aspects commonly encountered in wetlands and pens creating stress to fish

A freshwater wetland beels

Investigations on the physicochemical parameters conducted in a typical freshwater beel (Ganrapota) reveal dissolved oxygen to be the most important parameter creating stress to fish. The DO level remains below 2 ppm for nearly 8 hrs at night. Moreover the unionised ammonia level is recorded ranging from 0.05 to 0.23 ppm which is also acting as a stress factor. The aspects of the environmental parameters is typical of the various beels in Assam, West Bengal and Bihar which are in various stages of eutrophication and choked with submerged and floating vegetation.

Stress in fish and its method of diagnosis

The term stress or stressor or stress factor is defined as the force or challenge in response to which there is a compensatory physiological change in fish. Thus, an environmental or biological stress is of significance if it requires a compensating response by a fish, population or ecosystem.

Methods for stress diagnosis

Several biochemical and physiological procedures have been developed to assess the severity of the physiological effects resulting from stress. The physiological parameters of importance for assessing stress in fish at the primary, secondary and tertiary levels are discussed below.

Conceptual Frame work of Stress response

The conceptual frame work is to consider the stress response in terms of primary secondary and tertiary changes.

i) ***Primary response*** : Following perception of a stressful stimulus by the central nervous system the stress hormones *viz.*, cortisol and epinephrine are synthesized and released into the blood stream.

ii) ***Secondary response*** : Changes in the blood and tissue chemistry and in the haematology occur, such as elevated blood sugar levels and reduced clotting time. Diuresis begins followed by blood electrolyte losses and osmoregulatory dysfunction. Tissue changes, include depletion of liver glycogen and interrenal Vit. C, hypertrophy of interrenal body.

iii) ***Tertiary response*** : Manifest in reduction of growth, resistance to diseases, reproductive success and survival. These may decrease recruitment to succeeding life stages as a result population decline occur.

Use of the physiological response as indicators of stress

Several of the many changes that occur in response to stress can be used as measurable indices of the severity of stress on fish. These changes are a direct or indirect result of the physiological response to environmental changes and can be quantified and used as predictive indices.

Primary stress response

Plasma cortisol : A relatively direct assessment of the severity and duration of the primary stress response can be obtained by monitoring the rise and fall of plasma cortisol or catecholamines (epinephrine and nor epinephrine) concentrations.

Secondary stress response

The secondary changes that occur mainly in the blood chemistry also characterize the severity of stress in fishes *viz.*, blood glucose, chloride, lactic acid. They are frequently used for assessing stress response. Hyperglycemia for blood glucose and hypochloremia for blood chloride is the physiological effect of concern during stress response. Accumulation of lactic acid in muscle or blood hyperlacticemia is also an indicator of stress due to bright or severe exertion.

The haematological parameters also provide useful information about an animals tolerance to stress.

Haemoglobin/Haematocrit : Its increase or decrease following acute stress can indicate whether haemodilution or haemoconcentration has occurred.

Leucocyte decrease (leucopenia) commonly occur during the physiological response to acute stressors. The blood clotting time and changes in the leucocyte count are among the most sensitive parameters indicating stress response.

Histopathology : Since many of the biochemical changes that occur in response to stress are the end result of cellular pathology histological examinations can frequently provide information on the effect of stress factors on fish. For example interrenal hypertrophy, atrophy of the gastric mucosa and cellular changes in gills are indicative of stress response.

Tertiary stress response

Experience have shown that several tertiary stress responses including changes in the metabolic rate, health, behaviour, growth, survival and reproductive success can indicate that unfavourable environmental conditions have exceeded acclimation tolerance limits of fish.

Metabolic rate : It is a fundamental aspect of animals performance and is affected by stress.

Reproduction : Detrimental effects on reproduction as manifested by oocyte atresia, spawning inhibition and decreased fecundity and hatching success are taken into consideration for assessing stress response.

Disease : Incidence of fish disease is an important indicator of environmental stress. Fish disease is actually the outcome of the interaction between the fish, their pathogens and the environment. If the environment deteriorates stressed fish is unable to resist the pathogens that they normally can resist. Certain diseases are proving to be useful indicators that tolerances of adverse environmental conditions have been exceeded.

Biological indicators of stress

In all of these water areas mentioned above the very common initial symptom of stress exhibited by fishes is excessive secretion of mucus from gills and body surface. In fact this physiological aspect of fishes can be fruitfully utilized for fish stress detection or detection of suboptimal water quality.

There are certain trichodinid parasites (*Trichodina* sp., *Tripartiella* sp.) ubiquitously present in fish gills especially of Indian major carps which can serve as good indicator of stress in fish. Excessive mucus secretion serve as substrate for these trichodinids which increase in number. A methodology has been developed where the presence of these trichodinids above 20 numbers in 0.05 ml of gill mucus in indicative of stress.

Indicators of health condition of fish stock

Any occurrence of fish disease in a water body is generally recognised by fish becoming restless, rubbing its body against pond dykes, splashing, surfacing, whirling non-acceptance of food etc. However, there are some external symptoms of healthy fish as reflected by :

i) ***Escape reflex***

Healthy fish react to external agitation such as quick motion, stamping on the bank, sound etc. and quickly submerge under water. Sick fish do not react to external agitation and can be caught easily.

ii) ***Defensive reflex***

A freshly caught fish from water toss about quite violently when laid on ground. After a while the fish calms down. Sick fishes are sluggish in water as well as out of it.

iii) ***Tail reflex***

When a live fish is held by the head and the posterior portion is free, it exhibits the tail reflex which occurs irregularly. Here the fish keeps the posterior and caudal fin in a horizontal position or even slightly obliquely upward, while the caudal fin is always stretched in a fan-shape.

Fish diseases commonly encountered in wetlands and pens

Fish diseases caused by protozoan parasites

They are probably the most important group of animal parasites affecting fish. The protozoan parasites afflicting fish fall under the phylum Ciliophora with the typical parasites *Trichodina* and *Tripartiella;* Phylum Sarcomastigophora with the typical parasite *Costia* and Phylum Myxozoa with the typical parasite *Myxobolus* spp., *Thelohanellus* spp.

General morphology and identification of Trichodinid Parasites

The trichodinid parasites *viz., Trichodina* or *Tripartiella* are hemispherical-bell shaped. The aboral surface is concave. The adoral cilia surround the buccal cavity and the marginal cilia gives it a spiral rotating movement. The parasite attaches itself to the host surface by the attachment disc reinforced by border memberane. The ring of denticles and radial pins located internally provide rigidity to the parasite.

Life cycle and transmission

They have a simple life cycle and reproduce by binary fission and is directly transmitted from one host to the other.

Common disease encountered in fish culture

Trichodinosis

The disease is very common in the fry and fingerlings of cultured fishes. The most common symptom in an affected fish is pale colour of the gills with a creamish coating due to excessive secretion of mucus. The causative organism is urceolariid ciliates of the genus *Trichodina* and *Tripartiella.*

General morphology and identification of Myxozoan Parasites

The prominent feature of the myxozoan parasite is the spore. The spore usually consists of two valves joined by a suture. The valves are of various shapes. Within the spore there are one, two or more polar capsules. Within the capsule is the coiled polar filament opening outside the capsule by an apperture. The remainder of the spore cavity is occupied by the sporoplasma, the infective part of the spore.

Life cycle and transmission

It has a direct life cycle. The spores are ingested by the fish. The sporoplasma comes out and moves through the blood stream and reaches the appropriate site of infection. Here it undergoes repeated nuclear division in the trophozoit and forms mature spores.

Common diseases encountered in fish culture

White gill spot disease

The gills of fishes predominantly *Catla catla* are covered with whitish cysts of different sizes. This infection reduces the absorptive surface of gills. Excessive mucus secretion occurs and fishes surface for gulping air. The causative organisms are *Thelohanellus catlae* and *Myxobolus bengalensis*.

Scale spot disease

The scales are covered with whitish cysts. In acute cases scales become perforated and degenerated. Scales become loose with ulceration. The causative organisms are *Myxobolus rohitae* in *L.rohita* and *Myxobolus sphericum* in *C.mrigala.*

Fish diseases caused by helminth parasites

These flatworms are predominantly parasitic in fish and have a varied type of host-parasite relationship. They are mostly dorso-ventrally flattened and bilaterally symmetrical. They may be segmented or unsegmented and most of them are attached to the host by characteristic attachement organs. The flatworms which infect fishes in aquaculture or open waters broadly fall under three classes; the Monogenea, Cestoda and Trematoda.

Monogenea

General morphology and identification of Monogenean parasites :

They are small worms and ectoparasitic in nature. The posterior extremity of the body has the characteristic attachment organ called opisthapter. It is armed with chitinoid structures important for identification. The anterior end of the parasite bears a small sucker. Eyespots are frequently present anteriorly.

Life cycle and transmission

Monogeneans predominantly have direct life cycle. Most of them are oviparous depositing eggs which on hatching release a free swimming larva which seeks a host, becomes attached to it and metamorphose to adult ones. Some are viviparous and give birth to young worms which attach to new host on their release.

Common diseases encountered in fish culture

Dactylogyrosis and Gyrodactylosis : The causative organism for the disease is *Dactylogyrus* sp. and *Gyrodactylus* sp. While *Dactylogyrus* sp. predominantly infests the gills, *Gyrodactylus* sp. mostly infests different body surface and occassionally gills. When gills are infected their is hypersecretion of mucus affecting respiratory surface and very often the fishes are irritable and surfacing takes place. There is growth retardation and loss of weight.

Trematoda

General morphology and identification of trematodes parasites

They are dorso-ventrally flattened, unsegmented and usually oval in shape. Two attachement organs are present, the oral sucker near anterior end and the ventral sucker or acetabulum, a little below the oral sucker.

Life cycle and Transmission

The digeneans are oviparous and in most cases the eggs hatch outside the host to release a free swimming miracidium larva. This larva locates the first intermediate host *i.e.,* the gastropod. Within this host the parasite undergoes asexual reproduction and forms the cercaria larvae which, when released, locates the suitable second intermediate host, which is the fish. Here the cercaria encyst to form the metacercarial stage. The life cycle here is completed when the infected fish is eaten by a suitable final host *i.e.,* the bird.

