WORKSHOP
ON

AQUATIC ANIMAL DISEASES IN ASSAM

20th September 2016

Workshop Manual

National Surveillance Programme for Aquatic Animal Diseases
ICAR-CENTRAL INLAND FISHERIES RESEARCH INSTITUTE
REGIONAL CENTRE
Guwahati– 781006, Assam

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Edited by

P. Das, B. K. Bhattacharjya, P. K. Parida, B. K. Behera & B. K. Das

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Editorial team:

P. Das, B. K. Bhattacharjya, P. K. Parida, B. K. Behera & B. K. Das

Cover design

P. Das, P. K. Parida & S. Sahoo Das

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Aquatic Animal Diseases in Assam

Under the National Surveillance Programme for Aquatic Animal Diseases

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Patron	**:**	**J. K. Jena, DDG, Fisheries Science, ICAR, New Delhi- 110012**
Convener	**:**	**B. K. Das, Director ICAR-CIFRI, Barrackpore**
Co-Conveners		**B. K. Bhattacharjya & B. P. Mohanty**
Organizing Secretaries	**:**	**B. K. Behera & P. Das**
Co-organizing Secretaries	**:**	**S. Yengkokpam, A.K. Sahoo, S. Borah & B. C. Ray**
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Editorial team	**:**	**P. Das, B. K. Bhattacharjya, P. K. Parida, B. K. Behera & B. K. Das**
Cover design	**:**	**P. Das, P. K. Parida & S. Sahoo Das**

Contents

A BRIEF ACCOUNT OF ACTIVITIES OF ICAR-CIFRI REGIONAL CENTRE-GUWAHATI

B. K. Bhattacharjya[1], P. Das and B. K. Das[2]

[1]ICAR-CIFRI Regional Centre, HOUSEFED Complex, Guwahati-781006
[2]ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata-700120

ICAR-Central Inland Fisheries Research Institute, Barrackpore, established the sub-centres of the two All India Coordinated Research Projects (AICRP) at Guwahati in May, 1971: (i) "Propagation and Stocking of Seed of Air-breathing Fishes for Culture in Swamps" (with the main centre at Darbhanga) and (ii) Investigations on Riverine Carp Spawn Prospecting (main centre at Allahabad). Subsequently, the Brahmaputra survey unit (under the Riverine and Lacustrine Division of CIFRI, Allahabad) was established at Guwahati in October, 1972. Another sub-centre of AICRP on "Composite Fish Culture and Fish Seed Production" was established in Guwahati in 1975. All the units and sub-centres were merged to form the CIFRI Research Centre, Guwahati in 1982. An Operational Research Project (ORP) on Composite Fish Culture and Integrated Fish-Livestock Farming was also initiated at Guwahati in 1984. In 1997, the Floodplain Wetlands Division of the Institute was shifted to the Guwahati Centre. The Centre was renamed as the Northeastern Regional Centre in September, 2001 and on 6th November in the same year a Laboratory-cum-Office complex of the Centre was created at HOUSEFED Complex, Dispur, Guwahati. The Centre was upgraded to CIFRI Regional Centre in March, 2008.

Salient achievements

Carp spawn prospecting investigation in River Brahmaputra: The centre carried out studies on the availability of natural seed of Indian major carps in Brahmaputra River in late sixties. The finding of the study showed that natural seed of IMC was available in the lower stretches of the river from Guwahati to Dhuburi during the southwest monsoon season (June to September).

Fish catch estimation of River Brahmaputra: The Brahmaputra Survey unit collected primary data on fish landing, catch composition and length-weight of selected commercially important fishes for the first time. These studies have shown that the river has as many as 42 landing/ fish assembly centres on both the banks. Fish catches at Catch at Uzanbazar, Fancybazar (Guwahati), Dhubri, Tezpur and Jorhat fish landing centres declined during the period from 1973 to 1979. However, fish landings at Uzanbazar fish assembly centre slightly improved during eighties and nineties after the merger of the centre with Fancybazar landing centre. A total of 116 t (1987), 14.5 t (1992), 251.8 t (1997) and 273 t (2001) of fishes were recorded at Uzanbazar centre after which it reached a plateau. Fish catch composition in the river markedly changed over the years. Miscellaneous species have started dominating (40- 50%) the total catch and a small-sized minor carp, *Aspidoparia morar* emerged as the single most commercially important fish species in the entire stretch from chaikhowaghat to Dhuburi.

AICRPs on Composite fish culture and Air-breathing fish culture: A series of experiments were conducted on these aspects under the agro-climatic conditions of the northeastern region as part of respective All India Coordinated Research Projects during the seventies. Experiments on composite fish culture and carp seed production was conducted in the Ulubari Fish Farm of the Department of Fisheries, Assam in the seventies (1973-79). During the same period, field experiments on air-breathing fish (e.g., magur, singi, koi) culture were carried out in bamboo cages in Ghorajan and Peetkati beel of Kamrup district, Assam.

Fisheries ecology of River Brahmaputra: The centre carried out studies on various aspects of ecology and fisheries of Brahmaputra River and its 42 important tributaries. These studies generated baseline information on the present status and dynamics of fisheries ecology of this major river system. The results were useful in outlining the possible reasons for the decline in fisheries of R. Brahmaputra and provided the basis for formulation of interim guidelines for the rejuvenation of its fisheries. Water, soil, plankton, benthos data of river Brahmaputra at Guwahati were again assessed from July 2004 to June 2006 to understand time-scale variations in fisheries ecology of the river stretch. Data on fish landing at Uzanbazar (Guwahati) fish landing centre is being collected and for estimation of fish catch and species composition.

Fisheries ecology of floodplain wetlands (beels): Studies conducted by the Centre have generated a large volume of scientific information on the ecology and fisheries of beels located in different agro-climatic sub-zones of Assam (most important fisheries resource of the state covering 1 lakh ha). These studies have shown that the present average fish yield in beels of the state under capture fisheries (221 kg $ha^{-1}yr^{-1}$) and those under supplementary stocking (450 kg $ha^{-1}yr^{-1}$) is far below their production potential (1000-

1500 kg $ha^{-1}yr^{-1}$). Results of these studies formed the basis for formulation of guidelines for optimizing fish production from the beels for the benefit of fishers, beel managers and other stakeholders (e.g., Assam Fisheries Development Corporation Limited, Directorate of Fisheries, Revenue Department, Mahkuma Parishads, etc.).

Fisheries ecology of rivers of the Northeast: The first ever synoptic studies on the ecology and fisheries of important rivers of six northern states (excluding Assam) conducted by the Centre (as part of an AP Cess Fund Project) revealed that most of these rivers/hill streams presented pristine ecological conditions congenial for fish production. However, fisheries exploitation in most of these rivers were patchy owing to a variety of reasons like inaccessible terrain, fast currents, heavy monsoon discharge, severe winter and prevailing destructive fishing practices.

Fisheries ecology of northeastern reservoirs: Investigations carried out on the ecology and fisheries of Umrang and Khandong reservoirs bordering Assam and Meghalaya generated primary information on these reservoirs and formed the basis of formulating fisheries development plan for them. The Institute also carried out feasibility studies on Nogmahir and Kyrdemkulai reservoirs of Meghalaya.

Documentation of indigenous fishes: The eastern Himalayan region has been recognized as one of the global hotspots of biodiversity. However, the vast aquatic biodiversity of the region is only partially explored till date. This pristine resource is vulnerable to depletion due to natural and anthropogenic causes. The Centre carried out studies on germplasm inventory, habitat evaluation and gene banking of fresh water fishes in prioritized habitats of Assam and Meghalaya under an NATP (GPI) project. A total of 28 rivers of NER were surveyed wherein 81 species of economically important and endangered fishes were recorded. Salient habitat parameters and anthropogenic influences were also assessed and documented. In addition, 49 indigenous fin-fish species landed at Uzanbazar (Guwahati) and Amingaon (North Guwahati) landing centres of River Brahmaputra were collected and documented. Besides, 48 indigenous fin-fish species were documented from four floodplain wetlands (*beels*) of Cachar district in southern Assam viz., Fulbari *anoa*, Sibnarayanpur *anoa*, Baskandi *anoa* and Siri *anoa*. In addition, 45 fin-fish species including exotic common carp were documented in Dipor beel, Kamrup district.

Indigenous ornamental fishes: Extensive field studies conducted in Assam and neighbouring states during 2002-07 showed that as many as 148 indigenous fish species occurring in the region had potential ornamental value. Enquiries with trade circles revealed that as many as 123 indigenous ornamental fish species occurring in the region (mainly caught from the wild) are being exported through exporters based in Kolkata. Most of the current export from the state is based on natural collections alone with rare riverine/ wetland species like *Channa aurantimaculatus, C. barca, Sisor rhabdophorus, Hara hara, Conta conta, Ctenops nobilis,* etc. having greater overseas demand. Studies conducted in Dikhu River of Nagaland showed the presence of many potential species in this hitherto unexplored habitat. Further, the Centre has successfully induced one indigenous ornamental fish species having overseas demand (*Colisa lalia*) to spawn in captivity using the simple technique of environmental stimulation.

Economics of beel fisheries: The beels were divided into 4 categories on the basis of productivity *i.e.* low productive beels (less than 100 kg/ha), medium productive beels (100 to 250 kg/ha) high productive beels (250 to 400 kg) and very high productive beels (more than 400 kg/ha). Cost per ha of beel area varied between Rs. 5696 to Rs. 10960 in Assam with an average of Rs. 7631. The lease rent constitute most important cost in the management (42.7 %) followed by monitoring demarcation or barrier and stocking with around 10 to 11 %. Optimum economic size of harvest from beels and model for optimum lease rate in beels of Assam was determined.

Socio-economics and livelihood studies: Investigations on the socio-economics and livelihood of the fishers of the Northeast have been a new area of research undertaken by the centre. Formulation of means and mechanisms to strengthen the standard of living and food security of fishers is the focus of this research. Preliminary studies on these aspects were carried out in Assam and Manipur. Detailed studies on livelihood of the fishers dependent on the floodplain wetlands (beels) of Assam are currently underway.

Qualitative and physiological studies of northeastern fishes: Twenty commonly available fish species were analysed for their proximate composition, lipid content and cholesterol content. Moisture content varied from 70-80% with highest value in *Heteropneustes fossilis* and the lowest in *Clupisoma garua*. Based on crude lipid content which varied from 1.2- 30.4% with the lowest in *Catla catla* and the highest in *C. garua,* fishes can be categorized into three groups: below 5% (8 species), 5-15% (8 species) and above 20% (4 species). Crude protein content of the fish species varied from 59.8-90.3% with the lowest in *C. garua* and the highest in *C. catla*. Ash content varied from 4-7% with lowest (3.9%) value in *A. testudineus* and the highest (15.3%) in *C. nama*. Significant inverse correlation was found between crude protein and crude lipid as well as moisture and crude lipid at 1% level and 5% level respectively. Recent studies on proximate analysis of *Tenualosa ilisha*, *Amblypharyngodon mola* and *Puntius sophore* collected from different landing centres of R. Brahmaputra (under ICAR Outreach activity on nutrient profiling of fish) during three different seasons (pre-monsoon, monsoon and post-monsoon) showed seasonal changes in nutritional values. Results suggested that these fishes had high nutritional values in terms of lipid and protein contents during the pre- and post-monsoon seasons, whereas, the nutritional values (especially lipid contents) were reduced during the monsoon season.

Nutrient and energy status of organism in different trophic level of beel ecosystem: Trophic level organisms of both plant and animal kingdoms were collected from Puthimari beel, Barpeta, Assam for studying distribution pattern of biochemical nutrients like crude protein, crude lipid, energy value, phosphorus and copper.

Nutrient dynamics in beel ecosystem with special emphasis on primary nutrients: Surface and bottom water layers of clear, submerged and floating macrophyte zones in two shallow and medium size wetlands of Assam *viz*. Puthimari beel, Barpeta and 46, Morakolong beel, Morigaon were studied for nutrient dynamics of phosphate, nitrate and silicate through different macrophyte zones.

Role of aquatic enzymes: Sediment was collected from three zones (clear, submerged and floating macrophyte covered) in two beels, one closed and one seasonally open and compared for dehydrogenase, alkaline phosphatase and acid phosphatase activity.

Information flow and extension strategies in floodplain wetland fisheries: Data were collected for communication and information flow from 71 beels located in Lower and Central Brahamputra Valley of Assam. The beels located in Morigaon, Nagaon, Kokrajhar and Bongaigaon have got higher penetration of new information through group communication media like demonstration, exhibitions and fish farmer days. Barpeta, Kamrup, Dhubri, Sonitpur and Darrang had medium group information flow while Nalbari, Goalpara, Dhemaji and North Lakhimpur had least group information flow. Almost all the lessees have one radio set in their household through which they are getting the new information as well as market rate. In the use of print and electronic media for information access, the fishers of Bongaigaon, Dhubri, Goalpara, Kamrup, Kokrajhar Morigaon, Nagaon and Sonitpur were in upper level. In the middle level come the fishers of Barpeta and Lakhimpur districts. Nalbari and Dhemaji have got least penetration of print and electronic media in terms of gathering information. In addition, one case study was taken up to assess the management practices being employed in Katal fishing at different beels and river stretch in Lakhimpur and Dhemaji district.

Fishery resource assessment through GIS application: 553 beels (including some large tanks) covering an area of 20,740.3 ha in 17 districts of Assam were physically surveyed for collecting ground truthing data like location, area, shape, water depth, water retention period, river connectivity, macrophyte infestation, lease details, fishing rights, supplementary stocking status, fish catch and species composition, fishing gear, etc.. Data collected were handed over to Resource assessment unit for preparation of GIS on wetlands of Assam.

Fisheries ecology of Manipur wetlands: The Centre studied various aspects of ecology and fisheries of Loktak, Takmu, Ikop and Karung *pats* (floodplain wetlands) of Manipur. A few more pats of the state (e.g., Ungamlen, Waithou, Utra & Sana pat) were studied last year under fiels surveys with the aim of determining the actual and potential fish production from these resources as well as for formulating management guidelines to enhance their fish production. These studies showed that, all the wetlands except Takmu pat faced the problem of encroachment for agriculture or pond aquaculture in the peripheral areas.