Common diseases encountered in fish culture

Black spot disease : The fingerlings and young ones of mostly *Catla catla* are affected with black ovoid patches on the body surface. These are pigment patches overlying metacercarial cysts of digenetic trematodes; *Diplostomum* sp. The presence of these black spots is the diagnostic feature of the disease.

Cestoda

General morphology and identification of cestoda parasite

Cestodes do not have an alimentary canal or any body cavity. Most of them are equipped with one attachment organ, scolex. The scolex is normally followed by a narrow unsegmented neck passing into the long body. They body is flattened dorso-ventrally. The body is segmented and is called proglottids.

Life cycle and Transmission

The eggs of this parasite is released by the faeces of bird (*Anhinga melanogaster*) in wate rwhere it hatches into a coracidium larva which enters the first intermediate host an invertebrate where it develop into a procercoid. The procercoid enters the second intermediate host, the fish and develops into the plerocercoid larvae .

Common diseases encountered in fish culture

Ligulosis

The pleurocercoid larva of the cestoda *Ligula intestinalis* cause this disease. This larval stage is very often found infecting *Catla catla*. The symptoms are abdominal distension, reduced growth and dark colouration.

Fish diseases caused by crustacean parasites

Crustacean parasites are frequently reported in fishes. Crustacean parasites in most cases do not cause serious problems to fish health except irritation and localised ulceration. But several instances are reported where severe infestation by the crustacean parasites resulted in mortality of fish in different fish culture areas.

The crustaceans which infest fishes in our fish cultute systems fall under the sub classes (1) Entomostracea - having the orders Copepoda and Branchiura and (2) Malacostraca - having the order Isopoda.

Copepoda

General morphology and identification of Copepoda parasites

They are ecto-parasites. In head region they bear six pairs of appendages *viz.*, two pairs of antenna, one pair of mandible, two pairs maxillae, and one pair of maxillipeds. The thoracie region bears six pairs of swimming legs. The abdomen consists of 1-4 segments, the last segment terminates into two flat branches the caudal rami. The shape of the body varies from oblongate to elongated shape in parasitic forms.

Life cycle and Transmission

The development of most parasitic copepodes is direct without change of host. Most of the larval development is completed within the eggs. Thus, when the eggs hatch they either give rise to metanauplius larva or copepodite larva. This process shortens the free living period. They produce 3-4 broods in a year. Females are generally the parasitic ones and attach themselves to the host fish.

Common diseases encountered in fish culture

Lernaeosis

The disease is caused by parasitic females of genus *Lernae,* commonly known as anchor worms. They are relatively large, 5-22 mm and during attachment to the host they assume a vermiform shape with anterior attachment organ buried deep in host tissue.

An infested fish exhibits symptoms of rubbing against the sides or bottom of the pond. Heavy infestation leads to lethargy, emaciation and retardation of growth. The parasite destroys scales and causes haemorrhagic and ulcerated areas at the point of penetration. A large number of fish species *viz., C.catla, L.rohita, O.gouramy, C.idella* and a number of minor carps are susceptible to lernaeosis.

Ergasilosis

The disease is caused by the parasitic females of the genus *Ergasilus, Neoergasilus* sp. They have a cyuclops like body, narrowing posteriorly and has a total length of 1.5-2.5 mm. They predominantly attach to the gills and fins of fish by means of the second antenna which is stout and clawed and feed on the blood and epithelium. Sometimes infestation may be to the tune of 150 number per square cm. Heavy infestation results in respiratory distress, anemia and retarded

growth. Prominent symptoms exhibited by heavily infsted fishes are frequent surfacing, listlessness and mortality under oxygen depleted conditions.

Branchiura

General morphology and identification of branchiuran parasite

The most important fish parasite under Branchiura, as far as fish culture is concerned, is *Argulus* sp. The parasites, commonly called fish lice are flattened dorsoventrally. The cephalothorax is broad, the dorsal part has a convex cephalothoracic carapace, whose posterior part is heart shaped. The cephalothorax is sunken at the ventral side, on which there are two faceted eyes, first antenna is transformed into a clasping organ. The mamilla are transformed into enormous suckers. The abdomen is small and its rear end forms two lobes.

Life cycle and Transmission

Argulus matures remaining attached to the host. It is capable of free swimming for sometimes either to lay eggs or in search of new host. The fertilized females leave the host and lay eggs which ar stiking in nature on submerged vegetation, rocks, sticks etc. The nauplius, metanauplius and in some species the first copepodid stages develop within the eggs which hatch as metanauplius or copepodids. The copepodid stages are seven in number, finally forming adult. The period for completion of this life cycle is 3-6 weeks.

Because of the parasite infestation, affected areas develop ulceration. The toxic secretion of the buccal gland of the parasite causes intense inflammatory reaction. Infestation is accompanied by excessive mucus secretion, lethargy, irrigation and retarded growth.

Epizootic ulcerative syndrome

Symptoms : The fishes become lethargic, float on the surface of the water sometimes with head projected out of water. Initially the disease appear as red colored lesions haemorhagic in nature. These red lesions spread and enlarge gradually become deeper and assume the form of ulcers. With further advancement scales fall off, ulcers become deep necrotizing ulcerative lesions. Histopathologically it is characterized in having mycotic granuloma.

Causative agent : investigations on the suspected causative agent *viz.*, virus, bacteria and fungus could not conclusively establish the primary causative agent. However the international consensus is the fungus Aphanomyces sp. to be the prime agent causing EUS.

Common diseases in prawn and their remedial measures

The culture of prawn *viz., Penaeus monodon* in brackishwater and *Macrobrachium rosenbergii* in freshwater has recently attracted the attention of aquaculturists in India. This is because of the fact that the potential of developing the culture of these organisms into an economically successful industry has been recognised. However, along with its development one of the most important problem limiting its production in India is diseases. Since systematic culture of prawns in India is a recent development, work on their diseases is also in its infancy. However, from the experience of different workers engaged in prawn farming in India and abroad several diseases have been identified and certain remedial measures developed.

Disease and their environment

Outbreak of disease in prawns is usually significantly related to poor environmental condition.

There are various ways in which the prawn the environment and the pathogenic organisms can interact.

i) Poor environmental condition can directly cause disease *eg.* low dissolved oxygen below 4 ppm.

ii) Poor environmental condition can stress prawn and then it can be infected by an opportunist pathogen example deteriorating pond bottom condition may lead to *Vibriosis*.

iii) Prawns may harbour some pathogenic organisms which will cause damage to it only when the host is stressed by poor environmental condition *eg.* Monodon baculovirus in hepatopancreas of prawn.

The presence of a pathogen in the tissue does not mean that it is the main cause of the problem. In majority of the cases the original cause of the problem is environmental. This must be taken into account when considering prevention or control of disease. For the farmer the most important aspect of disease diagnosis is the ability to detect the earliest stages of poor health or abnormalities in the prawn.

Symptoms of prawn disease in the farm

Outward observation

While observing from the pond dyke a healthy prawn should not be visible during culture. When the prawns are stressed by poor environmental conditions or suffering from some other disease they often come to the surface of the water or edge of the pond because of high dissolved oxygen. In some cases they may also be avoiding high levels of toxic sbstances at the bottom of the pond. It is important to check the ponds during night and in the early morning, since sick prawn will come to the surface and edge in large numbers at this time. At the first sign of prawn surfacing at the edge of the pond the bottom should be checked for dead prawn in areas, where waste accumulates.

Observation during sampling

During sampling close observations will reveal various predictive symptoms of disease outbreak. As such the factors to be looked into are :

i) ***Color of prawn*** - The color of normal prawn is related to their environmental conditions. For example in shallower ponds or in clear water the prawn will tend to be darker, than those in deeper or less transparent water. Change in colour can also be an indication of poor health. Stressed prawn will often develop a blue coloration as opposed to the normal green color. Most injuries in prawns turn black or brown after a short period of time. This is due to the production of the pigment melanin which is toxic to microorganisms and can protect the prawns from injections. For example appendages that have been nibbled by other prawns will turn black at the end and areas of shell that have been infected with bacteria will also turn black.

ii) ***Soft shell*** - Very often the external shell is soft. Normally the shell hardens within 24 hours of moulting. If it fails to harden it may be wrinkled and torn and more susceptible to superficial injections.

iii) ***Change in gill colour*** - Healthy prawns keep their gills clean, but lethargic or diseased prawns clean their gills less frequently allowing fouling organisms and debris to accumulate. This material gives the gills a brown colour. If gills are damaged they develop brown or black colour due to deposition of melanin.

iv) ***External fouling*** - Very prominent symptom of unhealthy prawn. Organisms grow on the surface and simultaneously they collect inanimate debris lending green or muddy color to the prawn. Healthy prawn clean

themselves regularly and any persistent fouling is removed during moulting. Unhealthy prawn tend to clean themselves less often and moult less frequently.

v) *Changes in gut* - An empty or partially empty gut indicates that the prawn has not been eating. This may either be due to lack of food, adverse environment or poor health. The colour of the hepatopancreas can change, most significantly to a yellow colour in the so called yellow head disease. In case of septic hepatopancreatic necrosis the hepatopancreas will be small as well as discoloured.

vi) *Change in the muscle* - In many cases the abdominal muscle do not fill the carapace. This is observed either immediately after moulting or in cases of chronic starvation or where prawn appetite is reduced due to chronic disease. The muscle may become opaque for a number of reasons example due to chronic stress, microsporidean infection (cottom shrimp) or as in cramped muscle syndrome. The muscle may also develop brown or black lesion as in black splinter disease.

Diseases encountered during culture

Studies conducted by several workers in India and abroad reveal a large number of pathogenic organisms afflicting *Penaeus monodon* and *Macrobrachium rosenbergii*. However, in this communication for the sake of clarity the different organisms producing similar type of disease manifestation have bben grouped into smaller number of disease syndrome.

A. Non invasive external fouling

Symptoms : Fuzzy mat on shell and gills. The appearance of prawns with external fouling depends not only on the type of organisms involved but also on any additional debris which become attached. Fouling on the gill frequently causes a dark coloration and can even result in the gills appearing black.

Impact on host : The main effect of fouling is to interfere with movement and respiration. Affected prawns are often attracted to the water at the side of the pond with higher level of dissolved oxygen.

Causative organisms : Protozoans *viz., Epistylis* sp., *Zoothamnium* sp., *Vorticella* sp., *Suctoria* sp., bacteria *viz., Leucothrix* sp., fungi, macro invertebrates *viz.,* barnacles and algae.

Host species : *Penaeus monodon* and *Macrobrachium rosenbergii.*

Method of control : Any form of treatment for fouling has to address the initial problem as well as the presence of organism. This usually involves improving the water quality to encourage the prawn to be more active and to moult regularly. Chemical treatments is done for cases of external fouling persisting even after improved water quality.

The most commonly used chemical is formalin (37 to 40% formaldehyde) @ 25 to 30 ppm. The prepared solution in water should be distributed uniformly in the water area and dissolved oxygen levels should be maintained.

B. Externally invasive disease

There are a number of infections which start on the outside of the shrimp and invade through the carapace.

Symptoms : Black spot or black or brown areas in different organs or portions of prawn.

Impact on host : Primarily the invasive organisms cause lesions, erosions or depressions in shell and when such invasions affect an inflammatory reaction in the internal tissue either gill or muscle in any portion, it leads to melanization.

Causative organisms : The invasive organisms are *Vibrio* sp., *Pseudomonas* sp., *Aeromonas* sp., Fungi- *Fusarium* sp.

There are however a large number of other conditions which can result in significant melanization of the gill or the condition knowns as 'black gill'. Some of the potential causes are;

i) localised bacterial infection viz., *Vibrio* sp.
ii) fungal infection, *Fusarium* sp.
iii) Protozoans
iv) acid waters, soils etc.

Area of the carapace other than the gill can be affected by localized damage. Appendages may be damaged by other shrimp or they can be affected by localised infection due to poor pond bottom condition. In ponds where the prawns cannot avoid the accumulated waste, swollen tail may be seen.

Host species : *Penaeus monodon* and *Macrobrachium rosenbergii*

Methods of control : The treatment of all these external invasive conditions depends on the original cause. If the causes of the irritation is removed the melanized tissue especially in the gills may be discarded at or before the next moult, returning the gills to normal appearance.

Better pond management in many cases eliminates the disease condition.

C. Vibriosis

The term vibriosis is used to refer to all types of infections caused by species of the genus *Vibrio* including bacterial shell disease and black gill.

Systemic infections appear to be the most common form of vibriosis either associated with poor water quality with other diseases. In acute form the symptoms though non specific areas.

a) abnormal behaviour *eg.,* prawns at the side or surface of the pond
b) lethargy
c) inappetite
d) discoloration either red or blue

If prawns are severely stressed or the bacteria are highly pathogenic, a large number of prawns may die within a short period of time. Chronic infections often result in formation of black nodules in many tissues.

Some forms of disease outbreak due to *Vibrio* sp., have been given specific names as under :

i) *One month mortality syndrome :* In culture ponds if benthic algae are allowed to grow on the pond bottom during early stages of culture the algae may subsequently decompose. The prawns come in close contact with this decomposing material after moulting and are exposed to stressful environment and large number of bacteria. This result in the prawns developing shell lesions and systemic bacterial infections.

Host : *Penaeus monodon* and *Macrobrachium rosenbergii*

ii) *Black splinter disease :* It is a condition in prawn where a chronic melanised lesion develop in the muscle of the abdomen.

Host : *Penaeus monodon*

iii) *Luminescent bacterial syndrome* : It is very common in hatcheries and growout ponds. It is caused by some species of *Vibrio* which are luminescent. When present in large numbers they may cause the affected animals to glow in the dark.

Host : *Penaeus monodon*

iv) *Septic hepatopancreatic necrosis* : Here large areas of hepatopancreas is destroyed and the area turns dark. This condition is brought about by *Vibrio* infection. However, there are reports that similar condition is also associated with toxins (aflatoxin) in food or presence of other types of bacteria.

Causative species : *Vibrio parahaemolytieus, V. alginolyticus, V.anguillarium, V.vulnifieus, V.fluvials.* certain other gram negative rods, including *Pseudomonas* sp., and *Aeromonas* sp., may occasionally incriminate the bacterial disease syndrome in prawns.

Methods of control : Vibriosis is very often associated with other problems in the culture ponds. Any mortality of prawn will have some *Vibrio* sp.

Treatment of vibriosis must always involve improving the environment. Maintain adequate water quality with low bacterial biomass, a stable phytoplankton bloom and proper feeding programme. Sterilise or filter recirculated water. Routinely monitor prawn and pond for early diagnosis of a problem. Avoid temperature extremes, handling, overcrowding and other stressors. Antibiotic therapy.

There are certains norms to be followed before we go for antibiotic therapy (i) it is essential to improve pond environment (ii) use abtibiotics only for bacterial infections but not for viruses, fungi or protozoa (iii) use an antibiotic to which the bacteria are sensitive. Antibiotics either oxytetracycline or Erythromycin etc., should be treated for 5 days. Prawns harvested after atleast 14 days.

D. Viral infection in Hepatopancreas

The hepatopancreas of prawn is affected by the following viruses :

i) Monodon baculovirus (MBV)
ii) Baculovirus penaei (PB)
iii) Type C.baculovirus
iv) Hepatopancreatic parva like virus (HPV)

These viruses damage the cells of the hepatopancreas and make shrimp more susceptible to stress or other diseases. The severity of their effect and the age at which infected shrimp are most sensitive vary with different viruses. It has proved to be difficult to demonstrate conclusively the effect of these viruses on the health of shrimp populations.

The viruses are detected by their effect within the cells of the hepatopancreas. With the exception of the type C. Baculoviruses, they cause inclusion bodies in the nuclei of the affected cells. All these viruses are thought to be spread by excretion in faeces and subsequent ingestion by other shrimp. The infection may spread between the brood stock and the larvae by this route.

Host : *Penaeus monodon*

Methods of control : The pond disinfectants are widely used for reducing the load of bacteria in viral disease. The disinfectants used are buffered iodophores (CHI_3) and calcium hypochlorite. Lime can also be considered to be a pond disinfectant. Chlorine is also used as disinfectant.

Yellow head disease

Symptoms : The disease is characterisd by pale body colour with yellowish gills and hepatopancreas. It is commonly seen in 50 to 70 days post stocking.

Impact on host : In this disease abnormalities should be observed, in the haemocytes including shrinking of nuclei, breakdown of nuclei and cytpolasmic inclusions.

Host : *Penaeus monodon*

Causative agent : Yellow head baculovirus

Method of control : It is important to differentiate yellow head disease from other causes of mortalities. With yellow head disease the best course of action in most cases is to conduct an emergency harvest, regardless of the stage of production.

White spot disease

Symptoms : White spots appear on the carapace and extend to other parts.

Impact on host : Marked hypertrophy and intra muscular inflammation

Host : *Penaeus monodon*

Causative agent : A virus described as SEMBV (Systemic Ectodermal and Mesodermal Baculovirus) no tratment available. Prevention is the best method of control.

Method of control : The methods used for containing this disease is mainly preventive as discussed

i) Every pond should have a reservoir pond and inlet water should be kept 4-5 days prior to use. This water can be sedimented, disinfected (say @ 30 mgl^{-1} chlorine) and aerated prior to use in culture.

ii) Entry of wild prawn and crabs is prevented.

iii) Used trash fish, crabs and othe rcrustaceans which can serve as potential carrier of SEMBV should be avoided in culture ponds

iv) Carefully select post larvae

v) Maintain optimum water quality to avoid stress in prawn.

E. Microsporideans

Symptoms : Prawns appear cooked although alive. The infected muscle of the abdomen turns opaque and white. The appearance of the muscle has led to the condition being called cottom shrimp or milk shrimp.

Causative agent : The muscles of affected shrimp contains areas that are replaced by a large number of microsporidean cells. Each cell undergoes internal division to produce a small group of spores. The causative organism is *Agmasoma* sp.

Methods of control : There is no suitable treatment and control involves removing affected individual. This is possible because affected shrimp will often swim on the surface of the pond at night.

F. Soft shell syndrome

Symptom : The body muscle is soft and not tight

Causative agent : It may be associated with exposure to a variety of insecticide as well as a number of different environmental condition *viz.,*

i) poor quality feed

ii) overstocking or underfeeding
iii) low soil pH
iv) low water phosphate

Methods of control : Treatment involves improving the environment wherever possible, avoiding agricultural run off or other sources of pesticides and ensuring high quality feed with 1:1 ratio of calcium to phosphorus.

G. Cramped tail condition

Symptoms : It is described as a condition of prawns having a dorsal flexure of the abdomen which cannot be straightened.

Causative agent : This condition occurs during summer months especially with the handling of shrimp in the air where it is warmer than the culture system. The exact cause is unknown, other stress factor may be the cause of this condition, as reported.

Health monitoring of prawn larvae

1. External fouling with protozoa, bacteria on fungus is thought to indicate poor quality larvae. If a large proportion of the post larvae have external fouling it may indicate poor water quality and or that post larvae are not moulting regularly.

2. The appendages and rostrum of the post larvae should be of normal shape and without erosions or black discoloration. The abdominal muscle should be clear and it has been suggested the muscle to gut ratio in the six abdominal segment should be around 4:1. The gut should also be full of food.

3. There are certain aspects of behaviour of the post larvae (*P.monodon*) that are thought to indicate good health. Healthy post larvae swim with straight bodies, respond quickly to external stimuli and actively swim against the current when water is stirred. When the current subsides they tend to cling to the sides rather than being swept into the centre of the container. Unhealthy post larvae may be lethargic, unresponsive and may swim with arched bodies.

4. The health condition of post larvae can be further evaluated by the following tests.

Salinity test - the larvae are exposed suddenly to a salinity of 15-20 ppt. If no mortality occurs over two hours of exposure and they recover and resume feeding within 24 hrs they can be considered healthy.