Ecology and fisheries of Meghalaya wetlands: Ecology and fisheries of three beels of Meghalaya *viz*., Boro beel (N 25^o 44.499'& E 89^o 57.755') in West Garo Hill district and Katuli (N 25^o 28.25' & E 89^o 52.29') and Kumligaon (N 25^o 30.42'& E 89^o 54.28') beels located in South West Garo Hill district have been studied. Boro beel (80 ha) is an open beel, whereas Katuli (36 ha) and Kumlingaon (20 ha) beels are seasonally open ones. Ecology and fisheries of these beels located in the foothills region of Garo Hills were more or less similar to those of Lower Brahmaputra Valley in Assam. A total of 65 nos. of fishes were recorded from Boro beel. Sporadic landing of *Hilsa ilisha* was reported during June-July, 2015 indicating migration of anadromous Hilsa to the beel connected to the river Brahmaputra through river Jinjiram.

Occurrence of exotic species in inland open waters of Northeast India: An extensive study covering 10% of listed beels of Assam and all the major fish landing centres of river Brahmaputra in Assam during 2005-06 showed that though exotic fishes occurred in many beels and a couple of landing centres of R. Brahmaputra, none of them established their natural populations in these open water bodies. Fish catch data collected from Takmu lake (Manipur) and Umiam lake (Meghalaya) suggested dominance by exotic fishes especially *Cyprinus carpio*.

Documentation of advanced maturity of IMCs: Studies conducted in Assam and Tripura states during 2011-13 (under NICRA project on 'Assessment of spawning behaviour of major fish species in inland environment with a view to harness the beneficial effects of temperature) showed that maturity of the IMCs advanced by nearly one month (from April to March) and the spawning season also extended for nearly one month (from July to August) in the two NE states. Extensive studies covering 150 functional hatcheries of Assam and 7 hatcheries of Tripura showed that a number of minor carps (*Labeo calbasu, L. bata, L. gonius*), new exotic fishes (*Barbonymus gonionotus* and *Hypophthalmichthys nobilis*) and indigenous catfishes (*Pangasius pangasius* and *Ompok pabda*) were used in addition to the IMCs and exotic carps.

Standardizing fish stock enhancement protocols: IMCs (rohu, catla and mrigal), major exotic carps (grass carp, common carp and silver carp), minor carps (*L. gonius*, *L. bata*), other exotic carps (bighead carp, silver barb) and clown knife fish (*C. chitala*) were the main candidate species in the beels of Assam. The institute suggested a species ratio of 40 surface feeders (SF), 30 column feeders (CF) and 30 bottom feeders (BF) for shallow wetlands (average post-monsoon season depth < 2 m) and 2 SF: 1 CF: 1 BF for deeper wetlands (>2 m depth). Stocking of carried-over seed (15-20 cm size) was found to be most suitable for stock enhancement programs in wetlands of Assam in terms of survival rate. For fresh seed, survival rate was satisfactory (>70%) in case of advanced fingerlings of more than 10 cm for seasonally open wetlands and 8-10 cm in case of closed ones. Optimal stocking density of carp fingerlings was estimated at 3000 and 3600 fingerlings/ha for closed and seasonally open wetlands respectively. At present the centre is carrying out studies on sustainable management of beels of Assam for enhanced fishery and livelihood. These studies have shown that the present level of stocking (up to 2,500 FL/ha) did not affect limno-chemical variables and biotic communities (including indigenous fish species) significantly in the selected beels.

Refinement and demonstration of pen aquaculture technology for beels: Experiments on pen aquaculture of carps was initiated in Bagheswari beel, Kamrup district, Assam in 1996. Subsequently, the Institute refined the technology to enhance fish production from the beels and seasonal rivers of Assam. The resultant technology is a low-cost one, wherein cheap and locally available materials (e.g., bamboo and LDPE mosquito netting) are used for pen construction as well as for supplementary feeding (rice polish, mustard oil cake). The studies showed that fry of major Indian/exotic and minor carps (*Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*, *Ctenopharyngodon idella, Cyprinus carpio, L. gonius* and *L. bata*) could be successfully raised to advanced fingerling size. However, exotic carps were reared only in closed beels so as to avoid their possible escape to other beels and adjacent rivers. Raising of carp fingerlings in pens (size ranging from 50 to 500 m^2) erected in marginal areas of beels was successfully demonstrated in 9 beels spread over four districts of Assam under the NATP (*Jai Vigyan*) project on *Household Food and*

Nutritional Security for Tribal Backward and Hilly Regions. Two pen culture demonstrations were conducted during 2008-10 in Damal beel, Morigaon district, Assam using net lined split-bamboo screens, wherein individual pen size was increased to 741 m^2. Another pen culture demonstration was undertaken in Takmu lake of Manipur, wherein a pen measuring 100 x 100 sq. ft. has been constructed using only nets in collaboration with the Directorate of Fisheries, Govt. of Manipur during March to November, 2012 for growing of table fish including the indigenous *Osteobrama belangeri* (*pengba*). This simple technology has already been adopted by selected beel managers/ fishers of Assam for raising carp fingerlings/ table fishes.

Refinement of cage culture for raising stocking material: Experiments on rearing air-breathing fishes like magur, singiand koi were initiated in bamboo cages in Ghorajan beel of Kamrup district, Assam in 1973. Later on, refinement of the technology for *in situ* raising of carp fingerlings in beels by using low-cost polyethylene floating net cages (individual cage size size 6x3x1.5 m, later down-sized to 4x4x1.5 m) has been successfully carried out in selected beels of Assam since 2002. . In each beel, a battery of 8/9 polyethylene net cages (size 6x3x1.5 m later modified to 4x4x1.5 m) was suspended from rectangular or U-shaped bamboo platform using empty PVC containers as floats and brick/ earthen sinkers. The studies showed that fry of both minor and major carp (*C. catla*, *L. rohita*, *C. mrigala*, *L calbasu*, *L. gonius* and *L. bata*) could be successfully raised to advanced fingerling size. Recently, a stocking density of 200 fry/ m^3 was experimentally determined to be the optimal stocking density for *Labeo rohita* fry for seasonally open beels of Assam based on growth responses, feed efficiencies and economic aspects. Similarly, stocking density of 300 fry/ m^3 was found to be optimal for raising *C. mrigala* seeds in seasonally open wetlands of the state.

Fish disease surveillance in Assam: ICAR-CIFRI is part of the "National Surveillance Programme for Aquatic Animal Diseases (NSPAAD)" sponsored by NFDB, Hyderabad and led by ICAR-NBFGR, Lucknow. The surveillance programme was launched in Assam through a Launching workshop on National Surveillance Programme for Aquatic Animal Diseases jointly organized by the Institute's Guwahati regional centre and the College of Fisheries, AAU, Raha, Nagaon at the College of Veterinary Science, AAU, Khanapara, Guwahati on 29th January, 2014. Presently, active fish disease surveillance is being carried out by the Institute in three districts of Assam *viz.*, Kamrup, Barpeta and Cachar. Besides active surveillance, passive surveillance is also being carried out in different places of Assam. To support the surveillance programme one fish disease diagnostic laboratory has been established by the Centre under the project.

Other activities

Human resource development (HRD): The Centre conducted over 30 training programmes (both on and off-campus)/ farmers' seminars on various aspects of open water fisheries over the past 15 years to train more than 500 individuals (fisheries officials, fish farmers) of the region as part of thrust given by the Institute on human resource development in the region. The participants of these trainings included fisheries officials, academicians, beel managers of Assam Fisheries Development Corporation, beel lessees, fishers and beneficiaries of pen culture demonstration projects. The Institute also jointly organized a training programme on all aspects of inland fisheries development for the fish farmers of Meghalaya at Umiam in collaboration with two other ICAR institutes, *viz*., CIFA, Bhubaneswar and ICAR Research Complex for the Northeastern Hill Region, Umiam. It conducted another collaborative training programme for the KVK functionaries Umiam of the region with other ICAR fisheries research Institutes with funding support from the ICAR Zonal Coordinating Unit II (renamed as ATARI), Umiam, Meghalaya. In addition, the centre conducted 3 field demonstrations, 3 Fish Farmers' Days and participated in 12 exhibitions. A collaborative off-campus awareness camp-cum-training programme on 'Recent advances in floodplain wetland management with integrated farming, fish health management and fish feeding management' was jointly organized by CIFRI Regional Centre, Guwahati; Bodoland Territorial Council, Kokrajhar; Aquaculture Development Organization for ST, SC & Backward Classes, Assam and Aqua-International, Kolkata at Koklabari, Baksa District, BTC in April, 2013.

Infrastructure development: Keeping in view the research and development need of the Northeastern region, the institute has established modern laboratories at HOUSEFED complex, Dispur, Guwahati in June 2001. The laboratories are equipped with sophisticated scientific instruments like High Performance Liquid Chromatography, AAS, Cooling centrifuge, Laminar flow, high resolution microscope with image processing software, UV-Visible spectrophotometer, Flame photometer, etc. The centres library contains over 800 books, 190 bulletins, five regular scientific journals besides special publications of the institute, training manuals, seminar/ workshop proceedings, current contents, etc. The Institute also created adequate infrastructure facilities including lecture rooms, auditorium, discussion room, instructional laboratory, trainees' hostel, etc. for conducting regular training programmes at the same complex.

Networking with line departments and other stakeholders: CIFRI recognizes the need of active cooperation and collaboration with the state fisheries departments and research institutes in order to cater to the genuine research and training needs of the region in the field of open water fisheries. For institutionalizing such a linkage, it organized a *regional consultation on fisheries development of the Northeast* in 2001 by involving the fisheries Secretaries and Directors of the state fisheries departments as well as research institutes working in the region. The suggestions made in the meeting are being incorporated in the work plan of the centre. The centre carried out most of its reserach and field demonstrations in floodplain wetlands under the administrative control of the Assam Fisheries Development Corporation and Assam Agricultural University, Jorhat. Further, the services of scientists of the centre have been spared for participating as resource persons in various training programmes/ zonal workshops/ farmers' seminars, awareness camp, etc. on fisheries and aquaculture organized by the departments of fisheries, Govt. of Assam/ Meghalaya/ Tripura, State Institute of Rural Development, Assam; National Institute of Rural Development, NER Centre, Guwahati; AAU, Jorhat; Indian Institute of Entrepreneurship, Guwahat; Bodoland Territorial Council, Kokrajhar; NGOs, etc. Recently, the Institute organized a meeting of stakeholders' on R&D linkages in open water fisheries in NE Region at its Guwahati l Centre on 11th April, 2013 on the occasion of visit of QRT to the Centre, which was chaired by Dr. M. V. Gupta, Former Assistant Director General, World Fish Centre & World Food Laureate. Officials/ representatives from the Directorate of Fisheries, Govt. of Assam (led by the Director), Assam Fisheries Development Corporation, Guwahati; Bodoland Territorial Council, Kokrajhar; Livestock Research Station, Assam Agricultural University, Mandira, Kamrup (R) district; Rastriya Gramin Vikash Nidhi (NGO), Assam centre, Guwahati as well as fish farmers from BTC participated in the meeting. Detailed discussions took place on the problems facing open water fisheries development in the Northeast region and R&D needs for the future. The Institute has signed a Memorandum of Understanding (MoU) with the AFDC Ltd. for carrying out collaborative pen aquaculture demonstrations in 30 beels under the administrative control of the corporation durning 2012-13. Action has also been initiated to sign similar MoUs with the Directorate of Fisheries, Assam (for carrying out collaborative pen aquaculture demonstrations in 10 beels) as well as with the NRC on Pig (ICAR), Rani, Kamrup (R) District, Assam (for carrying out collaborative pig-cum-fish culture model development) during 2013-14.

Consultancy services: The Institute provided consultancy services to the Department of Fisheries, Govt. of Assam; NEEPCO, Shillong; NHPC, New Delhi; GMR, Londa; Bhilwara energy Ltd., etc. on various aspectes like investingating possible establishment of population of exotic carps in the natural water bodies of Assam, design of fish pass facilities for dams in AP, fish migration studies and designing of fish hatchery for HE project, estimation of minimum environmental flows for downstream of dams, and so on.

Collaborative work programmes under NEH Component of ICAR-CIFRI: The Institute has been carrying out collaborative work programmes in collaboration with line departments and other stakeholders of open water fisheries in the Northeast under the NEH component in the XII FYP. The prioritized areas were identified in an inception workshop on "Scientific fisheries management of wetlands and reservoirs of NE Region" organized at the centre on June 20, 2012. Officials from fisheries departments of Assam, Meghalaya, Arunachal Pradesh, Manipur and Tripura, Assam Fisheries Development Corporation (AFDC) Ltd. as well as scientists/ teachers from NRC on Pigs (ICAR), Rani, Kamrup, Assam and College of Fisheries, CAU, Lembucherra participated in the workshop. Under this component, the Institute has carried out large-scale collaborative pen aquaculture demonstrations in collaboration with AFDC Ltd. (in 30 beels), Bodoland Territorial Council, Kokrajhar (4 beels), Department of Fisheries, Govt. of Manipur (2 pats) and Directorate of Fisheries, Assam (10 beels). We also carried out collaborative pen aquaculture for fisheries enhancement in Mer beel (Nagaon district), Assam in collaboration with AFDC Ltd. as well as development/ refinement of model for pig-cum-fish culture in collaboration with the NRC on Pig (ICAR), Rani, Kamrup (R) District, Assam during 2013-14. Collaborative fish stock enhancements in Sarbhog beel (Barpeta district), Assam is currently underway in collaboration with AFDC Ltd.

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NATIONAL SURVEILLANCE PROGRAMME FOR AQUATIC ANIMAL DISEASES: ICAR-CIFRI COMPONENT

B. K. Behera[1], B. K. Bhattacharya[2], A. K. Sahoo[1], P. Das[2], S. Sahoo Das[2], A. B. Gohain[2], A. Das[1], P. Paria[1] and B. K. Das[1]

[1]ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata-700120
[2]ICAR-Central Inland Fisheries Research Institute, Regional Centre, Guwahati-781006

Aquaculture is presently one of the fastest growing food sectors in the world and developing countries in particular, account for the bulk of this increase in production. However, diseases are a primary constraint to the growth of the aquaculture sector. A multitude of factors have contributed to the health problems currently faced by aquaculture. Over the past few decades, aquaculture has expended, intensified and diversified and based heavily on movements of live aquatic animals and animal products (brood-stock, seed and feed). This trend has been triggered by changing circumstances and perspectives, especially world trade liberalization. New outlooks and directions have accelerated the accidental spread and incursion of diseases into new populations and geographical regions, for example, through movements of hatchery produced stocks, new species for culture, enhancement and development of the ornamental fish trade. Translocation of pathogens and diseases with movement of their hosts has recently gained focused attention in many regions. There is now convincing evidence of the serious socio-economic environmental and international trade consequences arising from trans-boundary aquatic animal diseases.

In India, the losses due to disease in fresh water have been estimated to be 10-15 % of total value of fish production and the loses due to *Argulus* infestation alone in carps were estimated to be in the range of Rs. 29,500/- to 70,000/- per hectare. In 2010-11, large scale mortalitydue to epizootic ulcerative syndrome resulting in economic loses of Rs. 10,000/- to 20,000/- per hectare was observed in some of the fish farms. Due to wide spread and huge economic losses incurred on account of diseases, many countries have been giving increased emphasis on improved surveillance, reporting and response to disease emergencies in aquatic animals.

What is surveillance?

Surveillance is the systematic ongoing collection and analysis of information related to animal health and timely dissemination of related information to those who need to know so, that need action can be taken. Most often, it is perceived that survey is synonymous with Surveillance. But there are fundamental differences between two. Aquatic animal health survey is one time collection of health information from a specified population and this can provide a piece of evidence about estimation of disease occurrence.

Need for disease surveillance

The primary purpose of surveillance is to impose collection of information on the distribution and occurrence of aquatic animal diseases; detect new and exotic infectious diseases in aquatic animals and provide support to farmers experiencing disease problems in a scientifically accurate and cost-effective manner. It also includes the reporting obligations of the country to World Organization for Animal Health (OIE) and regional Quarterly Aquatic Animal Disease (QAAD) Reporting System of Network of Aquaculture Centers in Asia-Pacific (NACA).

Surveillance is a mechanism applied to collect and interpret data on the health status with on the animal populations and to accurately describe their health status with respect to specific disease of concern. Surveillance is an integral component of aquatic animal health management programme that supports early warning of disease of concern, contingency planning and monitoring of disease control measures. A well-organized surveillance programme can have several benefits, such as:

- Heath advice to farmers and other stakeholders involved in trade of live aquatic animals.
- Accurate certification of exports.
- Reporting to International organizations on health status.
- Verification of freedom from diseases.
- Effective aquatic animal emergency disease preparedness.

A standardized surveillance and reporting system assists in the identification of the range and distribution of pathogens affecting aquatic animals in the country, and better targeting of affecters to control and reduce the risk of spread of fish diseases. Surveillance of national basis will inform the competent authority of disease situation in the country, provide early warning disease emergency, facilitated more specific contingency planning and strengthen international confidence on country's fish health status.

What information needs to be collected for surveillance?

The identification of abnormalities in the animal behavior or appearance can provide early warning of emergencies. It is to be noted that the definition of an "emergency" in respect to farmers and governments may differ. For farmers, an emergency would be a disease or its syndrome that can cause significant mortality and/or production loss. At the same time, they would be little concerned about pathogens or diseases that do not affect production or profit directly from their farm. On the other hand, the above developments are also important form the government perspective, because governments are concerned with a number of issues other than mortality and/or production losses. e.g., for the OIE (Office of International des Epizooties) listed diseases, the country is obliged to first notify the occurrence or reoccurrence of diseases; occurrence in a new host species; occurrence of a new pathogen strain or a new disease manifestation etc.

How to collect disease information?

Reporting of abnormal observations is often in the interest of both farmers and governments. There are two ways for collecting the information on abnormal observations. We can go and look surveillance of pathogens and diseases- active developments; or wait for the farmers to report them by way of passive surveillance.

The active surveillance provides quantifiable information on presence or absence of a specific disease in a defined population. It involves planned collection of precise field data on the presence of a specific disease or pathogen within a defined population. However, the cost associated with testing every farm for all the diseases listed by Office of International des Epizooties (OIE) or Network of Aquaculture Centers in Asia-Pacific (NACA) would be expensive as well as unbearable sometimes.

Therefore, the target should be to develop a cost effective system, and adoption of a passive surveillance approach. This should be the first step towards establishing a surveillance system in the country to deal with the problem. The passive surveillance is an ongoing observation of the disease profile of a susceptible population which is cheaper and requires fewer efforts. It is also well suited for the detection of new and exotic disease and emergencies. This system is often based on farmers notifying fisheries officers of a health concern in their aquaculture farms and data collected for other purposes (e.g. routine diagnostic checks) also can be used for this purpose.

What are the basic requirements for establishing a passive surveillance system?

Three simple rules *viz.*, recognition, recording and reporting (3 R's) are essential for a surveillance system to be sustainable.

Recognition: Farmers often perform routine assessment of aquatic animals in ponds (through pond-side observation, looking at feed trays etc.). Although this is not conducted on a representative sample of the population, it can still prove to be very useful as part of surveillance. Signs of abnormal behavior observed of farm animals can provide useful information on whether a pond is affected by a health problem. This information can be used as part of a passive surveillance system, as sick aquatic animals can be collected and submitted for quick tests of for more advanced diagnostic tests are not always required, as the occurrence of sick aquatic animals in conjunction with other information (poor growth, low survival, reduction in food intake, water quality parameters etc.)can aid in the presumptive diagnosis of the pond's health status.

Recording: Observation made on aquatic animals should be recorded carefully to be useful for surveillance purposes. To maximize accuracy, record keeping should be conducted at a level as low as possible: for example, it is better for the farmers to maintain records by themselves than by a fisheries officer recording information memorized based on what was listed to form the observation of the farmer. It is also desirable to record the presence of clinical signs rather than only the occurrence of the suspected disease. In addition, preferably data should not be aggregated, and the originality of the data collected should be preserved consistent with the flow of information. This means the, if pond-level data were collected, the data flowing through the system should be at pond level, and not aggregated into community level information.

Reporting: A critical step of any surveillance system is reporting by which the information should flow to the people, who need to evaluate the contents of the report and act upon it. These actions are particularly important in passive surveillance because of the passive nature of the system. The willingness and ability of each stakeholder to contribute to the system can strongly affect the accuracy of disease information being reported. It is generally preferable to move information within the system as fast as possible, especially when reporting relates to an emergency. The simplest, but also the slowest process of reporting disease information is a paper-based system. The faster method of transfer of information upwards in the surveillance system includes telephone, fax and email. In addition to farmers, disease diagnostic laboratories involved in testing the health of aquatic animals should also be essential part of a surveillance system, where large numbers of samples are tested for a wide range of reasons including; routine inspection of farms; testing of sick aquatic animals showing abnormal clinical signs etc.. In addition, to these, research/university laboratories often have high levels of capacity to detect pathogens and apply advanced diagnostic methods. So, such research laboratories should also be officially linked to a surveillance system and laboratory results should be reported to the system.

What should be the roles/responsibilities of each stakeholder?

Surveillance is a shared responsibility. Development and implementation of a successful national surveillance system is dependent on the cooperation of a broad range of stakeholders and institutions. Stakeholders in a surveillance system normally include: the so called 'eyes of the system', such as farmers, farm employees and hatchery workers. In addition, Fisheries officers; aquatic animal health researchers; feed company experts; diagnostic laboratories etc. would have to also play an important role.

Each stakeholder in a surveillance system should be aware of: information that needs to be collected and reported; the timing of information collection and reporting; te method used to record information (e.g. use of standard recording sheets); available tools and mechanisms for reporting surveillance information (e.g. telephone numbers of fishery officers/researchers and websites); feedback to be expected upon submission of surveillance information potential confidentiality of such information and action to be taken upon receiving surveillance information.

In addition, where possible, uniform diagnostic methods should be followed so as to increase the comparability of test results. Emergencies should identify be reported as promptly as possible. After receiving the surveillance data, it should be analyzed in a timely manner, with prime objectives of identifying emergencies such as the occurrence of new diseases or syndromes, or a significant increase in the occurrence of known diseases. Once surveillance information has been collected, processed and analyzed, it is important to communicate the results to the stakeholders involved in the information flow. This has the double advantage of providing opportunities for improved management and providing an incentive for continuing surveillance efforts, as receiving feedback is one of the most important factors in ensuring the sustainability of the system. Disseminating information more broadly (i.e. also to people not directly involved in the reporting of surveillance information) will not only allow the development and implementation of informed management strategies, but also encourage those who have not actively participated in the implementation of the system to contribute.

Objectives of NSPAAD

1. To improve the collection of information on the distribution and occurrence of aquatic animal diseases.
2. To rapidly detect new and exotic infectious diseases in aquatic animals.
3. To implement a national information management system for aquatic animal diseases of national concern.
4. To improve reporting requirements to World Organization for Animal Health (OIE) and regional Quarterly Aquatic Animal Disease (QAAD) reporting System and enhance compliance to OIE standards.

ICAR-CIFRI component of NSPAAD

ICAR-Central Inland Fisheries Research Institute (CIFRI) is part of the "National Surveillance Programme for Aquatic Animal Diseases (NSPAAD)". A total of 4 districts *viz*., Purba Medinipur, 24 Praganas (N), Burdwan and Nadia in West Bengal and 3 districts in Assam *viz*., Kamrup, Barpeta and Cachar have been selected for active fish disease surveillance. Besides active surveillance, passive surveillance is also being carried out in different places of West Bengal and Assam.

Assam component of NSPAAD

Assam is an important state in terms of aquaculture development and fish seed production in India and a major fish producing state in North Eastern India. In Assam, composite carp culture in ponds, polyculture system, semi-intensive fish farming, integrated fish farming (live-stock based), integrated fish farming (agriculture based), paddy-cum fish culture and enclosure (pen and cage) culture in beels are the important aquaculture activities. ICAR-Central Inland Fisheries Research Institute (CIFRI), Regional Centre, Guwahati and

College of Fisheries, AAU, Raha, Nagaon are carrying out the surveillance of fish diseases in Assam. A total of 8 districts *viz*., Kamrup, Barpeta and Cachar (under CIFRI), Nagoan, Morigoan, Sonitpur, Lakhimpur and Golaghat districts (under College of Fisheries, Raha)are selected in Assam for active surveillance because of fisheries importance in these districts.

Plan of work for NSPAAD in Assam

A. Immediate plan

- Collection of baseline information and gathering of information for passive surveillance (through State fisheries officials, Farmers, NGOs etc.) of the selected districts as per the template to be developed.
- Organization of awareness programme and orientation to the farmers.
- Developing linkage with the State Fisheries Departments (at least in the selected districts).
- Collection of samples from farms as and when necessary.

B. Plan of work to be undertaken in the five year period

- To undertake the passive surveillance for the entire state with greater focus on selected districts.
- Undertake targeted disease screening of minimum 10 selected farms in each of the identified districts (sampling frequencies should be at least at quarterly intervals or at suitable intervals as deemed fit).
- Survey of water-bodies (ponds/wetlands) in the identified districts of Assam with cluster approach.
- Identification of the key personnel responsible for these systems and creating awareness among the fishers about the disease surveillance and its importance. Initiation of e-message (24x7hr) alert from the fishers to the fish health center on mortality or any abnormalities.
- Creation of database on the species cultured, water bodies' types, frequent diseases, pathogens (parasite, bacteria, fungi and virus), new disease records, new pathogens.

- Collection of data on pond preparation, water quality, pond management, stocking of fingerlings/post larvae, status of fish/shrimps health at stocking, half way through the crop and at harvest on regular basis by the research team.
- Random sampling of Fish/Shrimp for health monitoring. If any mortality, testing the samples by Level I, II, III diagnostic methods.
- If any indication of disease incidence/mass mortalities, immediate knowledge sharing with other partners and nodal agent. Sample cross checking for the causative pathogen from other laboratories and record entry to the host/ nodal center.
- Visit of rapid action research team to the fish mortality/outbreak site and looking the possibilities of mortality/outbreak, causative factors and possible remedies.
- Development of Disease Reporting System in the line of animal disease surveillance.

Expected output

1. Uniform disease diagnostic protocol will be developed for the concerned fish diseases to our country.
2. Trained state fishery officers will be helpful in investigating disease outbreaks and reporting.
3. Effective fish disease surveillance system in the country will be implemented and reporting system will be strengthened.
4. Database on fish diseases of the country on temporal and spatial scale will help competent Authority on various aspects like import risk analysis, contingency planning etc.

Disease diagnosis

The three levels of diagnosis are given in the Table 1 will be followed in the aquatic disease surveillance program.