Formalin test - larvae are subjected to 100 mgl^{-1} formalin for 2 hours. If they survive and recover they are considered healthy.

Physico-chemical characteristics of Ganrapota beel,West Bengal

	Range of water quality parameters during year	Diurnal variation of water quality parameters											
		10 AM	*12 PM*	*2 PM*	*4 PM*	*6 PM*	*8 PM*	*10 PM*	*12 PM*	*2 AM*	*4 AM*	*6 AM*	*8 AM*
Temperature (water)	26-36	22.5	24.0	24.5	24.0	22.0	21.0	21.5	20.5	20.5	21.5	22	22.5
Alkalinity (mgl^{-1})	133-212	212	214	201	206	214	209	212	210	209	210	215	210
Hardness (mgl^{-1})	120-199	195	199	187	190	193	195	198	198	190	197	199	196
Unionised ammonia (mgl^{-1})	0.05-0.25	0.1	0.1	0.1	0.15	0.11	0.1	0.1	0.2	0.1	0.1	0.1	0.1
CO_2 (mgl^{-1})	1.0-8.0	1.0	1.0	1.0	1.0	1.5	1.0	1.5	2.0	2.0	2.0	1.5	1.0
Chloride (mgl^{-1})	3.7-9.5	7.5	7.0	7.8	6.9	7.2	7.5	7.5	7.3	7.4	7.9	7.8	7.0
DO (mgl^{-1})	6.0-9.0	6.5	8.0	9.0	9.0	7.5	5.2	3.5	3.0	2.0	2.0	2.0	3.0
pH	7.8-8.0	8.0	8.0	8.1	8.0	8.0	8.0	7.9	7.9	8.0	7.8	8.0	8.0

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COMMUNICATION APPROACH FOR ADOPTION OF PEN CULTURE TECHNOLOGY

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The recent achievements in inland fisheries production triggered off by the new scientific innovations in inland fisheries sector and their use in commercial scale particularly adoption of the modern inland fisheries technologies and strategy, has imparted a new dynamism to Inland fisheries development and has given new hopes and confidence to millions of fish farmers/fishermen. The Inland fisheries of India has heaved itself out of the ruts of traditional practices based on customs and traditions and is increasingly assimilating the modern and most scientific techniques for stepping up the fish production.

As a result of breakthrough in inland fisheries research and available large number of findings, several programmes in the development of inland fisheries have been initiated. The demands made upon transfer of technology for accelerating inland fish production are enormous and most formidable. Therefore, the integrated function in of research, education and extension has been the cardinal principles of inland fisheries development. There are 4 major organizational streams devoted to extension work for Inland Fisheries development

(i) The ICAR Extension System
(ii) Extension System of the Ministry of Agriculture/State Fisheries Department
(iii) Extension System of the Ministry of Rural Development/State Development Department
(iv) Development work done by Non Government Organizations.

Most of the programmes of these systems are for tackling the problems of weaker sections, specially the Small, Marginal and Landless fish farmers/fishermen for improving their economic condition.

Pen Culture Technology

The State of West Bengal has extensive floodplain wetlands in the form of cut-off river meanders (oxbow lakes), backswarms, sloughs and tectonic depressions. Popularly known as beels, these water bodies cover a sprawling 42,500 ha, supporting a variety of economic activities including fisheries, irrigation, navigation, jute retting and duck rearing, making them the lifeline for the surrounding local communities in rural Bengal. Irrespective of their origin, these lakes are considered as biologically sensitive ecosystems, as they play a vital role in the recruitment of fish population in rivers. While nearly half of the beels are situated in the districts of North 24 Parganas, Murshidabad, Hooghly and Nadia. They are also present in Burdwan, Cooch Behar, Maldah and North & South Dinajpur districts. According to the available estimates, fish yield from beels of West Bengal is very low at 100 kg/ha, although they have the potential to yield more.

Characteristics of new technology

The new technologies are sophisticated in nature and high input-intensive. These are interdependent on so many inter-related practices each one of which has to be applied rationally, in time and in the manner recommended by the scientists. Failure in any of them may upset the achievement of the desired yield level. A communicator, therefore, has to understand its characteristics in order to select appropriate extension methods and techniques for effective and rapid communication. This needs information transfer strategy for speedy dissemination of information through appropriate extension methods, techniques and media for increasing production with existing resources and lowering the price of the produce for consumers.

There are three main aspects to this job for getting information to people :

a) Getting new knowledge from a source
b) Interpreting the knowledge so that people understand it and
c) Transmitting the interpreted information to the people who will use it.

Communication of information

The management practices of the technologies are being communicated to the fish farmers by different communicators through various channels but effects of such communication are not always well pronounced as evidenced by fish farmers' inadequate knowledge, understanding, skill and sometimes negatives attitude gained, leads to either delayed or no action by them. But, whatever the technology has been profitable, feasible and communicated through appropriate extension

methods and techniques, the fish farmers' response has been spectacular. Communication is not a one-unit act but a process having continuity and consisting of distinct elements such as communicator, (Source-Inventors, Scientists, Extension Workers, Opinion Leaders etc.), Message (Innovation, New Ideas), Channel and Recipient (Fish Farmers, Members of the social system) all directed towards eliciting specific intended response from the recipient. In order that the process is complete and brings the intended response (desired behavioural change), it is crucial that these elements are well balanced, one fitting into other. The fault in one, may lead to breakdown of the entire process. This balance, however, is seldom found in real fish farm situation. The problem is aggravated by scores of factors operating at each element as determinant of communication effectiveness, the fidelity of the process.

We may now critically examine as to what the factors operating at each of the four major elements of the communication process which act and the absence or want of which pose problems reflecting on the effectiveness of the entire efforts spend on communication of inland fisheries information to the fish farmers.

A. *COMMUNICATOR*

The communicator being the person who starts the process may be an extension worker, block development personal, information officer, specialist or may be even neighbour, relative and friend, village leader and others. The shortcomings in the communicator retard the communication effectiveness.

a) *Communicators credibility*

The expertise knowledge level about the subject matter and trustworthiness with which a communicator is viewed by the recipient fish farmers have influence over his success as communicator. Studies have revealed that a communicator having poor credibility in the eyes of the fish farmers is likely to be less heard or relied upon.

b) Communication skill

Lack of proper communication skill to handle the entire operation effects the communication adversely. Some of the communicators do not listen to the communicatee patiently nor they encourage them to put forth questions and problems to be solved. How to initiate a discussion, repeat the messages and influence public opinion - are all important in which most of the communicators are often found deficient. A communication devoid of these facts is likely to have little impact on the mind of the rural people.

COMMUNICATORS ATTITUDE TOWARDS MESSAGE AND ITS RECIPIENT

When we read an article, when we listen to someone, we get an impression of the writer's or speakers' attitude towards his subject matter. His attitude quite often is reflected in his messages. Evidence are available that even the extension personnel possess negative attitude towards innovations they are communicating just because they have been asked to communicate.

Likewise, instances are not rare when communicators possess negative attitude towards recipient fish farmers/fishermen. When readers or listeners realize that writer or speaker really likes them they are much less critical of his messages, much more likely to accept what he says.

CULTURAL AND LANGUAGE COMPATIBILITY OF COMMUNICATOR WITH THE RECIPIENT

No source communicates as a free-agent without being influenced by his position in a socio-cultural system. A communicator needs to know the cultural context in which he communicates, the cultural beliefs and values that are dominant for him, the accepted norms of behaviour that are acceptable, are required or not required in his culture. Foster's and Roger's studies have revealed that the wide cultural differences between a communicator and fish farmers act to impede effective communication. Erasmus found that some extension personnel have been found to be far more eager to demonstrate their social distance from the fish farmer than to demonstrate improved practices.

Language incompatibility between communicator and communicatee in terms of not only dialect but also appropriateness and communicability of words and differences in their interpretation are big obstacles to mutual understanding.

B. MESSAGE (Innovation)

The code of the message i.e. the language, the content of the message i. e. the ideas to be communicated and the treatment of the message i. e. how a message is to be presented to a particular type of audience need to be chosen judiciously and keeping in mind the type of message and the comprehension and the receptivity of the audience (fish farmers / fishermen).

PERCEIVED ATTRIBUTES OF MESSAGE (Innovation)

In general, a number of attributes of innovations as perceived by the receivers influence their rate of adoption.

The five attributes of innovation as observed by Rogers and others are :

(i) ***Relative advantage*** i. e. the degree to which innovation is perceived as better than one it supercedes

(ii) ***Compatibility*** i. e. the degree to which an innovation is perceived as consistent with the existing values, part experience and the needs of the receiver

(iii) ***Complexibility*** i. e. the degree to which an innovation is perceived as relatively difficult to understand and use

(iv) ***Trainability*** i. e. the degree to which innovation could be tried on a limited basis and

(v) ***Observability*** i. e. the degree to which results of the innovation are visible or could be felt by others..

C. *CHANNEL*

The sender and receiver of message must be connected or tuned to each other and channels of communication serve as physical bridges between sender and receiver of messages. Personal contact by fish farm or pond visit, group discussions, demonstrations, fish farmers' days, exhibitions, film show, radio, written materials like bulletins, newspaper, pamphlets etc. are some of the channels commonly used for inland fisheries extension work.

Selection and use of channel

Proper selection and use of channels varying with type of audience (background), type of message and recipient's stages in adoption process constitute a third determinant of successful communication. Without proper use of channels, message, no matter how important, will not get through to the intended audience. The relative effectiveness of each channel of communication has been experimentally found to differ and invariably it has been reported that no one channel alone is effective.

D. *RECIPIENT OF MESSAGE*

Success in communication depends on what the recipient of the message does in response to message received. A fish farmer responds to message with mental or physical action. Action that can be attributed to a given communicative effort by a communicator may be assumed to be the result of the degree to which the four elements - communicator, messages, channel and recipient have been effective. Significant gains in knowledge, attitude, skill and action are the product of effective communication.