Table 1: Three levels of diagnostic information, associated requirements and responsibilities

Level – Activities	**Skills and equipment's**	**Responsibility**	**Requirements**
Level – 1 1. Observation of animal and the environment. 2.Clinical Examination 3.Gross pathology	1. Knowledge of normal feeding, behaviour growth of stock, etc. 2. Frequent/regular observation of stock 3. Regular, consistent record-keeping and maintenance of records – including fundamental environmental information 4. Knowledge contacts for health diagnostic assistance 5. Ability to submit and/or preserve representative specimens	• Farm Workers • Managers • Fisheries Officer • Extension Officers • Field Veterinarians • Local Fisheries • Biologists	• Field keys • Farm keeping formats • Equipment list • Model clinical data sheets • Pond-side checklist • Protocols for preservation and transport of samples.
Level II 1.Parasitology 2.Bacteriology 3.Mycology 4.Histopatholo gy	1. Laboratories with basic equipment 2. Personal trained /experienced in aquatic animal pathology. 3. Keep and maintain accurate diagnostic records 4. Preserve and store	• Fish biologists • Aquatic Animal Veterinarians • Parasitologists • Mycologists • Bacteriologists • Histopathologi sts	• Model laboratory records keeping system • Protocols for preservation /transport of samples to Level III

	specimens 5. Knowledge of /contact with different areas of specialization within level II and Level III.	• Technicians	• Model laboratory requirements and equipment and consumable lists • Contact information for accessing Level II and Level III specialist expertise. • Diagnostic manuals
Level III 1.Viroligy 2.Electron Microscopy 3.Molecular Biology 4.Immunology	1.Highly equipped laboratory 2.Highly specialized and trained personal 3.Keep and maintain accurate diagnostic records 4.Preserve and store specimens 5. Maintenence of contact with people responsible for sample submission.	• Virologists • Ultrastructural histopathologists • Molecular biologists • Technicians	• Model laboratory requirement • Equipments and consumable lists • Contact information for reference laboratories. • Protocol for preservation of samples for consultation and validation • Diagnostic manuals

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CHEMOTHERAPY AND AQUACULTURE MEDICINE

B. K. Das and B. K. Behera

ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata- 700120

Fish therapeutics had their beginning in early sixties. Therapeutics in the broadest sense includes any and all remedial agents or measures that will promote the relief from pain, restore health, or prolong the life of a fish and shellfish. Pharmacotherapeutics deal with the use of drugs in the prevention and treatment of disease. Many drugs stimulate or depress biochemical or physiological function in fish in a sufficiently reproducible manner to provide relief from symptoms or ideally, to alter favorably the course disease. The absorption, distribution, biotransformation and excretion of a drug, all involve its passage across cell membranes. Regulation of activity by increasing or decreasing fish and shellfish movement, physical restraint, expansion or reduction of swimming area, removal or addition of objects or decorations in tanks and increasing water flow, thereby forcing swimming or addition of objects are considered as a form of treatment. Therapy is applied for fish to prevent attacks of bacterial, viral, fungal, algal, protozoan, helminthes, cestode, crustacean and other parasitic organisms.

Domestication in aquaculture is increasing day by day in the world aquaculture but the development and commercialization of aquaculture medicine is not gaining momentum. The country like India does not have a regulatory mechanism and for the use of aquaculture medicine and its prescription which will reach to the farmers for safe guard the whole aquaculture in the country. The use of pharmaceutical agents in treating fish diseases and modulating fish growth is rather un-sophisticated. The primary means of administration include water treatment, incorporation in feed (medicated feed), and by injection. It needs to be pointed out that the conditions of the water, the earth-pond, and equipment all play an important role in the well-being of eggs and the growing fish. Similarly, adequate farming practices are also a critical component. For instance, newly introduced fish stock should be quarantined prior to release to the pond/ tank. Use of unapproved drugs or misuse of approved drugs in cultured fish poses a potential human health hazard. These substances maybe toxic, allergenic, or carcinogenic, and/or may cause antibiotic resistance in pathogens that affect humans. Reasons for the use of drugs in aquaculture include the need to (1) treat and prevent disease, (2) control parasites, (3) affect reproduction and growth, and (4) provide tranquilization (e.g., for weighing). Relatively few drugs have been approved for aquaculture. This factor may lead to the inappropriate use of unapproved drugs, general-purpose chemicals, or approved drugs in a manner that deviates from the labeled instructions.

Therapy

FAO (1991) Definition: Fish are subjected to therapy in those cases when a disease is so developed that the life or performance of the fish is immediately endangered or expected to be endangered in the subsequent period. Therapeutic treatment should be regarded as emergency measure resorted to when prevention has failed.

Therapy: Administering of a drug or a chemical or its combination in water, or through feed or via any other means, after a disease is diagnosed.

Classification of Therapy

Therapy in fish may be classified into:

- Physiotherapy
- Psychotherapy
- Surgery
- Regulation of environment
- Nutritional therapy
- Immunisation
- Hormone therapy
- Prophylaxis as a therapy
- Drug therapy

Therapeutics is given in the form of aqueous preparations, alcoholic preparations, fatty and oily preparations, solid preparations and gaseous preparations.

Therapeutants

Factors to be studied prior to treatment:

1. Disease

2. Properties of the pharmacological agent under consideration.
3. Species under treatment
4. Environmental conditions.

Factors should be considered:

1. Pathogen.
2. Value of fish.
3. Legal considerations.
4. Cost of treatment
5. Mode of treatment
6. Mortality rate
7. Environmental variables
8. Other factors

Method of administration and mode of action

The poikilothermic nature of fish must be considered while searching for the proper drug and route of administration. The fundamental principle of treating fishes is the same as for any other animals.

The mode of administration can be broadly categorized into:

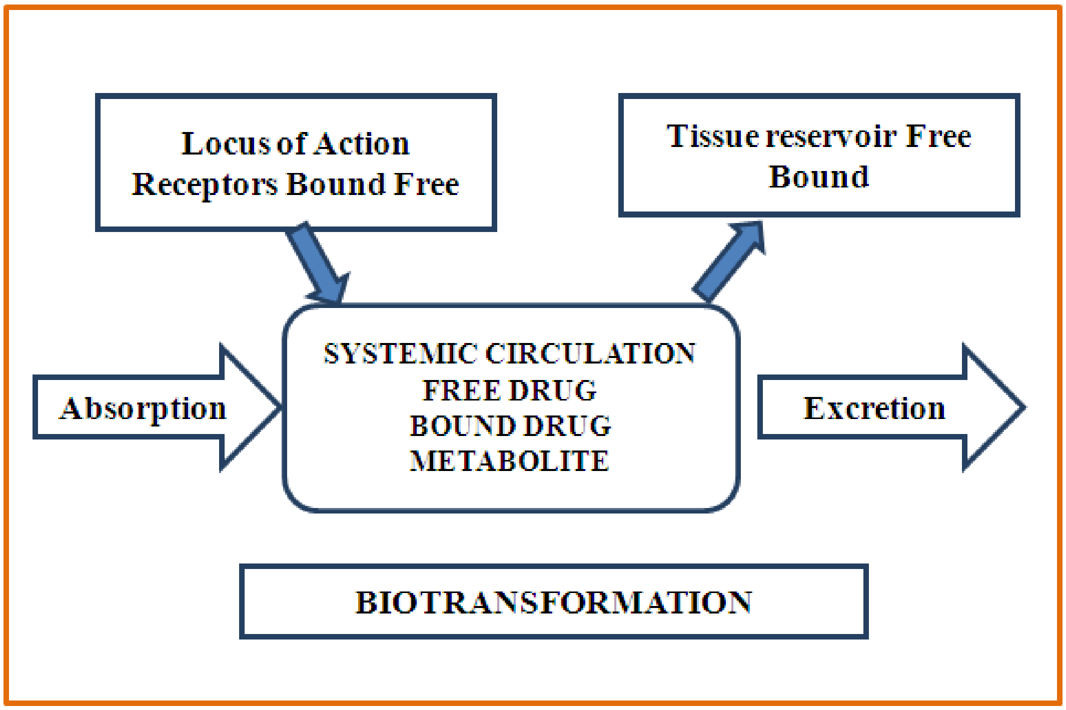
i). Tropical application

ii). Administration by baths: dips, short baths, flush, long baths and constant flow

iii). Oral administration

iv). Parental administration: Intramuscular, Intravenous and Intraperitoneal injection

The schematic representation of the inter-relationship of the absorption, distribution, binding, bio-transformation and excretion of a drug and the concentration of its locus of action is given below.



Chemotherapeutic agents

Globally, few new chemotherapeutic agents have been approved for use in aquaculture since the last one decade. The concern is attributed due to environmental impact of a new chemical entry especially on nontarget organism, cost of developing a new product and medicated feed etc. This may be classified in to medical disinfectants, antiparasitic agents and antibiotics.

Medical disinfectants are used to disinfect fish eggs and clean ponds, equipments, etc. They include iodophores, salts, organic chlorocompounds, aldehydes, hydrogen peroxide, quaternary ammonium compounds and antiseptic dyes. They are primarily targeted to fungi and ectoparasites. Formalin and chloramin T are most commonly used disinfectants in North America. Formalin is useful in the treatment of ectoparasitic infection especially by protozoa and skin and gill flukes.

Antihelminthic drugs are used to control round worms, tapeworms and flukes. Praziquantels (a pyrazinoisoquinoline) is registered in Norway for use against intestinal tape worm and administered in feed with a withdrawal time of 14 days. Albendazole and fenbendazole are not advised to use against fluke and larval tapeworms. Dichlorovos and trichlorphon are organophosphates used to treat sea lice infestation by immersion bath method in the salmon industry. The compounds are cholinergic inhibitors and affect both the host and parasitic alike. The therapeutic indexes are low.Additionally they affect the other organisms in the aquatic environment. A newer organophosphate azamethiphos has recently gained attention due to higher potency and greater therapeutic index. Other chemical agents include hydrogen peroxide and synthetic pyrethroid such as cypermethrin, deltamethrin and Butox are used to control carp lice and other parasites. Avermectin have not approved for use aquaculture except UK where ivermectin under the cascade procedure when authorized products fail to show effective control over sea lice infestation. In India these chemicals are in use in carp culture as and when required to control the carp lice.

Drug and chemicals may be grouped according to physiological effect they produce or by the site of their activity on the fish body. Those acting on the skin or other body surface at the point of application are known as drugs with local actions, while those acting inside the body, remote from the point of application, either through absorption or entrance into the blood stream, and are considered to have a systemic action.

Drugs

In pharmacology, a drug is "a chemical substance used in the treatment, cure, prevention, or diagnosis of disease or used to otherwise enhance physical well-being.“

All drugs are chemicals but all chemicals are not drugs.

Ex: Drug -> Formalin, Ormetropin, Sulfamerzine, NaCl, Onion, CaO, H_2O_2.
Chemicals – CaOH, Lime, NaOH, Tris Buffer.

Drug metabolism

Similar to mammals. Fish metabolize drugs at about one by tenth the rate of mammals. Temperature optimum for drug metabolism in fishes is lower than those in mammals. Site: liver, kidney, gut mucosa.

Table 1: List of chemicals and drugs and their doses for treatment of various pathogens.

CHEMICALS/DRUGS	DOSE	TREATMENT FOR (PATHOGENS)
	VIRICIDES	
Betadine	100ml/l -painted on	Virus
Benzal Konium Chloride	0.02g/l –do-	
Volan a adhesive ointment it is applied	Mixed with cortisone	Lymphocytosis
Sodium hypochloride	10 ppm for 24h	Virus
	BACTRICIDES	
Acriflavin, neutral	10 ppm	Columnaries disease
Alcohol iodated	100 ppm bath for	Acinetobacter
Coryne	Lominutes	Bacterial Kidney disease
Ampicilin, Sodium	Undermined	Gram +ve and Gram –ve bacteria
Aquarol	80 ppm	Bacterial fin rot
Arycil	Intraperitoneal injection of 1.cc. of a 1% solution, then 5% solution, three times	Bacteria (Carp Pod)
Aureomycin	13 ppm	*Flavobacterium columnare, Vibrio*
Bacitracin	250-300 mg/gal of water	Gram +ve bacterial
Betadine	10 mn bath at 10-100 ppm	Acinetobacter, Furunculosis.
Benzakonium chloride	0.5 ppm	Bacterial gill disease, Fin rot, Myxobacterial disease
Colistin sulphate	undetermined	Gram +ve & *Pseudomonas*
Copper sulphate	1-2 ppm	Bacterial fin rot
Erythromycin	10mg/kg of fish/day in fed for 21 days	Corynbacterium & several Gram +ve & Gram –ve bacteria

Ethionamide	As per the condition	Fish Tuberculosis
Fumagilin	0.5 ppm	Bacterial gill disease (BGD)
Furanace	1ppm or 0.4 to 0.8mg/kg of fish per day for 1 month	BGD, BHS, Cold water disease, fin rot, *Pseudomonas*, *Vibrio anguilarum*
Gentamycin sulphate	20mg/gal of salt water	*Aeromonas*, *Pseudomonas*
Griseefulvin	10 ppm	Gram –ve bacteria
Iodophors	100 ppm for 10-15 min bath	*Pseudomonas*, BHS
Kanamycin	0.02-0.05 g/l of water	*Aeromonas*, *Pseudomonas*, Mycobacterium, Vibrio
Malachite green	1g/10m^2 of tank surface 2-3 times alternate day	Columnaris
Merthiolate	Swab on fish ulcer	Fin rot, Ulcer
Neomycin	250 mg/gal salt water pseudomonas	Gram +ve & Gram –ve bacteria
Nitrofurantoin, sodium	As prevailing condition	-do-
Nitrofurazone	10 ppm	*Vibrio anguillarum*
Novobiocin	As per the prevailing situation	Gram +ve & Gram –ve bacteria
Oxalinic acid	Orally 3mg/kg of fish, once, daily for 5 days	*Aeromonas* & *Coumnaries*
Oxytetracycline	10 ppm in water	As furanace
Ozone	26-65 ppm	All types of bacteria
Pencilin, potassium	1ppm daily	Bacteria (gill infection)
Polymyxin B, sulphate	50mg/kg body wt. in feed	Gram –ve bacteria
Potassium permanganate	20 ppm for one hour	Bacteria on skin
Quaternary ammonium	2-4 ppm active ingradients-1 hr bath.	BGD, Cold water compunds disease, columnaris.
Streptomycin	As per chloramphenicol	Gram +ve and Gram –ve bacteria, BHS, fish tuberculosis, *Pseudomonas*

Sulfamelthazine	200 mg/kg of body weight per day with food for 14 days.	Columnaris, Furnuculosis BKD, cold water disease, ulcers, red mouth disease of trout
Sulfanamide	100-250 mg/l for long duration bath.	All bacterial diseases
Vanomycin hydrochloride	No specific (Undetermined)	Gram +ve *Cocci*
CIFAX **CIFACURE**	Not specified Mixture of chemicals	Epizootic ulcerative syndrome, Gram –ve bacteria Treatment of ornamental fish disease
	FUNGICIDES	
Acriflavin, neutral	3-10 ppm prolonged bath	Saprolegnia
Aureomycin	10-20 ppm in water	Saprolegnia
Bacitracin	250-300 mg/gal of water	Marine fungus
Calcium cyanamide	200 g/m^2 distributed on the bottom and banks of drained but still wet ponds.	*Branchiomyces* sp.
Cholramin-T	10 ppm	Saprolegnia
Chlorine	1 ppm for 3 days	*Ichthyophonos hoferi*
Copper sulphate	5 ppm for I hr on fish eggs	Branchiomyces-*B demigrans*, Saprolegnia
Formalin (40%)	100 ppm for 3 hrs or 40 ppm for 24 hrs	Achyla, Aphanomyces, B. demigrans, *B. sanguinis*, Loptomitus, pythium, Saprolegnia.
Furanace	0.05-0.2 ppm added to ponds	Phythium, Saprolegnia
Gention violet	0.3 ppm	Saprolegnia
Idoform	2 ppm	-do-
Malachite	5 ppm as a 1 hr flush daily	(Achyla, Aphanomyces, *Ichthyophonus hoferi*, Saprolegnia)

Methylene blue	3cc of 1% solution in 10l of water as long duration bath (3-5 days)	Antifungal agents on fish eggs, Saprolegnia
Oxytetracycline	12.5 ppm daily	Saprolegnia
Ozone	As mentioned in Bactericides	All types of fungus
Phenoxethol	100-200 ppm for 12 hrs.	*I. hoferi*
Potasium dichromate	20 ppm	Saprolegnia
Potassium permanganate	5-10 ppm for 2 hrs.	Saprolegnia, Achylasis.
Silver nitrate	10,000 ppm applied topically	Saprolegnia
Sulfanilamide	As mentioned in bacterial disease	All types of fungal disease.
Sodium chloride	10-15 g/l of water as a short bath of 20 minutes.	Saprolegnia
	ALGICIDES	
Acrolein	3 ppm in water	Herbicides
Ammonium sulphate	100 ppm	Pyrmnesium
Copper sulphate	2-3 ppm	Blue green algae, pyrmnesium
Copper sulphate+Cupravil	2ppm+3ppm 1-2 kg/ha	All type of algae
Cutrine (Copper sulphate+ Triethanolamine)	According to field condition	-do-
Diquat	2-4ppm of the active ingradients for 1 h	Blue green algae
Diuron	According to field	-do-
Ethylmercuric	0.5ppm	Pyrmnesium phosphate
PMA (Pyridyl mercuric acetate)	0.2ppm	-do-
Paraquat, dichloride	0.5ppm	Blue green algae

FDA low regulatory priority aquaculture Drugs

- Acetic acid
- Calcium chloride
- Calcium oxide
- Carbon dioxide gas
- Fuller's earth
- Garlic (whole form)
- Ice
- Magnesium sulfate
- Onion (whole form)
- Papain
- Potassium chloride
- Povidone iodine
- Sodium bicarbonate
- Sodium chloride
- Sodium sulfite
- Thiamine hydrochloride
- Urea and tannic acid

FDA high enforcement priority aquaculture drugs

- Chloramphenicol;
- Nitrofurans;
- Fluoroquinolones and Quinolones;
- Malachite Green;
- Steroid Hormones.

Drugs prohibited for extra-label use

The following drugs and families of drugs are prohibited for extra-label use in food-producing animals

- Chloramphenicol;
- Clenbuterol;
- Diethylstilbestrol (DES);
- Dimetridazole, Ipronidazole, and other
- Nitroimidazoles;
- Furazolidone, and Nitrofurazone;

- Fluoroquinolones;
- Glycopeptides

Table 2: Prescribed kilograms of active substance of antimicrobial drugs in Norwegian aquaculture

Groups of Substances	**Active substance**	2005
Tetracyclines	Oxytetracycline	0.01
Amphenicols	Florfenicol	198
Sulfonamides + Thrimethoprim	Suldadiazine + trimethoprim	0
Fluoroquinolones	Enrofloxacine	0.1
Quinolones	Flumequine Oxolonic acid	3 1076
Combinations of Antibacterials	Procaine penicillin dihydrostreptomyci	0 1278

Source: *K. Grave et al. / Preventive Veterinary Medicine 83 (2008) 156–169*

NB: Enrofloxacine and procaine penicillin + dihydrostreptomycin were prescribed as injectable preparations for brood fish only

Table 3: Drugs approved by the FDA for use in aquaculture (USA)

Drug	Species	Indication	Dosage regimen
Oxytetracycline (Terramycin)	Pacific salmon Salmonids Catfish Lobster	Mark skeletal tissue Ulcer disease, furunculosis bacterial hemorrhagic septicemia Bacterial hemorrhagic septicemia Gaffkemia	250 mg/kg/day for 4 days 2.5 to 3.75 g/100 lb /day 2.5 to 3.75 g/100 lb /day 1 g/ lb medicated feed for 5 days
Sulfadimethoxine, Ormetoprim (Romet-30)	Salmonids Catfish	Furunculosis Enteric septicemia	50 mg/kg/day for 5 days 50 mg/kg/day for 5

			days
Tricanemethane-sulfonate (MS-222, TMS, Finquel	Fish	Sedation / anesthesia	15–330 mg/ l (fish)
Formalin	Salmonids, catfish, largemouth bass,	Protozoa and Tanks and raceways	up to 170 ml/ l up to 1 h at above
Sulfamerazine	Rainbow, brook	Furunculosis	10 g/100 lb /day for up to 14 days

Source: *Z. J. Shao / Advanced Drug Delivery Reviews 50 (2001) 229 –243*

Treatment process: It's all about 4Ks……..

1. Know the water
2. Know the fish
3. Know the chemical
4. Know the disease

Types of Treatments:

- Water Borne
- Oral
- Injection

Do not feed the fish 24 hour prior to treatment (Oral)

Water borne:

Addition of drugs in to water.

- Can cure ectoparasitic as well as systemic diseases.
- Dosage critical.

How the drug does get inside the body of the fish?

Three pathways: Gastro-intestinal pathway, Gills and Skin

- Understand the interaction between the drug and the medium.
- Drug uptake via the GIT dependant on the Osmoregulation pattern.
- Higher dosage of drug is warranted if drug interacts with ions in the water.

- Chemical activity and rate of uptake of drug dependant on pH, temperature, water hardness, light etc.
- Lack of proper studies in this field.
- Study after effects of drug utilisation
- Most common method.
- Easy and non-stressful.
- Dose problems.
- Unstable and formation of toxic by-products.
- Used mainly for surface dwelling pathogens.
- Can also be used for systemic diseases.
- Biological filters.
- Common method when drugs of low therapeutic value are used

Water borne treatments: 2 types

A. High drug concentration- short exposure time
B. Low drug concentration- long exposure time.

Which one will we use if both are feasible?

- Perform bio-assay when drug is used for first time.

Disposal of drugs.

Antibiotic Therapy

Antibiotics are substances that can destroy living matter. They are chemotherapeutics with special properties. Antibiotics selectively inhibit or destroy pathogenic organisms without doing any appreciable harm to the host organism being treated. Generally this constituents a bacterial organism invading the body of a vertebrate animal, i.e. fishes. They may impose either a bacteriostatic (detected by checking microbial growth) or a bactericidal (kills the microbial agent) action on the microbe, depending on their activity or dosage concentration.

Bacteriostatic antibiotic

If the action is bacteriostatic, the supposition is that microbial cell division or reproduction is somehow being interfered with, thus slowing down the disease process so that natural body defenses may keep from being overwhelmed and to give them time to wall off or destroy the invading microbe.

Bactericidal antibiotics

The bactericidal antibiotics go to work chemically on the pathogen itself and actively cause it to be destroyed. The ability of an antibiotic to interfere with the development of life processes of bacteria without seriously damaging vertebrate cells depends upon the interference with or inhibition of metabolic functions essential to the microorganism but not to the host.

The drugs currently available may be broken down into various classes according to the anatomical or biochemical sites on the microorganism at which they exert their primary effect.

List of Banned Antibiotics in India

1. Chloramphenicol
2. Neomycin
3. Nalidixic Acid
4. Sulphamethoxazole
5. Aristolochia spp and preparations thereof
6. Chloroform
7. Chlorprpmazine
8. Colchicine
9. Dapsone
10. Dimetridazole
11. Metronidazole
12. Ronidazole
13. Ipronidazole
14. Other nitroimidazoles
15. Clenbuterol
16. Diethylstilbestrol (DES)
17. Floroquinolones
18. Glycopeptides

19. Nitrofurans including Furazolidone, Nitrofurazone, Furaltadone, Nitrofurantoin, Furylfuramide, Nituratel, Nifursoxime, Nifurprazine and all their derivatives.
20. Sulfonamide (except approved sulfadimethoxine, sulfabromomethazine and sulfaethoxyrphyidazine)

Anesthetic agents

Anesthetic agents are used primarily in fish farms/ hatcheries/ laboratories to provide analgesia and immobilization to the fish prior to transportation/grading or drawing blood for experimentation. Many factors influence the efficacy of an anesthetic agent, i.e. number fish in the bath at a time, fish size and body fat, disease state as well as environmental factors such as pH and temperature. An inverse relationship has been reported between weight fish and recovery times to tricaine methanesulphonate. The anesthetic agent may be classified in to immersion or injectable. The only registered agent in North America is tricaine methanesulfonate and its level of withdrawl time is 5 days in Canada and 21 days in USA. The withdrawal time for Benzocaine is 21 days in Norway and another agent i.e. metromidate an immidazole based nonbarbiturate hypotonic agent is marked for use in non food fish. A newly developed agent AqUI-S has been reported to be stressless to fish and environmentally friendly. In India, clove oil is also used to as an active ingredients. Sodium penta barbital a CNS depressant is the best choice due to its lipophilic characteristics resulting in longer duration of action. Ketamin hydrochloride has also been used in aquaculture as an injectable anesthetic agent.

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FISH HEALTH MANAGEMENT ISSUES IN INLAND OPEN WATERS

B. P. Mohanty, P. K. Parida, A. Mahanty and S. Bhowmick

ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata- 700120

Fisheries and aquaculture are important food production sector, which is providing nutritional security as well as contributing to the agricultural exports. With diverse resources ranging from deep seas to lakes in the mountains and more than 10% of the global biodiversity in terms of fish and shellfish species, the country has shown continuous and sustained increments in fish production since independence. The total fish production is 9.57 million metric ton, out of which 6.13 million metric tons from inland fishery sector. Constituting about 6.3% of the global fish production, the sector contributes to 1.1% of the GDP and 5.15% of the agricultural GDP. The role of the sector in increasing food supply, generating job opportunities, raising nutritional level and earning foreign exchange has been continuously increasing (ICAR - ICLARM, 2004). As per FAO, 2014 fish accounts for more than 50 percent of the total animal protein intake. Fish is also is the most important source of essential fatty acids, and a unique source of micronutrients and plays an important role in providing nutritional and health security to a large mass of people in developing countries like India (Mohanty, 2011). Even though, fish production in India has increased over the years, there still potential of production enhancement from different inland open water resources. However, fish diseases and other fish health issues are the major stumbling blocks in production enhancement and needs to be addressed to sustainably increase fish production.

Inland open water resources

Inland open water comprises of rivers, lakes, flood plain wetlands and reservoirs. The river system in India comprises 14 major rivers (catchments >20,000 km^2), 44 medium rivers (catchments 2,000 to 20,000 km^2) and innumerable small rivers and desert streams (catchments area <2,000 $km^{2)}$, having a total length of 29,000 km. The floodplain lakes are primarily continuum of rivers Ganga and Brahmaputra. These are in the form of oxbow-lakes (Mauns, Chaurs, Jheels, Beels as they are called locally), especially in Assam, Manipur, West Bengal, Bihar and eastern Uttar Pradesh (2.12 lakh ha Reservoirs are constructed on intermittent water courses, which serve the purpose of electricity production, irrigation demand, flood control and also for fish production. Reservoirs are classified as small reservoirs less than 1000 ha, medium reservoir (>1000 ha and < 5000 ha) and large reservoir (>5000 ha). The total reservoir area of the country is around 3.51 Million ha. Inland open water systems occupy an important position in the fisheries sector of India because of their magnitude as well as their production potential.

North-eastern states like Assam possess large amount of open water resources in the form of rivers and wetlands; 4820 Km of water spread area in rivers and around 3 lakh ha of water spread area in reservoirs, beels, derelict water bodies, ponds and tanks which can contribute largely to fish production sector if managed properly. Figure -1 below is depicting the water resources map of Assam and Table 1 is showing the different inland open water resources of Assam.