Recipients' characteristics

The fish farmer / fishermen being the receiver in the communication process, several personal, social, psychological , economic and other factors characterizing a particular fish farmer influence communication effectiveness and largely determine what type of reception a particular massage will get from farmers of specific characteristics. Various studies in this direction have suggested that fish farmer's socio-economic status, level of education, age, adoption status, the stage at which he is in adoption process, existing level of knowledge about the message, his attitude towards self, towards communicator and towards message, his change proneness, value orientation, aspirations of future attainments, his part experiences and many other present pre-conditions for the communication to be effective.

Human Resource Development in adoption process

The human resource development in open water inland fisheries sector through extension education needs group or community approach rather than a purely technological approach. Extension education is a science dealing with the transfer of technology and behavioural changes involved in the process of technological transfer and adoption . The technology development and transfer system depend on the behavioural pattern of the clients. This involves the clients, their interests, attitudes, motivations, aspirations norms, traditions, value systems, customs and resources. Extension education based on a two-way-flow system of communication, would help to work out and convey these basic facts and factors to scientists concerned and thereby aid in the development of appropriate technology. Meaningful utilization of technology by the client system in turn would lead to the desired level of human resource development. Evolving a technology alone won't lead to its utilization. It requires the awareness and the need for a change from the existing pattern on the part of the client system. In other words adoption occurs only when there exist an imbalance between a person's need and his actual situation. The role of an extension specialist here is in creating the awareness of the existing system if it is below the mark and help people to achieve the level of self actualization through adoption of improved technologies. According to the study on inland fishermen only 21% of them had education upto primary standard, 7% secondary and 2% continued studies above secondary level. Various studies have shown that fishermen are mostly low in literacy and usually belong to the poorer section of the society. Fishermen of India who form the back-bone of the fishing industry, are characterized by low socio-economic status resulting from poverty, remoteness of dwelling places, lack of credit and low productivity of traditional fishing implements. This backwardness of fishermen often impedes their access to innovations and participation in welfare programmes. Building up opinion leadership which will help in two-step-flow of communication may be the best

approach in this context. Conducting non-formal education programmes and adult education campaign will be helpful in building up leadership.

It is the fact that there are two major objectives of a fisheries extension service. The first and major goal is the welfare of people in fishing communities. The second goal is the conservation and efficient exploitation of the fishery. The first goal refers to socio-personal development while the second means technological development. The fulfillment of the first goal is a pre-requisite for the second.

Human resource development through transfer of technical ideas and skills may help efficient utilisation of large water bodies like wetlands which are common property resource. Modern management system delineating sectorial approach of with special emphasis on pen culture operation are required to be propagated through group or community action. Their active involvement will help in adoption of pen culture technology in wetlands and will also motivate other groups to step in the process.

Farmer Participatory Approach in development of the techonology

Now it is clearly understood that not only physical and biological conditions are the deciding factors for a technology for a particular area, but the prevailing socio-economic and cultural circumstances of the target group of farmers also play important role in identification of appropriate technologies for a particular group of farmers within an area. The fact that the technologies are highly location specific is also appreciated, leading to the consideration that the technologies should be tailored for different biophysical, socio-economic and cultural situation. The inclusion of this change in technology generation has laid the emphasis of this approach delineating the adaptive research to be conducted in fish farmers' field with their farming system perspective in view under their management and with their active participation. In this category of approach beginning is made with the knowledge, problem analysis and priorities of fish farmers and fish farm families. This approach takes whole farm as system, not an individual activity, further the fish farmers and researchers are activity involved in the technology generation process.

Conclusion

The prime objective on the programmes of diffusion of Pen Culture technology can not be achieved unless communication is taken as an important component and ingredient towards development. The constructive application for adoption of Pen Culture technology calls for proper planning that takes equal note of the national priorities and needs, community resource utilisation *vis* a *vis* social upgradation.

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PRACTICALS

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LABORATORY METHODS ON FISH PATHOLOGY

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ANATOMY OF FISH

Knowledge of the anatomy of fish is essential for the study of fish diseases. It is essential to know the normal anatomical features of various organs and tissues to assess the modifications that occur due to parasitic infection or infestation.

Normally the head of a fish merges into the trunk. The head is constituted of the mouth having the lower and upper jaws. Around the mouth some fish species have barbels. The upper side of the head has two nasal appertures behind which there are two eyes.

The trunk of the fish body is covered with scales. There are some genus like *Mystus* which are scaleless. The lateral line, sensory in nature is formed by small openings in the scales, and located on both sides of the body. The fins are located in the trunk region. They are the paired pectoral fins and ventral fins and single dorsal, anal and caudal fin. The fins are supported by fin rays. The skeleton of the adult bony fishes are ossified and the skeleton of head, trunk and fins can be differentiated. The trunk skeleton is composed of a number of spinal vertebrae. Each has a cylindrical body with a saucer shaped cavity at each end. From the upper side of the vertebrae two erect prominencies surround the spinal canal containing the spinal cord. These prominences join above the canal to form a spinous process. From the lower side of the vertebrae two spines project down and are joined to the ribs in the region of the body cavity. The fins are supported by a large number of tiny bones.

The muscles are also of different types in the head, trunk and fins.

Digestive system

It starts with the mouth cavity which goes into the spacious pharynx. The pharynx open out bilaterally into five branchial slits covered with variously shaped branchial rakers which stand out from the inner side of the branchial arches. The pharynx leads by a short oesophagus into the stomach or into the intenstine. From the stomac extends the pyloric caeca. The intestine is of variable length and remain coiled inside. The liver is a big and prominent organ inside and is attached to the intestinal loop. It's color is normally greyish red. The gall bladder is situated on the dorsal side of the liver. The pancreas lies diffuse over the liver or around the stomach. The spleen is usually small and is joined either to the liver or to the intestine and have a dark reddish color.

Circulatory system

The heart is located under the gills towards the ventral side. From it the aorta opens out through an enlargement called bulbous arteriosus. After a short course in the anterior region of head the aorta ascends and branches into 8 branchial enteries. From each branchial artery, which runs through outer periphery of the branchial arch, arteris enter into the branchial filaments in which they branch into a dense network of capillaries. The blood from the gills is carried away by eight branchial veins which join above the gills and form two long arteries which connect the head and then the aorta descends. The aorta descends under the spine and forms a arteries supplying the internal organs and the muscles with blood.

Gills

The gills are placed on either side of the head in the branchial cavity. On each side there are four branchial arches. On the convex side of the brachial arches there are forked bright red branchial filaments.

Kidney

The kidneys lie between the swim bladder and the roof of the body cavity. They are elongated in shape, brownish red in color.

Air Bladder

The air bladder fills up the space above the digestive system and gonads and overlaps the kidneys with its upper end. The swim bladder consists either of one or two compartments. The gonads lie by the sides of the body cavity and reach a considerable size before spawning. A sexually mature male has opaque,

creamy testes. The ovary of a sexually mature female has a transparent membranous envelope containing spherical eggs.

Skin

The skin consists of two basic layers, the dermis and epidermis. The epidermis is normally covered with a layer of mucous. The dermis is interwoven with a multitude of pigment and fat cells. The scales are formed and are embedded in the dermis. The majority of our fish have cycloid scales.

Eye

The eye in the majority of fish is large. The eye ball rests in the eye socket. The sclera has a rigid outer covering. In the eye ball there is a spherical lens. The space behind the lens is filled with a transparent gelatinous vitreous humor.

Nervous system

The nervous system consists of the brain, the spinal cord peripheral nervous system, and the autonomic system. The brain is enclosed in the cranial cavity in the upper part of head behind eye.

All these organs and tissues of fish can act as substrate or a habitat for colonization by various protozoan, helminth and crustacean parasites.

Examination of fish organs for pathogens

The fish sample is first examined on the external surface and then it is dissected through the ventral surface to exhibit the various internal organs for study.

Skin

- The external surface of the skin of the fish sample is examined by a magnifying lens or if it is a small fish under dissecting microscope.
- Then smears of the external surface of the skin is made and examined under microscope.
- After completing the above examination the fish is skinned for observation of dermal and subcutaneous cysts or other pathogens of the skin.
- Examination of the skin is done because it serves as the habitat for the pathogens *viz.*, bacteria, ciliates, myxozoans, gyrodactylids, metacercariae larvae, copepods and fungi.

Gills

- The gills are dissected out after removal of operculum.
- Gills may harbour bacteria, flagellates, ciliates, myxozoans dactylogyrids and fungi.

Eyes

- The eyes are carefully removed from their orbits with a bent forceps or scalpel.
- It is investigated for bacteria, myxozoa, trematode and fungi.

Brain

- It can be examined fresh or in histological sections.
- It may harbour, bacteria, ciliates, myxozoans or fungi.

Muscle

- Muscle areas which look, discolored, swollen or hardened should be teased apart under magnifying lens or dissecting microscope for detail examination of isolated muscle fibres.

Digestive canal

- Cut the oesophages just behind the oral cavity.
- Pull out and straighten the gut along its whole length down to anus when it is again cut through.
- Open the gut wall by scissors with a blunt tip.
- Intestinal wall may be kept for sections.
- The intestinal cavity harbours bacteria, ciliate, flagellate, myxozoa, trematodes, cestodes, acanthocephala, nematode and fungi.
- The intestinal wall is the habitat of various developmental stages of protozoans.

Peritonial cavity

- It is opened by a curved cut begining at the anus and following its upper broder to the dorsal edge of operculum, returning to the anus along the mid ventral lines.
- The fluid or any foreign body should be examined.

Liver

- It is a massive organ lobed on either side of the anterior portion of the gut.
- Squash preparation of liver may be made.
- Histological sections may be made.
- Liver harbours bacterial cysts, myxozoans, fungal cysts, encapsulated larvae of various worms.

Kidney

- It is located just below and pressed to the vertebral column divided into the anterior and posterior kidney.
- It is examined through contact smears or histological sections.
- Kidney harbour myxozoans, bacteria.

Heart

- Very prominently seen in the anterior portion of the body ventrally placed.
- It harbours various myxozoans.