Table 1: Inland open water resources of Assam

Types of inland water bodies	**Numbers**	**Water Spread Areas**
Rivers		4820 Km.
Registered beels	430	60215 ha.
Un-registered beels	767	40600 ha.
Forest Fisheries	71	5017 ha.
Derelict Water Bodies/Swamp	3887	116444 ha.
Reservoir	2	2553 ha.
Ponds and Tank	367701	60571 ha.
Community Tank	6308	5141 ha

Source: Dept. of Fisheries, Govt. of Assam

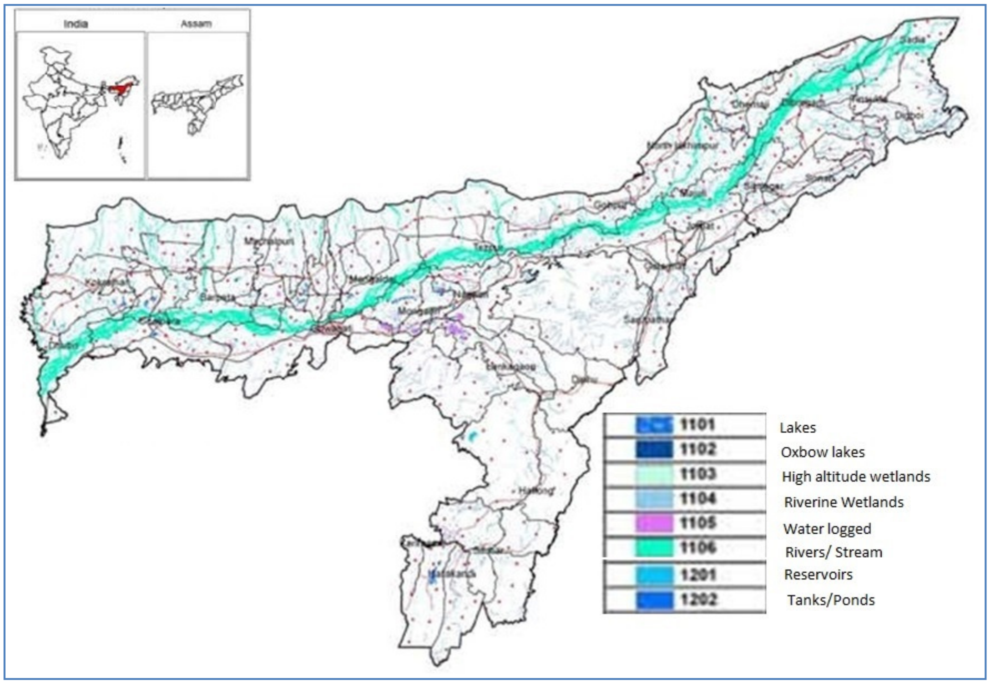


Fig 1. Water resource map of Assam showing lakes, oxbow lakes, rivers, water logged area, ponds. Source: MoEF, Govt. of India

Rich native fish fauna, especially the SIF resources of NE States

Small indigenous fishes (SIFs) are the major constitutes of inland open water bodies. *Amblypharyngodon mola*, *Chanda nama*, *Esomus danrica*, *Gudusia chapra*, *Puntius chola*, *Puntius sophore*, *Osteobrama cotio*, *Parambassis lala*, *Parambassis ranga*, *Xenentodon cancila*, *Ailia coila* etc are few important SIFs found in Assam and north eastern states. These SIFS are playing an important role in nutritional security as they are rich in protein, calcium, vitamins, apart from micro nutrients. Assam is blessed with number of flood plain wetlands (beels), and these water bodies contributing significantly to the total fish production of Assam along with SIFs. The aquatic environment needs to be kept safe in order to get sustainable fish production, so that the fish in our aquatic environment will be healthy and provide healthy nutrition for human life.

Health management issues in inland open waters

As we are moving towards 2nd blue revolution, there is a huge pressure on increasing fish production from these inland open water systems. However, fish health management issues are of great concerns in increasing fish production from the open water systems. Commonly, the fish disease issues in open inland water bodies are over looked for years. There is poor documentation of disease problems occurred in inland open water bodies.

Health of fish depends on health of its environment in which it is living in. Diseases are inherent to aquatic ecosystems and characterized by ''any impairment that interferes with or modifies the performance of normal functions, including responses to environmental factors such as toxicants and climate, nutrition, infectious agents; inherent or congenital defects, or any combination of these factors'' (Wobeser, 1981). There are numerous factors involved in causing fish disease. The causes of diseases can be grouped into those associated with environmental, genetic factors of the host and virulence of the infectious agents (e.g., microbial pathogens). Diseases can directly influence performance, susceptibility to predation, success of reproduction, and other critical factors required for survival and propagation of a species (Kinne, 1984).

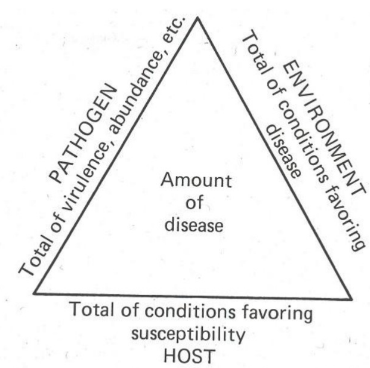


Fig -2: Disease triangle

Three major factors contribute to the development of fish disease: a susceptible host, a virulent pathogen, and a favourable environment (Fig-2). A disease results when these three factors occur *simultaneously* (Figure). Environmental extremes can influence many diseases through increasing stress. This relationship is graphically presented by the use of sets and subsets (Kemeny et al., 1957) as is done in regard to fishes by Snieszko (1973, 1974) and Wedemeyer (1974), and in regard to dental caries by Sherp (1971). It can also be presented in the form of an algebraic equation: $H + P + S^2 = D$, where: H = species and strain of the host, its age, and inherited susceptibility to any particular disease; P = the agent causing the disease with all its variability; S = stress of the environment; and D = the disease which results if the components on the left side of the equation are in proper qualitative and quantitative relationship. In this equation, the square of S is used because importance of the stress for causing a disease (Snieszko, 1978). It is clear from the above equation that environmental condition is very much important for fish health, any change in the environment can affect the health of the fish.

Ecosystem health assessment and fish health management

The environment is perhaps the least bothered element of the host, pathogen, and environment relationship but important for fish health. The aquatic environmental quality can be measured but not limited to dissolved gases, pH, temperature, turbidity and contaminants. Variables related to the geomorphology, limnology, and hydrology of the aquatic environment that are critical to fish health, as they change with time and with human intervention (Rahel, 1997). Significant alterations of habitat due to power generation, flood control, irrigation, logging, grazing, mining, etc. have affected wild fish populations, often in a negative manner. Balancing the costs and benefits of these activities and human dependence on them with the health of our fish populations is the supreme challenge for fisheries managers. However, with industrialization and urbanization a lot of contaminants are polluting inland water bodies and affecting fish health along with economic loss to the poor fishers.

Aquatic pollution with biologically active chemicals and xenobiotics has become an issue of great public health concern. The aquatic environment is continuously loaded with contaminants, either due to direct discharges or due to hydrologic and atmospheric processes. Increasing number and amount of industries, urbanization, agriculture and aquacultural operations are the main sources of pollution. It has been estimated that about 70 % of industrial wastes are dumped untreated into water bodies and up to 90% of wastewater in developing countries flows untreated into rivers, lakes and highly productive coastal zones, threatening health, food security and access to safe drinking and bathing water (UN-Water, 2014).

The contaminants present in the water adversely affect the health of fishes making them prone to diseases, retards their growth and reproduction. For sustainable fish production in open water systems, it is necessary to assess the health of both fish and its environment. However, fish health monitoring in open water ecosystem is quite challenging as there in joint toxicity and the impact could be a synergistic effect of many pollutants. In open water systems, natural and anthropogenic contaminants leading to environmental pollution include heavy metals, pesticides, insecticides, bacteria, organic pollutants, industrial wastes and affect both fish as well as environmental health. These contaminants not only affect the fish health but also transported through the food chain and also affect human health.

Common contaminants found in open water systems

Inland open water systems like rivers, flow through very large distances and carry large amount of contaminants with them. Similarly, wetlands act as sinks of such contaminants. Chlorine, Arsenic, Mercury, Cadmium, Lead, Phenols and Polychlorinated biphenyls (PCBs), pesticides and oil and refinery products are major contaminants in the open water sources and can causes mass mortality of fish in inland open water. The fishes contaminated with xenobiotics can also affect human health on consumption. Apart from these contaminants, untreated domestic sewage is also major culprit to pollute the open water bodies.

Fish health management issues in cage farming

The inland open water fish production has largely been shifted from capture based fisheries to culture based fisheries over the years and are carried out mainly in cages. The cage culture practices have been drastically increased during the last two decades because of low initial investment, simplified culture and harvesting practices and flexibility in using resources many economic advantages. However, in spite of having many advances, like any other animal production system, diseases are one of the major concerns in sustainable production and growth of this sector. The high fish densities, along with the high feeding rates, often reduce dissolved oxygen and increase ammonia concentration in and around the cage, especially if there is no water movement through the cage creates stress in fish and makes them more susceptible to diseases (Karnatak and Kumar 2014). Wild fish around the cage can transmit diseases to the caged fish. The crowding in cages promotes stress and allows disease organisms to spread rapidly (Karnatak and Kumar 2014). Increasing intensification and lack of adequate health management measures result in frequent occurrence of diseases. As in other aquaculture systems, environmental factors such as temperature, dissolved oxygen, suspended particulate matters etc. are critical and any adverse changes in these parameters would make the fish susceptible to diseases. Similarly, crowding, handling stress and feed management also play a crucial role in disease occurrences. Unlike closed systems, the risk of pathogen incursion through cohabiting animals and pathogen-contaminated water is more in open cage farming (Vijayan et al. 2015).

Fish health issues in wetlands

Wetlands are one of the most productive ecosystems and support livelihood of thousands of people through fishing. The wetlands associated with floodplains of rivers cover an estimated area of 3.54 lakh ha and are a common feature of the Indian landscape, especially along the Ganga and Brahmaputra river systems and form a major inland fisheries resource in the country (TNAU Agritech portal). Wetlands are directly or indirectly linked with the rivers and the wetlands act as sink to large amount contaminants brought through the river water which makes the fishes highly susceptible to pathogens. Among parasitic disease infection of Argulus and Mixobolus is predominant and among bacterial diseases, infection of *Aeromonas* (causes dropsy) and *Pseudomonas* (causes fin rot and tail rot) are major diseases. The water of wetlands needs to be kept safe from contaminants as domestic waste and agricultural waste water are ultimately reaching wetlands, will affect the health of wetlands and to fish. The wetland environment should be free from contaminants and desired water quality is required for sustainable harvesting of fish from these wetlands.

Biomonitoring tools for ecosystem health and fish health assessment

Fish health monitoring in open water ecosystem is quite challenging as there in joint toxicity and the impact could be a synergistic effect of many pollutants. In open water systems, natural and anthropogenic contaminants leading to environmental pollution include heavy metals, pesticides, insecticides, bacteria, organic pollutants, industrial wastes and affect both fish as well as environmental health. The field of environmental genomics has enormous potential to understand how genes and genetic changes interact with environment stimuli. Stress proteins (Heat shock proteins, hsps) are highly conserved proteins represent a defense reaction of cells in response to several environmental factors such as heat, hypoxia, chemical exposure, infections etc and some of them act as molecular chaperones assisting in the refolding of proteins that are damaged during stress condition. Pollution of river Ganga has been a principal environmental concern. River Ganga represents the main freshwater resource for the India, meeting demands of 37% of India's population residing in its basins. It drains water in a vast range of land area and 47% of the total irrigated area in the country is located in the Ganga basin alone (Sharma 1997). However, Ganga has become highly polluted and it is mostly polluted by domestic wastes, industrial pollutants, heavy metals, pesticides, oil spills and other sources. Pollution of river Ganga has attracted both international and national attention and rejuvenating programme has been taken by Govt. of India for abatement and pollution management in river Ganga.

Pollution management in large river system like Ganga primarily requires periodic monitoring and quantitative assessment of pollutants in different stretches. Environmental quality is often assessed in terms of physical and chemical parameters only (Bere, 2013). However, there is growing concern that only chemical data of pollutants in environmental matrices is not sufficient to predict how it can affect the biotic components. This is because; simultaneously there can be numerous contaminants present in a particular ecosystem and their mutual interactions can lead to changes in their chemical characteristics which can lead to changes in bioavailability and toxicity (Schettino et al., 2012). Therefore, the need to detect the effects of contaminants at low concentration in complex environment on several molecular and cellular processes in aquatic animals has increased.

To develop biomonitoring tools for pollution monitoring in large open water ecosystems like river Ganga, we studied the gene expression profiles of a battery of *hsps,* viz. *hsp27*, *hsp47*, *hsp60*, *hsp70*, *hsc70*, *hsp90* in liver and gill tissues of riverine catfish *Rita rita,* collected from different stretches of river Ganga viz. Kanpur, Allahabad, Varanasi, Farakka (reference site), Serampore, Howrah. The *hsps, hsp47, hsp70, hsc70, hsp90* were found to be up-regulated while *hsp27* was down-regulated in all the stretches studied.*Hsp70* and *hsp47* expressions were highly up-regulated in samples from Kanpur and Howrah stretch. The findings suggested that *hsp70* and *hsp47* could be potential biomarkers (or biomonitoring tools) for fish health monitoring in open water ecosystems.

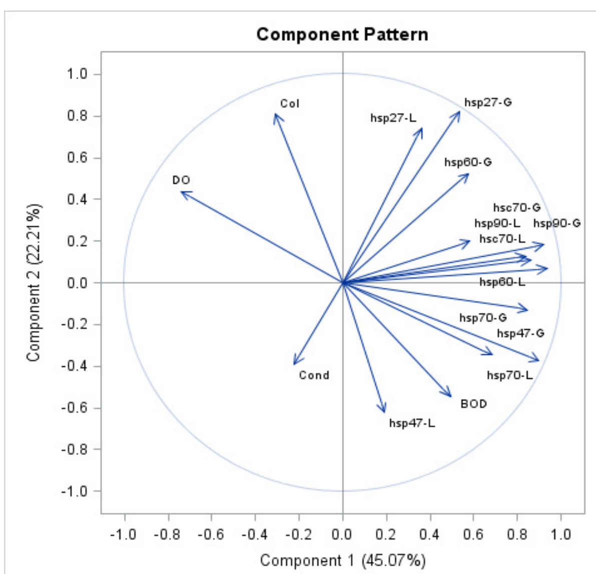


Fig. 3. Principal Component Analysis (PCA) of measured variables, including, heat shock protein genes expression (*hsp27, hsp47, hsp60, hsp70, hsc70, hsp90*) and water quality parameter. It showed the relation between *hsp* gene expression and water quality parameters. PCA analysis showed that that *hsp70* and *hsp47* could be potential biomarkers (or biomonitoring tools) for fish health monitoring in open water ecosystems.

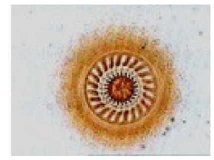
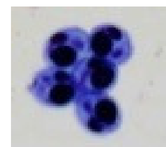
Fish health management and disease containment for achieving second blue revolution

As we are moving towards achieving second blue revolution, it is necessary to have proper fish health management systems for sustainable growth and production in the fisheries sector. Periodic monitoring of the aquatic ecosystem and fish health would be helpful in disease management in fishes. Healthy aquatic environment will help in healthier fish and higher fish production whereas polluted water will provided unhealthy fish and have significant negative impact on human health.

Fish diseases often occur depending upon the climatic conditions and the aquatic environment as such changes favour the growth of different pathogenic organisms and put stress on fish; the stressed fishes are more vulnerable to pathogen attack. As prevention is better than cure, fishers and all stakeholders have to be careful about the fish diseases before their occurrence. In this context, based on our experience and farmers' observations and ITK, a fish disease calendar (Table 2) has been prepared which enlists various diseases occurring in different seasons/months of the year; this could be useful to the fishers, aqua farmers and entrepreneurs to take precautionary, preventive measures to safeguard against disease outbreaks.

Table 2: Fish Disease Calendar

Seasons/Months	Symptoms	Name of disease
Winter (Nov -Jan)	Costia causes dullness of skin & gills. Infected fish become restless, secrete excessive mucus & shows comparatively big head.	Costiasis
Summer and winter (Apr - May, Nov	White spot on the skin, gills, fins, and cornea of the infected fish. The animal becomes restless and gasping air at the water surface.	Ichthyophthiriasis

- Jan)	Infected fish reacts by rubbing their body against pond bottom and side.	
Monsoon and winter (Jun -Sep, Nov - Jan)	Fish becomes restless, lethargic, loss body weight and body colour becomes dull with excessive mucus secretion.	Trichodiniasis 
Monsoon and winter (Jun -Sep, Nov - Jan)	Scale and body surface are covered with white cysts, affected fish become lethargic.	White scale spot disease 
Winter and summer (Apr - May, Nov –Jan)	Gills and other internal organs are covered with white cysts, affected fish become lethargic.	White gill spot disease
Summer and winter (Apr -May, Nov -Jan	Fish shows erratic swimming, appearance of local lesions, pale gill colour, excessive mucus secretion, falling of scales, rubbing of body against any submerged objects.	Dactylogyrosis 
Summer and winter (Apr -May, Nov – Jan)	The skin of fish becomes spotted dark and covered with bluish gray mucus layer. In case of gill infection the fish swim listlessly below the water surface or they gather on the side, slowly suffocates, gills are spotted and filled with blood.	Gyrodactylosis
Summer (Mar - May)	Numerous small black nodules or cysts are found all over the body	Black spot disease (Digenea)
Winter (Nov - Feb)	Fish shows yellowish white granules on lip, skin and fins. Adult worm are detected in the intestine or the body cavity of diseased fish.	Nematods & Acanthocephalosis
Winter (Nov - Feb)	Mechanical damage to gill lamina, gill colour faded, can be seen through	Ergasilosis

	microscope under low magnification.	
Winter (Nov - Feb)	Hook like attachment on the nostril/ head regions, fish become restless and rub against any hard substrate found in the pond due to irritation.	Lernaeosis
Round the year	Fish shows- erratic swimming behaviour & reluctant to accept feed. Parasite is visible with naked eye and ulceration is seen at the attachment site	Argulosis (Carp lice) 
Winter (Nov – Feb)	On the skin local erosion surrounded by inflammated reddish zone which gradually turns into a large deep ulcer. In acute cases protruding eyes and accumulation body fluids in the body cavity is seen.	Furanculosis
Winter (Nov - Feb)	Lesions occur in the skin of the head region and back as well as gills.	Columnaris
Summer (Mar - May)	Erosion and disintegration of fin and tails, as the lesion develops the outer fin margin becomes frayed and disintegration of soft tissues between fin rays starts.	Tail and fin rot
Winter (Nov - Feb)	Fish shows pale swelling gill with excessive secretion of mucus, sluggish movement, sign of asphyxiation and surfacing.	Bacterial gill disease
Winter and post monsoon (Nov- Jan, Sep - Oct)	Fish shows small pimple like reddish areas on the body surface and letter develop into ulcers.	Ulcer disease
Winter (Nov - Feb)	Fish kidney shows grayish- white necrotic zones filled with purulent material.	Bacterial kidney disease

Winter (Nov - Feb)	Fish shows whitish fungal mesh which looks like cotton wools appears in the infected parts of fish body. Sometimes lesions appear as gray white patches on various parts of the body like- skin, fins, eyes, mouth.	Saprolegniasis (Cotton wool disease)
Winter (Nov - Feb)	Fish congregate near the inlet of water & refuse to take feed. Infected fish gill becomes grayish white and finally drop off.	Branchiomycosis

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COMMON FISH DISEASES IN ASSAM

B. Kalita

College of Fisheries, AAU, Raha, Nagaon, Assam- 782103

Assam has heterogeneous ecological system in terms of rivers and tributaries, ponds and tanks, beels, low lying areas and reservoirs. The environment of these systems has its own variation in respect of biodiversity as well as biotic and abiotic component of ecosystem. The Indian major carps remain in the mainstay in poly and composite fish culture systems. However, recent introduction of pangus and paccu in composite fish culture may bring the risks of introduction of some new exotic fish pathogens in the culture system. Assam being situated in sub-tropical region, enjoying humid tropical climate is expected to have wide number of parasites in the freshwater. Intensification of fish culture, failure to maintain optimal water quality parameters, environmental degradation due to anthropogenic activities and climatic change has led to a number of fish disease outbreaks in fish culture system of Assam. Therefore, it is essential to know the pathogens responsible for causing various types of fish diseases so that specific management practice can be administered to protect the fish stock. This reports provide a brief account of the common fish diseases that have been recorded in fish culture activities during investigations under a surveillance programme.

Parasitic diseases

Parasitic fish disease constitutes one of the serious problems in the fisheries sector. Environmental stress due to sub optimal water quality or due to lack in accurate culture practices which makes the fish more susceptible to parasitic infection. Proper management or optimal environmental manipulation can reduce the risk of parasitic epizootics in farmed fish. A total of certain numbers of parasites have been identified from different species of fish from different aquatic systems. In general, the symptoms of parasitic diseases in fishes includes- erratic movement of fish, stops feeding, loss of weight, erosion of scales, erosion at attachment sites, deformation of gill filaments, reddening of fins, bulging of eyes, opaque white gills, clogging of gills, over mucated body, surfacing of fish and rubbing the body surface on rough objects near or at the bottom of the pond. The most common fish parasites that have been recorded are describe in brief underneath.

The Myxozoan parasite, ***Myxobolus mrigalae*** has been found infecting the fingerlings of *Cirrhinus mrigala* in rearing ponds, however, the fingerlings of other two species of catla and rohu were not affected. The clear globular white cysts were superficially located on the body surface and scales. Affected fishes become very lethargic. Microscopic observation of cysts reveals the presence of two polar capsules and host specificity confirms the species, *Myxobolus mrigalae*. However, the incidence was not severe in terms of mortality.

Another important ciliate parasitic disease is the white spot disease ('*Ich*'. disease) caused by ***Ichthyophthirius multifiliis*** which frequently affect the ornamental fish. The occurrence takes place during the winter season and mostly affecting the black shark (*Morulius chrysophekadion*), white shark and black molly *(Poecilia sphenops)*. *Ichthyophthirius multifiliis* appears to have been spread as a result of transportation of ornamental fish from different parts of the country. The probability exists in the introduction of the parasite through ornamental fishes that been transported from other parts of the country to Assam. The infectivity of the parasite increases during the winter months.

The most important crustacean parasites, ***Argulus foliaceus*** and ***Larnea cyprinacia*** have also been identified. The incidence of *Argulos*is causing heavy economic losses in the production of cultured fish by reducing the growth rate and sometimes causing mortality. High infestation also has been recorded in aquarium fishes particularly in gold fish, *Carassius auratus*. It is observed that among all the cultured carp species rohu (*Labeo rohita*) shows highest incidence of *Argulus foliaceus* followed by other species in the culture ponds. Probable risk factors associated with the infestation are high organic load, stocking of infected seeds and rising water temperature in summer months, while the incidence of anchor worm, *Lernae cyprinacea* has been recorded only in gold fish reared in ornamental fish unit. Moreover, it has also been observed that in short time most of the gold fishes suffered from this parasitic attack resulting in mortality due to punctuate haemorrhages, lesions and physical destruction of the fish tissues. However, the incidence of *Lernea* infection is very rare in Assam and not recorded in culture fisheries.

The monogenean trematodes, ***Gyrodactylus* spp**. and ***Dactylogyrus* spp.** commonly known as skin and gill flukes, respectively. They appear like microscopic worms up to 2 mm in length attached to the surface of fish by a posterior hook attachment organ. *Gyrodactylus* has 16 while *Dactylogyrus* has 14 marginal hooks which has a taxonomic importance. Mostly fry and fingerlings of Indian major carps are infected in nursery and rearing ponds. Colour of infected fish begins to fades and in heavy infection develop bluish film on the body of the fish in case of *Gyrodactylus,* while, in case of *Dactylogyrus* colour of the gills of the infected fish fades and interference with the gill function and respiratory activities.

The digenetic parasite, ***Clisnostomum* sp**. was also recorded from *Colisa fasciata* in an unmanaged culture pond nearby margin of a beel. The whole body cavity of infected fish filled in with numbers of the parasite with bulged stomach was the most distinctive features. Interesting to note that infestation of the parasite was very specific to the host, *Colisa fasciata* as the other fish species were not infected in the same pond. The occurrence of the parasite was recorded in the winter months.

The another important digenetic parasite, ***Isoparorchis hypselobagri***, a metacercarial larvae was recorded from the bottom dwelling fishes, *Mastacembalus armatus, Notopterus notopterus* and *Wallago attu* in a small tributary. The parasiticcysts causes extensive damage in muscle tissue and body cavity in *M. armatus* and *N. notopterus* and *W. attu*. Highest infestation occurs during winter months when water temperature declines. Moreover, some of the Cestodes spp and Nematodes spp. have been recorded from different fish species during the investigation and are under process of identification under the NSPAAD (National Surveillance Programme for Aquatic Animal Disease) project, College of Fisheries, Raha.

Bacterial diseases

The majority of bacteria causing diseases in fish are saprophytic in nature. Several fish pathogens may be found on the surface or in the gut of the fish but only causes clinical disease when the fish is under stress. The stress factors may be chemical, biological, physical and procedural. Generally, overcrowding, temperature changes, handling, grading and predators attack are some of the stressful conditions that can result in outbreak of bacterial disease. A large number of pathogenic bacteria are gram negative and only small number of gram positive bacteria, which are able to cause significant disease in some fish. Some of the common bacterial disease that has been identified are described below.

Infectious abdominal dropsy (dropsy): This disease has been observed frequently in cultured and aquarium fishes. The abdomen of the fish gets distended and mild ulceration occurs due to secondary infection. If the condition continues for long time the scales falls off leading to ulcer formation. The causative agent is *Aeromonas hydrophila*, which is an opportunistic pathogen and ubiquitous in aquatic environment particularly in water with high organic load.

Fin and tail-rot disease: The incidence of fin or tail-rot disease in fish, a contagious infection, is also very common which is caused by pathogenic strains of *Aeromonas* spp and *Pseudomonas* spp., where fin and tails become greyish or whitish frayed and disintegration of soft tissues making the fish more imbalance. The appearance of the disease is seemed to be favoured by the ecological factors of the culture system.

Eye disease of catla: It is caused by a variant of the bacterium *Aeromonas liquefaciens*, where the eyes look reddish due to vascularisation and become opaque. The eye balls gets putrefied leading to death of the fish as the fish cannot trace out the feed.

Bacterial Haemorrhagic Septicaemia (BHS): BHS is caused by pathogenic strains of *Aeromonas* spp. (*A. hydrophila, A. sobria, A. caviae*) in cultured and freshwater fishes. This is probably the most common bacterial disease of freshwater fish. Outbreaks are associated with rising water temperature, crowding, handling or transfer, low oxygen levels and poor nutritional status of the fish. The stress related condition can lead to a rapid risk in mortality in suspected fish. Clinical signs range from sudden death with high morbidity in acute case. Skin lesion includes various sized areas of haemorrhage, necrosis at the base of the fins. These lesions may progress to reddish grey ulceration with necrosis of the underlying musculature. Fish may appear sluggish and dark in colour with tail-rot.

Ulcer disease: It is an economically important bacterial disease in freshwater culture system. The disease initially appears as a small pimple like reddish areas on the body surface. The fin may also be attacked, in this case the symptoms of the disease is unlike that of fin and tail-rot with destruction of the soft inter ray tissue and fraying of the fin rays. The mouth and jaws erodes away. Species of *Aeromonas* and *Pseudomonas* spp. are associated with the disease condition.

Fungal diseases

Only small number of fungal species is pathogenic to fish. Majority of fungi are facultative parasites and attack the host when injured or secondary to other infection, while only *Aphanomyces invadans* is obligate and may cause severe mortality.

The most common fungal disease, ***Saprolegnia parasitica*** affects all types of fish species, usually acting as secondary invader in presence of their diseased conditions. Predisposing factors include high organic load in water, presence of large biomass of fish and dead or decaying fish or eggs in which fungus thrives and increasing the fungal load in water. *Saprolegnia* infection is usually worse at lower temperature and sexually matured fish appears to be more susceptible to skin infection. It is also common infection in egg incubation in hatcheries and occurs after handing or grading of fish. This infection is characterised by the presence of cotton wool like growth on fish or eggs. The woolly growth may be white or colour may vary depending on the colour particle that are trapped in it.

Epizootic ulcerative syndrome (EUS), is a serious disease of freshwater affecting wild and cultured fishes. The disease kills the affected fishes in a short time affecting a wide range of hosts. Usually it occurs during the colder months of the year or with decreasing temperature following the post monsoon period. The causative agent is *Aphanomyces invadans*. Clinically the disease commences with the presence of inflammatory blood blotches on the body surface that gradually become ulcerated. Histologically the changes become obvious with mycotic granuloma formation with cellular infiltration. Investigation reveals that the disease infestation is highest in *cirrhinus mrigala*, followed by *Cirrhinus reba, Catla catla, Labeo rohita and Hypophthalmicthys molitrix.* Moreover, it has been observed that rate of infestation is more in Indian major carps than exotic carps; particularly in those feeding at bottom strata of ponds. So, it is apparent that susceptibility of bottom dweller to EUS infestation in carp culture system requires more careful observations to exercise preventive measures and curative effects.The remedial measures both prophylactic and therapeutic so far tried for either controlling or containing EUS are applicable only in closed water bodies but not in large open waterbodies. The chemicals used for controlling in manageable water bodies are liming, $KMnO_4$, NaCl and bleaching powder and antibiotics. It has been reported that lime treatment has given encouraging results in checking the intensity and spread of the disease. A drug, CIFAX, formulated by CIFA is also showing encouraging results in controlling EUS in the region.