Examination of fish for protozoan parasite

Myxozoan parasites

The white cysts of myxozoan parasites are frequently located in the gills, scales, skin and other internal organs of fish. To examine these parasites the spores within the cysts are stained. The spore size, shape, location, number and shape of polar capsule, shape and size of sporoplasma etc. are the identifying characters.

Test sample: Fish with white spots in gills.

Collection, fixation and staining

Cysts are carefully teased out of the fish tissue and fixed in 70% alcohol.

Procedure : (Fresh preparation, Lugols' iodine preparation)

- For contact smear the different organs are smeared on a clean glass slide with a drop of 0.5% normal saline solution. The smear is covered with a cover slip, paraffin sealed and examined under microscope.
- The cysts, when present are teased out with sterile forceps, kept on a clean slide and pressed to release the spore.
- Spore suspension is made in 0.5%saline solution.
- Both the fresh smear preparation and fresh spore preparation are covered with cover slip and sealed with wax.
- If Lugol's iodine preparation is made, the fresh smear is stained with a drop of Lugol's iodine stain and then covered with a cover slip and sealed.
- The slide is then examined under different magnification of microscope.

Result :

i) In fresh preparation the detailed morphology of the spore without shrinkage is seen.

(ii) In Lugol' iodine stain, the polar capsule and coils of the filament are distinct. The iodinophilous vacuole in the sporoplasma of spore stain brown.

Procedure : **(Staining)**

- A thin uniform smear of spore is made on a clean slide.
- It is semidried and fixed in methanol.
- The smear is air dried.
- Washed in distill water thoroughly.
- The smear is covered with Geimsa stain (2 drops of commercial stain in 1 cc of distilled water) for 25-30 minutes.
- The stain is then drained out and washed with neutral distilled water.
- Slant and dry the slide

Result : In Geimsa staining, the sporoplasm stains prominent blue along with the nuclei. The polar capsule also stain blue.

Urceolariid ciliate

Urceolariid ciliates *viz., Trichodina* sp. and *Tripartiella* sp. are frequently found in the gills of fishes. There identification in fresh smear from gills is easy as they move about freely. But for species identification they are to be stained permanently by Kleins' Silver Impregnation technique.

Collection, fixation and staining

Test sample: A fish with pale cream coloured gills.

- Scrappings from the gills of living diseased fish are taken and a thin smear is made on a clean grease free slide.
- The smear is air dired.
- Place the slide on a staining rack and pour 2% solution of Silver nitrate for 7-8 minutes in a dark place.
- Wash thoroughly in distilled water.
- Place the slide on a petri dish with distilled water and treat under ultra violet lamp for 20 minutes. It is necessary to place the petridish on a white background.
- If ultraviolet lamp is not available place the petri dish in direct sunlight for 30 minutes on a white background.
- Wash in cold water and air dry.
- Mount in DPX.

Result : The denticles of the ciliate, which are the primary identifying character and radial pins stain brown.

Examination of fish for Helminth parasite

Collection, fixation, preservation and staining

Procedure : (Collection)

Monogenetic trematode like *Dactylogyrus* sp. infest gills. They are carefully teased out under dissecting microscope into watch glass containing normal saline. Digentic trematode and cestodes may be infesting various organs of the body. They are also similarly removed and placed in normal saline.

Procedure : (Fixation)

Trematodes and cestode parasites are fixed in AFA (Alcohol Formal Acetic Acid). Small worm like monogenetic trematodes are fixed directly in watch glass for 3-5 minutes. Bigger specimens of digenetic trematodes or cestodes are put on a glass plate and quickly pressed with cover slip. AFA fixative is gradually poured drop by drop through the side of the cover slip and fixed for 3-5 minutes. Nematodes and acanthocephalans are fixed in corrosive sublimate fixative.

Procedure : (Preservation)

Trematodes and cestodes thus fixed should be washed with 70% alcohol and then preserved in 70% alcohol.

Nematode and acanthocephalan parasites thus fixed should be treated with iodinated alcohol to remove all traces of Mercuric chloride and transferred to 70% alcohol.

***Procedure** : Staining (Trematode and Cestode)*

Semichons carmine method

- Take the preserved specimens in a watch glass.
- Wash thoroughly in 70% alcohol
- Place in diluted Semichons' carmine for 3-5 minutes or more according to thickness of the specimens.
- Destain in acid alcohol and wash throroughly in 70% alcohol.
- Dehydrate through 90% and Absolute alcohol grades.
- Clear in Xylol.
- Mount in Canada Balsam or DPX.

Haematoxylin staining method

- Take the preserved specimens in a watch glass.
- Wash thoroughly in 70% alcohol.
- Hydrate through down grades of alcohol upto distilled water.
- Pour few drops of stain on the specimen and keep for 5 minutes.
- Then replace the stain with distil water with 2 to 3 changes.
- Then dehydrate through 30% to 50% alcohol 1.0 min each.
- Destain in 70% acid alcohol until specimens turn light reddish purple, changing the alcohol, if noticeable color appears.
- Then treat briefly with stronger acid alcohol.

- Wash thoroughly with 70% alcohol till specimen turn bluish.
- Dehydrate through 90% and 100% alcohol grades.
- Clear in xylol.
- Mount in Canada Balsam or DPX.

Procedure : (Staining Acanthocephalan and Nematodes)

Because of the impervious cuticle, specially nematodes are difficult to stain. But if one wants to stain these specimen the staining methods described for Trematodes and Cestodes can be followed. Only care has to be taken that during staining and dehydration sufficient time gap is given.

However for studying unstained specimens Lactophenol method can be used.

Lactophenol method

- Place the preserved specimens from 70% alcohol on a slide.
- Trace of alcohol is removed.
- Mount with a drop of Lactophenol and observe after 2-5 minutes in the microscope.

Procedure for preparation of Fixative and Stain

Alcohol Formal Acetic Acid (AFA) Fixative

Alcohol 95%	:	50 cc.
Commercial Formalin	:	10 cc.
Glacial acetic acid	:	02 cc.
Distilled water	:	40 cc.
Corrosive sublimate acetic acid fixative		
Mercuric chloride saturated aqueous solution	:	10 cc.
Glacial acetic acid	:	10 cc.

Harris Haematoxylin stain:

Haematoxylin powder	:	01.0 gm
Absolute alcohol	:	25.0 cc.
Aluminium ammonium sulphate	:	15.0 gm
Distilled water	:	250.0 ml.
Mercuric oxide	:	0.5 gm.
Glacial acetic acid (optional)	:	2 to 10 .0 ml.

First dissolve the alum in distilled water and haematoxylin in absolute alcohol. Then heat the alum solution to boiling. Remove from heat and add the stain solution slowly with stirring.The solution while still hot, stir in mercuric oxide when a deep purple colour appears. Cool rapidly and filter. If acid haematoxylin is required add acetic acid. Stain is now ready for immediate use.

Semichons' Carmine Stain

Take in 50 cc of glacial acetic acid in a flask and add carmine powder upto super saturation.Plug the flask with cotton and heat to boiling. Then cool under tap water and filter the stain. The filtrate is the stock stain which can be diluted with 70% alcohol as desired.

Examination of fish for crustacean parasites

Parasitic copepods and branchiurans

Procedure : (Collection)

For the copepod parasites like *Ergasilus* present in gill filaments the best method is to tease them out of the filaments with a needle carefully so that the attaching bulla remains intact. Male copepods are often invisible among the mucus of the gills. Flushing the branchial chamber with a dropper on to a petridish often help in collecting males.Copepod parasites are invariably covered with mucus. If the parasite is directly transferred into the preservative the mucus will harden and stick on the body. This would make detail study difficult. The mucus can be removed if the specimens are placed in a dilute solution of sodium carbonate for 5-10 minutes and then rinsed with a dropper.

Live specimens of branchiuran *Argulus* sp. moving on fish body are collected in a petridish with normal saline.

Procedure : (Preservation)

Copepods and branchiurans are preserved in either 70% alcohol or preferably 4% formalin.

Procedure : (Fresh preparation)

- Take out the specimen on to a watch glass.
- Transfer the specimens to a cavity glass slide.
- Pour 1 to 2 drops of Lactic acid in the cavity and wait for 5 minutes.
- The specimen is now sufficiently cleared from its opacity and relaxed.

- Examine under the microscope.

Procedure : (Staining)

- Take out the specimen on to a watch glass.
- Pour cotton blue stain and leave for 1 minute.
- Transfer the stained specimen to a cavity slide.
- Pour 1-2 drops of Lactic acid to clear it and put a cover slip.
- Examine under microscope.

Examination of fish tissue (Histopathology)

Histology is the study of microscopic anatomy of the organism and morphology of tissues. The importance of histology in fish and prawn disease investigation lies in the fact that firstly it can demonstrate the location and morphology of the pathogens in tissue with the aid of a microscope, secondly the purpose of histology is to demonstrate changes occurring in various tissue due to disease.

Preparing specimens for histology

Procedure : (Fixation)

- The desired tissue of diseased fish or prawn is cut into small pieces preferably 4 to 5 mm square size.
- These pieces are put in vials and fixed in 10% formalin. The volume of the fixative should be at least 20 times the sample size.
- Fix the samples for more than 24 hours.

Procedure : (Embedding)

- The fixed samples are washed thoroughly in tap water.
- Trim the samples into smaller size of 0.5 x 0.4 x 0.4 cm^3 size.
- Decalcify the hard tissue (gill and muscle) in decalcifying solution. Then soak them in 5% sodium sulphate (Na_2SO4) for 1-5 hours and then rinse in tap water for 10-30 minutes.
- Dehydrate the tissue through ascending alcohol grades 30, 50, 70, 90, 100%.
- Then put the tissue in xylene to clear opacity from the dehydrated tissue making them transparent.
- Put the tissue in half xylene half paraffin for half an hour.
- Put the tissue in full paraffin for one hour for proper infiltration.

- The tissue is then embedded in paraffin which is allowed to solidify round the tissue.

Procedure : (Preparation of tissue blocks for sectioning)

- Tissue embedded in paraffin are trimmed in square block for sectioning.
- The blocks are fixed in block holder of the microtome .

Procedure : (Sectioning)

- The prepared paraffin blocks containing sample tissue are cut at 4-5 mm thickness in the microtome.
- The ribbon containing tissue is put into a box.
- The required size of ribbon is carefully transferred.

Procedure : (Stretching of tissue)

The ribbon is put in warm water (45-50^{o}C) placed in a big petri dish to stretch the tissue of wrinkles and make it flat.

Procedure : (Preparation of slide)

- The required size of ribbon is cut and transferred to microscopic slide covered with Mayer's albumen and containing a little water. The ribbon strip is then oriented on the slide as desired.
- The water is then drained out and the ribbon on the slide is then air dried overnight. The slide is now ready for staining.

Procedure : (Staining Haematoxylin and Eosin)

- Put the slide in xylene to dissolve the paraffin.
- Then hydrate the tissue in descending grades of alcohol starting from 100, 90, 70, 50, 30% and water with each step of 5 minutes duration.
- Rinse in water for 5 minutes.
- Stain in Haematoxylin for 5-10 minutes.
- Rinse in water.
- Dehydrate through 50%, 70%, 90% alcohol.
- Counter stain in Eosin.
- Wash in 90% alcohol.
- Dip in Absolute alcohol
- Clear in xylene
- Mount in Canada. balsam or DPX.

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WATER AND SOII, ANALYSIS OF OPEN WATER SYS'I'EMS

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Maintenance of a healthy aquatic environment and production of sufficient fish food organisms in a water body are 2 very important factors for boosting fish production. To keep the water body conducive for fish growth, physical and chemical parameters like temperature, transparency, pH, dissolved oxygen, total alkalinity, free CO_2 and nutrient elements like nitrogen and phosphorus may be monitored regularly. Where the physico- chemical factors are in normal range, the water body is usually productive, but when they are present in quantities above or below the optimum range the fishes and other aquatic organisms may be under stress which may lead to fish disease or fish mortality in due course.

1. Temperature

The temperature is noted with the help of a centigrade thermometer or by temperature selective electrode. Optimum range for carp growth : 23 - 30^0 C.

2. Transparency

Transparency of a water body is recorded with a *Secchi disc*. Dip the *Secchi disc* in water until it is invisible. Note the depth of the disc from water surface in cm. *Optimum range* : 20 - 50 cm.

3. pH

The pH of water sample may be determined accurately by using a pH meter which has been standardised against two buffer solutions of known pH. Optimum range : 7.4 - 8.2.

4. Dissolved oxygen

Winkler's method

Reagents

i.) Alkaline iodide : Dissolve 500 gm NaOH and 150 gm Potassium iodide in one litre distilled water. Keep the reagent in polyethylene container.

ii.) Manganous sulphate: Dissolve about 480 grams of Manganous sulphate in one litre of distilled water.

iii.) N/40 Sodium thiosulphate : Dissolve 6.205 grams of pure Sodiumthiosulphate in one litre of distilled water. Add 1-2 beads of NaOH as stabiliser. Keep in a ambre colour glass bottle. This thiosulphate solution may be standardised against N/40 $K_2Cr_2O_7$ solution.

iv.) N/40 $K_2Cr_2O_7$ soulution : Weigh 1.226 grams of pure $K_2Cr_2O_7$ and dissolve it in one litre distilled water. Place 25 ml of dichromate solution in a conical flask, add 1 ml alkaline Iodide, acidify with 2 ml conc. H_2SO_4 and keep in dark for 10 minutes. Dilute the distilled water and titrate the iodine with the (N/40) thiosulphate using starch as indicator. Adjust the strength of thiosulphate to exactly N/40.

v.) Starch : Take 1 gm soluble starch in 100 ml water, boil for one minute. Add a few drops of acetic acid as stabilizer.

Procedure

Collect water sample in 125 ml D.O. bottle, add 1 ml of Manganous sulphate solution and then 1 ml of alkaline Iodide solution. Replace the stopper and keep the bottle in dark for 10 minutes. Then add 1 ml of conc. H_2SO_4 and shake to dissolve the precipitate. Transfer 50 ml of the solution to a conical flask, add 1-2 drops of starch solution and titrate the solution with N/40 thiosulphate to a colourless end point.

Calculation

No. of ml of thiosulphate required x 4 = ppm of O_2
Optimum range: 5 - 1 0 ppm.
Ion selective electrode method:
Electrode is first calibrated and then reading is taken accordingly.

5. Free $C0_2$

Reagents

i. N/44 NaOH

Prepare 0.1 N NaOH by dissolving 4 gm of AR NaOH per litre and standardise it against 0.1 N H_2S0_4 using phenolphthalein as indicator. Dilute 100 cc of this 0.1 N NaOH to 440 ml with distilled water. This is N/44 NaOH. Store it in a polyethylene bottle.

ii. Phenolphthalein indicator

Dissolve 0.5 gm phenolphthalein in 100 ml 50% alcohol.

Procedure

Take 50 ml of water sample in a conical flask, add 2 drops of phenolphthalein indicator.
Add N/44 NaOH dropwise till the solution turns slight pink.

Calculation

No. of ml of N/44 NaOH required x 20 = ppm of free $C0_2$
Optimum range for carp culture ponds : 5 - 10 ppm.

6. Total alkalinity

Reagents

i). N/50 H_2So_4
ii). Methyl orange indicator solution.

Procedure

Take 50 ml of water sample in a conical flask and add 1-2 drops of methyl orange indicator. Titrate with N/50 H_2S0_4 until the solution turns pink,

Calculation

ml of N/50 H_2S0_4 consumed x 20 = ppm of total alkalinity.

Optimum range : 80 - 150 ppnl.

7. Total hardness

Estimation

Total hardness is determined by titration with standard ethylene diaminetetra acetic acid (EDT'A) disodium salt using Eriochronie black-T as indicator. The end point is from reddish brown to blue (APHA, 1980).

Optimum range-: 20 ppm and above

8. Dissolved Inorganic Phosphate

Reagents

i. 50% H_2SO_4
ii. Ammonium Molybdate (1 0%)
iii. Acid ammonium Molybdate
Add 15 ml of 50% H_2SO_4, to 5 ml of 10% ammonium molybdate.
iv. Stannous chloride solution Dissolve 1 gm stannous chloride AR in 100 ml of glycerine.
v, Standard phosphate solution.
Dissolve 4.388 gm KH_2P0_4 in 1 litre distilled water. This stock solution is 1000 ppm phosphate.
Dilute 1 0 ml of this stock solution to 1 litre with distilled water. This is 10 ppm phosphate.

Procedure

Place 50 ml of water sample in a Nessler tube, add 2 ml of acid ammonium Molybdate and 2 drops of stannous chloride. Mix and wait for 10 minutes. Measure the blue colour in a spectrophotometer at 690 rim. Similarly take four standard phosphate solutions in Nessler tubes and develop the blue colour by adding ammonium molybdate and stannous chloride. Measure the colours of the standard solutions by spectropliotometer. Determine the phosphate content of sample from the calibration curve drawn from standard phosphate solutions.

Optimum range for carp culture ponds: 0.2 -0.6 ppm

9. Nitrate nitrogen

Reagent

i) Phenoldisulphonic acid
ii) 12 N NaOH
iii) Standard Nitrate solution (1 0 ppm)

Dissolve 0.722 gm of KNO_3 in distilled water and make upto 1 litre. Dilute 10 ml of this stock solution to 100 ml containing 0.01 mg N/ml = 10 ppm N.

iv) Aluminium sulphate solution (10%).

Procedure

Evaporate to dryness 50 ml sample in a white porceelaein basin on water bath. Cool and add 2 ml of phenoldisulphonic acid and rub it with a glass rod. Wait for 5 minutes and add 2 ml of Aluminium sulphate solution. Now add 12 N Na0H solution slowly until it is alkaline. Add 20 ml distilled water and filter the solution. Take filtrate, make up the volume to 50 ml. Measure the yellow colour of the solution by spectrophotometer at 410 nm . Prepare four standard solutions of nitrate from the standard nitrate solution (10 ppm). Evaporate the solutions to dryness, add phenoldisulphonic acid, mix by glass rod and then add 12 N NaOH to make the solutions alkaline. Dilute with distilled water and make up the volume (to say 50 ml). Measure the colour of these four solutions by spectrophotometer at 410 nm. Prepare a standard curve from the standard solutions. Determine the concentration of unknown solution from the standard curve.

Optimum total nitrogen content in carp culture ponds : 1.0 - 2.6 ppm.

10. Specific conductivity

Specific conductivity of water sample may be estimated easily by using a conductivity meter.

Optimum range for carp culture ponds : 250 - 1 000 μmho/cm.

SOIL ANALYSIS

Collection

Collect soil samples from several locations of the water body by Ekman dredge. Mix the samples. Dry the samples in air. Powder it with a wooden hammer, strain through a 2 mm and then a 80 mesh seive and again air dry. Analysis may be done with the air dried sample but result should be expressed on the oven dry basis.

1. Soil pH

Electrometric method

Procedure

Take 10 gm soil in 50 c.c. beaker and add 25 mi of distilled water. Shake for half an hour. Dip the electrode of pH meter in the suspension and take the pH reading.

Optimum range : near neutral (6.5 - 7.5)

2. Organic carbon

Reagents

i) N $K_2Cr_2O_7$

Weigh exactly 49.04 gm of AR $K_2Cr_2O_7$ and dissolve it in 1 litre of distilled water.

ii) N Ferrous solution

Dissolve 278 gm Ferrous sulphate or 392.13 gm Mohr salt in distilled water, add 15 ml conc. H_2SO_4, and make up the volume to 1 litre. This solution should be standardised against N $K_2Cr_2O_7$ so that 1 ml Ferrous solution = 1 ml of N dichromate.

iii) Diphenyl amine indicator.

Dissolve 1 gm Diphenylamine in 200 ml of conc. H_2SO_4 and 40 ml of water.

iv) Phosphoric acid (85%)

v) Conc. H_2SO_4

Procedure

Take 1 gm soil sample in a 500 m] conical flask. Add 10 ml of N $K_2Cr_2O_7$ and 20 ml of conc. H_2SO_4 . Allow the mixture to stand for 30 minutes. Dilute with water 200 ml and add 10 of phosphoric acid. The excess of dichromate is titrated with N $FeSO_4$ using 1 cc of diphenylamine as indicator. The end point is green from a bluish colour.

Calculation

(10 - Nos. of ml of $FeSO_4$ solution required) x 0.3 --- Organic carbon
Optimum content in carp culture ponds : 1.0 - 2.5%

3. Available phosphorus

Trough's method

Reagents

i) 0.002 N H_2S0_4
Dilute 100 ml of standard 0.02 N H_2S0_4 to 1 litre. Adjust the pH to 3.0 with ammonium sulphate.
ii). 50% H_2SO_4
iii) 10% Ammonium Molybdate
iv) Acid ammonium Molybdate reagent
v) Stannous chloride solution.
vi) Standard phosphate solution (1 ml = 0.01 mg P.)
The methods for preparing reagents are the same as given for determination of phosphate in water.

Procedure

Place one gm air. dried soil sample in a 250 ml bottle. Add 200 ml of 0.002 N H_2SO_4 (pH-3), shake the mixture for 30 minutes in a mechanical shaker. Keep it for 1 0 minutes and filter. Take 50 ml of filtrate in a Nessler tube and determine its phsophate as for water.

Calculation

ppm of phosphate in solution x 20 = mg P/ 1 00 gm soil.

Optimum content in carp culture ponds: 9-19 mg/100 gm soil.

4. *Calcium carbonate*

Rapid Titration method

Reagents :

i.. N HCI : Dilute 175 ml of conc. HCI to 2 litres.
ii. N NaOH: Take 80 gm of NaOH in 2 litre of water.
iii. Bromothymol Blue indicator.

Procedure

Take 5 gm soil sample in a 250 ml bottle. Add 100 ml of 1 N HCI and shake for one hour. Allow to settle the suspension and pipette out 20 ml of the clear liquid in a conical flask. Titrate it with N NaOH using Bromothymol Blue indicator till it is just blue. Note the reading and carry out a blank taking 20 ml of 1 N HCI in a flask and titrating it in the same way.

Calculation

(Titre for blank - Titre for soil solution) x 5 = % $CaCO_3$
Optimum content in carp culture ponds : 1.2 - 2.5%.

5. *Available Nitrogen*

Reagents

i. 0.02 N H_2S0_4
Dilute 1 00 ml of 0. 1 N H_2S0_4 to 500 ml with distilled water.
ii. 0.02 N NaOH
Dilute 1 00 ml of 0. 1 N NaOH to 500 ml with distilled water.
iii. Methyl red indicator
Dissolve 0. 1 gm methyl red in 25 ml of ethyl alcohol and make up the volume to 50 ml with water.
iv. 0.32% $KMnO_4$
Dissolve 3.2 gm of $KMnO_4$ in 1 litre distilled water.
v. 2.5% NaOH Disssolve 25 gm NaOH in 1 litre distilled water.

Procedure

ii) Place 10 gm soil sample in a 500 ml Kjeldahl flask. Add 100 ml of 0.32% $KMnO_4$ solution, 100 ml of 2.5% NaOH, 2 ml of liquid paraffin and some glass beads. Distill the mixture and collect the distillate in a conical flask containing 20 ml of 0.02 N H_2S0_4 and a few drops of

methyl red indicator. Collect about 75-80 ml of distillate. Titrate the excess of 0.02 N H_2SO_4 with 0.02 N NaOH to a colourless end point.

Calculation

(20 - No of ml of 0.02 N NaOH) x 2.8 = Available nitrogen (mg/100 g soil).
Optimum content in ponds : 50-65 mg/1 00 g.

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STANDARD METHODS FOR BIOLOGICAL EXAMINATION OF PLANKTON AND BENTHOS

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Physical and chemical characteristics of water bodies affect the abundance, species composition, productivity and physiological condition of aquatic biota in pen environment. Biological methods used for assessing water quality include the collection, counting and identification of aquatic organisms. Whenever practicable, one should collect their own samples. Much to the value lies in personal observations of conditions in the field and in the ability to recognise signs of environmental changes as reflected in the various aquatic communities. The primary orientation is towards field collection and associated laboratory analysis to aid in determining the status of biotic communities under field conditions and to adjudge the influence of environmental conditions.

Plankton

The term *Plankton* refers to those microscopic aquatic forms having little or no resistance to currents and living free-floating and suspended in natural waters. Planktonic plants, *Phytoplankton* and planktonic animals *Zooplankton* are covered under plankton. Because of their short life cycles, plankters respond quickly to environmental changes and hence their standing crop and species composition are more likely to indicate the quality of water mass in which they are found and also to the biotic productivity of higher trophic level.

Sample collection

Establish a sufficient number of stations in as many locations as necessary to define adequately the kinds and quantities of plankton in the waters to be studied. If it can be determined or correctly assumed that the plankton distribution is uniform and normal, use a scheme of random sampling to accommodate statistical testing. Collect composite samples and use appropriate

statistical tests to determine population variability. In shallow area of 2 to 3 meter depth, subsurface samples collected at 0.5 to 1.0 m may be adequate. Daily vertical migrations occur in response to sunlight and hence samples may be collected daily depending upon availability of personnel or when this is not possible, weekly-bi-weekly, monthly or even quarterly sampling still may be useful for determining major population changes.

Sampling procedure

Collection of plankton samples may be done by plankton net made of standard bolting silk cloth no. 25 (Mesh size : 0.03-0.04 mm). Preferably samples should be taken from all the extremities and middle points of a waterbody by collecting 50 litres of water through graduated enamel mug and filtering the same through plankton net. Concentrated plankton thus obtained are then adjusted to 10 ml and preserved in 5% solution of formaldehyde. Also plankton samples may be collected at three hourly intervals round the clock for diurnal studies on monsoon, winter and summer seasons. Label sample containers with sufficient information to avoid confusion or error.

The settled volume of plankton should be recorded in graduated tubes after 24 hrs. of sedimentation or instant centrifugation. The volume concentrated varies inversely with the abundance of organisms and is related to sample turbidity.

Sample analysis

Qualitative and quantitative analysis of collected samples is to be done in the laboratory as per well accepted counting method of individual species by using Sedgewick-Rafter counting cell. After shaking the vial containing concentrated plankton samples a sub-sample of 1 ml is quickly drawn with a wide mouthed long dropper and poured in plankton counting cell of 1 ml capacity. All the plankters encountered are represented in absolute number. At least three counting are made for each sample and data are presented in average values. Group-wise and species-wise representation of different forms are tabulised and percental values are to be worked out for estimating plankton productivity and population dynamics of specific waterbody. Quantitative estimation should be done as under :

1. Take a microscope with suitable oculars and objectives.
2. Take Sedgewick - Rafter counting cell or prepare a similar one of area 50 mm X 20 mm and depth 1 mm showing mm square rulings.
3. Note down the volume of plankton concentrate.
4. Shake well the plankton concentrate and transfer 1 ml to counting cell and cover it with rectangular cover glass.

5. Count plankters space-wise, genera-wise or group-wise in 10 square and find out the average. Ten counting units must be taken at random. Average number of plankters per counting unit of 1 cu mm should be worked out and no plankters should be shown as zero in the computation. The number of plankters in terms of species/genera/group per litre can be computed using the formula as under.

$$ni = \frac{(a\ 1000)c}{l}$$ where

ni = Number of plankters (in terms of species or genera or group per litre of original water)

a = The mean number of plankters per counting unit of one mm^2
c = Volume of concentrated plankton in ml
l = Total volume of water (filtered) in litres

Benthos

Benthic macroinvertebrates are animals inhabiting the sediment or living on or in other available bottom substrates of water ecosystems. Although they vary in size but macroinvertebrates are considered historically by definition to be visible to the unaided eye and are retained in sieve standard No. 40 which will retain only macroorganisms. This specific sieve is useful for standardization of bioassessment for species composition, taxa richness, diversity evenness, trophic levels and major taxonomic spatial and temporal patterns.

Sample collection

After gaining a thorough understanding of the factors involved with a particular body of water, select specific areas to be sampled. Most taxas are not distributed uniformly over the bottom since different habitats (sand, mud and gravel or organic material) support different densities and species of organisms. Even on a relatively homogenous bottom, animals tend to aggregate. Therefore, take replicate samples to evaluate this variability. Use at least three replicate samples per station to describe the macroinvertebrate community. Ideally, conduct a baseline survey to determine station, substrate characteristics and the number of samples necessary to achieve the desired level of accuracy.

Bottom sampler

Ekman dredge is best suited as a sampler for bottom biota for soft bottoms. Two sizes of this sampler are available namely 15.2 x 15.2 cm and 22.9 x 22.9 cm. The former is more convenient from the point of view of sampling.

Where, however, the bottom is hard. Peterson grab with an enclosure area of about 0.08 sq.m. may be used.

Collection procedure

1. Collect samples by Ekman dredge from randomly chosen stations.
2. Each sample may be transferred to suitable containers like enamel buckets or other larger sized containers.
3. Take sieve No. 40 which will retain macroorganisms.
4. Take suitable quantity of dredge material from the bucket and place it in sieve. Wash it with liberal quantities of tap water or water from other source.
5. Transfer the residue (macro-organisms) into a wide-mouthed bottle. Repeat the same procedure for other parts of sample.
6. Preserve the material in 10% formalin, if detailed analysis has to be done at a later
   date.

Quantitative evaluation and computation

1. Transfer small portions of screenings into petri dishes or shallow porcelain dishes.
2. Segregate the organisms into species, genera or groups according to the nature of the investigations.
3. Count them per qualitative identity under one or more of the above heads.
4. Compute for each individual group or for all groups the number of macro-organisms per square metre, whichcan be done as follows.

$$N = \frac{n}{ah}$$ where

N = Number of macr o-organisms in 1 sq.m.
n = Number of macro-organisms per sampled area
a = Area of Ekman dredge in sq.m.
h = Number of hauls