Nutritional diseases

While culturing fish in captivity, nothing is more important than sound nutrition and adequate feeding. Faulty nutrition impairs fish productivity and affects their health; a fact that fish nutritionist should keep in mind. Nutritionally balanced and quality controlled diets are of critical concern in fish production. Most deficiency diseases are complex, resulting from multiple deficiencies. The clinical situation is not rendered any easier by the general lack of specific clinical signs associated with such conditions. The most frequent description of nutritional origin is in appetence, darkening of skin, lethargy and poor growth.

Protein deficiency: Deficient in essential amino acid cause appetite depression and poor growth regardless of the type of amino acid in fishes.Tryptophan deficiency causes growth suppression, skeletal deformities and exophthalmia. Dietary methionine deficiency leads to reduced growth rate with the development of bilateral cataracts. Fatty liver is caused by feeding with poor quality protein diet with an imbalance in the amino acid profile. A feed with proper amino acid profile is the only treatment.

Carbohydrates deficiency: Carbohydrate deficiency in fish leads to lethargy, darkening of colour and poor appetite. Excessive dietary carbohydrate levels can result in hepatocyte degeneration and excessive glycogen deposition. Excess soluble carbohydrates cause hyperglycemia, build-up of liver glycogen and enlargement of the liver. Eliminating the excess starch from the diets can prevent the disease.

Lipids deficiency: Lipid deficiency in fish leads to poor food efficiency.Deficiency signs are elevated muscle water content, susceptibility to caudal fin erosion, shock syndrome, decreased haemoglobin, blood cell volume, swollen pale fatty liver, degeneration of gill epithelium. Eicosapentanoic acid (EPA) and Docosahexanoic acid (DHA) deficiency in broodstock leads to poor egg quality, hatchability and poor survival of larvae.

Vitamins deficiency: Vitamins are only required in small amounts but requirements may increase during growth and spawning. Absence of a particular vitamin leads to serious metabolic disorders, which are listed below:

Fat soluble vitamins:

Vitamin A: Essential for normal vision, embryonic development, maintenance of mucous membrane,bone development & corticosterone synthesis. Deficiency results in poor growth, keratomalacia, blindness, exophthalmia and haemorrhages at the base of the fins.

Vitamin D: Group of thermostable steroids responsible for calcium metabolism. Hypervitaminosis results in hypercalcaemia and increased haematocrit**.**

Vitamin K: Its primary function is as a component of blood clotting mechanism, but it is also bacteriostatic and has coenzyme properties. Deficiency leads to prolonged blood clotting time, anaemia and haemorrhages into muscles.

Vitamin E: Deficiency relates to anemia, muscular dystrophy, steatosis and associated with swim bladder, digestive and cardiac muscle pathology.

Water soluble vitamins

Some of the important water soluble vitamins and minerals with deficiency syndrome is listed in the Table 1 and Table 2 respectively:

Table 1

Vitamins	**Deficiency Syndrome**
Vitamin B_1 (Thiamine)	Disturbs CHO metabolism, nervousdisorders, poor growth, poor appetite
B2-Riboflavin	Poor appetite, corneal vascularisation, eyehaemorrhage, skin atrophy and anaemia.
B5-Pantothenic acid	Necrosis,cellularatrophy,sluggishness and poor growth
B6-Pyridoxin	Nervous disorders, oedema of peritoneal cavity, rapid and gasping breathing.
B9-Folic acid	Poor growth, lethargy, anorexia, darkcolouration
B12 Cyanocobalamine	Low haemoglobin, fragmentation of erythrocytes, poor FCR
Ascorbic acid	Scoliosis, Lordosis, impaired collagen formation, eye lesions.

Table 2

Minerals	**Deficiency**
Zinc	Reduced serum alkaline phosphate activity, reduced bone and serum zinc, poor growth high mortality, skin and fin erosion.
Calcium and Phosphorous(excess)	Reduced bone ash, poor growth, skeletal abnormalities and low feed efficiency
Iodine	Goitre in various fish species
Iron	Reduced haematocrit, cause anemia
Copper	Reduce serum copper, cytochrome C oxidase activity and hepatic SOD activity, poor growth
Manganese	Reduced haematocrit and haemoglobin, skeletal abnormalities, high mortality, low manganese in bone

Data are summarized from Halver (1980), Lovel (1989a) and Wilson(1991).

Environmental Diseases

There are various environmental adverse conditions which are termed as environmental diseases of which few have been described in brief:

Thermal stress: Fish can tolerate some changes in ambient temperature to certain extent. But sudden extreme changes in temperature may cause even death to the fish. The tolerance of temperature changes may vary from species to species. The tolerance capacity of fish depends not only on the environment in which they live but also on the rapidity of the changes. Two types of thermal stress are observed.

a. **Heat shock**, which is cause by sudden rise of temperature beyond the tolerable limit of the fish.
b. **Cold shock**, which is cause by sudden lowering of temperature.

Thermal stress may cause non acceptance of food, poor utilization of feed, restlessness and growth impairment.

Oxygen Depletion: Depletion of oxygen in water body puts the fish under stress and results in mass mortality. The general factors responsible for oxygen depletion are abundant plankton growth, high organic load, high stocking density of fish, low water level in the pond and temperature rise. Solubility of oxygen in water is inversely proportional to both temperature and salinity. The deficiency symptoms are that fishes starts gulping on the surface of the water and death occurs with open mouth.

Ammonia Toxicity: Ammonia is the primary nitrogenous metabolic waste product of fish, but is also formed by the decay of organic matter. It may be present in inflowing water, especially where agricultural runoff is encountered. Ponds with high stocking densities of fish which are fed with supplemental feeds, the ammonia content may increase up to undesirable levels. Un-ionised ammonia is highly toxic form will primarily cause gill epithelial damage with consequent hyperplasia and reduced ability to take up oxygen and causing mass mortality.

Acidosis: Acidosis occurs when pH goes much below the neutral value. It is generally brought by the environmental pollution. An increase in the CO_2 in the air is also associated with it. The symptoms of acidosis are dyspnea, swims indolently, skin and gills are coated with coagulated mucus and suffocative struggle and death.

Alkalosis: Increase in pH above the neutral value may cause alkalosis. This condition of water normally brought about by alkali pollution in water or when fish is subjected to newly construct concrete tanks.

Algal toxicosis: Bloom forming algae such as *Microcystis, Euglena* etc may cause severe damage and mortality in fish. The effects of algal bloom are cut off the light penetration and reduced the productivity of water and secrets toxin after death and may results oxygen depletion.

Gas bubble disease: This disease is observed in various fishes especially in their early stages. Gas bubble appear in the blood vessel are easily seen from outside in young stages.

Gas bubble appears on the surface of the body and near the eye also. The most striking effect of gas bubble disease is that fish keep moving restlessly on the surface of the water. Death of fish occurs when numerous gas bubbles blocked the blood vessel. The super saturation of oxygen and nitrogen in water leads to the occurrence of the disease.

Prevention and control measures

To prevent and control fish diseases it is necessary to maintain a good culture environment and prevent deterioration of water qualities. Use hygienic and nutritious feed to boost resistance of the fish stock and avoid the sources which may introduce pathogens to the culture system. Others measures include better management practices,drying of pond and removal of silt in every year or after interval, removal or prevention of entry of molluscs, weed fishes and preventing birds falling.

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FISH HEALTH MANAGEMENT: KEY FOR ENSURING SUCCESS OF AQUACULTURE VENTURES

P. Das[1], B. K. Bhattacharjya[1], S. Sahoo Das[1], A. B. Gohain[1] and B. K. Behera[2]

[1]ICAR-CIFRI Regional Centre, HOUSEFED Complex, Guwahati-781006
[2]ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata-700120

Fish health management has become an integral component of aquaculture operations for preventing outbreak of fish diseases that may occur due to environmental deterioration, improper feeding, overcrowding, etc. Sound status and normal functioning of all bodily organs denote healthy condition while any deviation from the normal functioning of one or of several organs due to adverse factor(s) is termed as diseased condition. For normal functioning, every individual requires a set of parameters within the physiologically acceptable limit for the species cultured. Any deterioration in these parameters from the normal range either singly or cumulatively puts stress or predisposes the organism health, disease or even cause mortality. In the aquatic ecosystem, the host (fish), the pathogen and the environment are in balanced state. Disease develops when there is an imbalance in these components (Fig. 1) caused by any stressors. Therefore, disease occurs if the balance between various stress producing factors e.g., adverse genotypic and physiological properties of fish, malnutrition, adverse ecological parameters and action of pathogens and parasites as well as susceptible fish is lost shifting the balance adversely towards the susceptible fish.

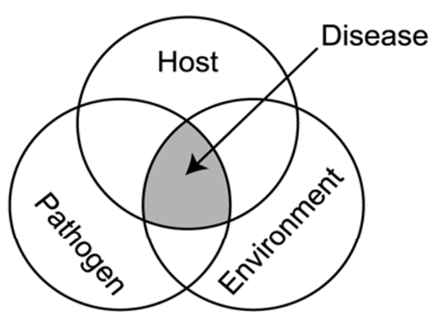

Fig 1. Occurrence of fish disease in an environment

Important factors contributing to fish diseases

- ✓ Rapid change in temperature.
- ✓ Rapid change in water and soil pH.
- ✓ High load of suspended solid.
- ✓ High stocking density.
- ✓ Insufficient dissolved oxygen
- ✓ High concentration of anoxic gases like hydrogen sulfide, ammonia, etc.
- ✓ Poor nutrition.
- ✓ Poor handling.
- ✓ Others.

Different types of fish disease

In a pond ecosystem system, different types of disease may occur which can be broadly categorized into following categories.

1. Bacterial diseases
2. Viral diseases
3. Fungal diseases
4. Parasitic diseases
5. Nutritional diseases
6. Environmental diseases

Principles of fish disease control

Even though many developments have taken place occurred in the area of fish health management the age-old principles of "prevention is better than cure" still holds goods. Prevention of disease is not simply a matter of trying to use modern amenities to halt disease. Prevention of disease starts with the sound management of the living aquatic organisms and their environment. By maintaining the health of the environment, one can prevent the occurrence of fish diseases to a greater extent. Different prophylaxis measures as well as chemical applications to control fish diseases in aquaculture system are briefly discussed in the following.

Prophylaxis treatment of disease

Disease prevention can be achieved by (1) proper sanitation of the environment establishments and appliances, (2) chemo-prophylaxis, (3) vaccination and (4) manipulation of the environment. The culture system should be properly prepared so as to create a pathogen-free and hygienic congenial environment for the species stocked. Management measures like clearance of aquatic macrophytes/ unwanted organisms, de-siltation, liming, etc. are helpful in maintaining the ecosystem healthy and productive. Careful selection of quality stocking material having better resistance towards disease and faster growth rate helps a fish farmer in achieving optimal fish production. Before planting a fish species to a new environment they should undergo quarantine checks so as to eliminate any undesirable traits or any associated disease agents. Diseased fish which carry virulent pathogens and are unmanageable should be destroyed to prevent the spread of fish disease.

Different methods of chemical treatment

Treatment may be applied in many ways and the particular type of treatment to be applied is be decided as per the specific situations encountered. There are three way of applying chemical treatment *viz*., (1) adding chemical to the water, (2) adding chemical to feed and (3) administering chemicals directly to individual fish. Different types of chemical treatments are:

1. **Dip:** Fish are placed in a hand net and dipped into a solution of the drug of required concentration for one to three minutes or less.
2. **Flush:** Here concentrated solution of the drug or chemical is added to the water inlet and allowed to pass through the tank or the raceway with water inflow.
3. **Short bath:** Here the specified amount of chemical or drug is added directly to the rearing or holding unit and left for a specified period of time.
4. **Indefinite bath:** This is most widely used in ponds where a low concentration of a chemical or drug is applied and is allowed to dissipate naturally.
5. **Feeding:** Treatment through feed aims at reaching the chemical to the body of the sick fish through its stomach at proper dosage.

6. **Injection:** Large and valuable fish may be treated by injecting the medicine in to the body at specified dosages.
7. **Topical application:** Sometimes valuable fish may be treated by direct topical application of the drug in affected areas/ parts.

Planning of effective treatment depends on several factors such as:

- Correct diagnosis of the disease.
- The prognosis of the disease.
- Economics of the treatment operation
- Knowledge about the disease causing organisms
- Tolerance of the fish to the given drug or chemical.
- Water quality of the environment.
- Type of the fish (e.g., species size, age, physiological condition, etc.).
- Properties of the drug or chemical
- Alternative course of action.

Common bacterial disease

Some of the important bacterial pathogens which cause diseases in fishes are *Aeromonas hydrophila*, *A. salmonicida*, *Pseudomonas fluorescens, Flexibacter columnaries, Edwardsiella tarda, Vibrio alginolyticus, V. parahaemolyticus,* etc.

Aeromoniasis

Aeromonas hydrophila and *A. salmonicida* have been described as primary and secondary pathogens of fishes throughout the world causing varieties of diseases. The diseases occur as an acute, subacute or chronic form in fishes. Haemorrhagic septicaemia or red mouth disease, dropsy, ulcerative disease or pop-eye disease are caused by *Aeromonas* spp. External signs of the disease are varied and include erythema (redness) at the base of the fins, in and around the mouth, skin within the opercula and around the anus. The organisms are capable of producing severe skin ulcerations. Internal signs are characterized by severe congestion and/or petechial haemorrhages in the peritoneum and most of the visceral organs. Slicing through the muscle may show pinpoint haemorrhages. Fish can be protected from *Aeromonas* infection by reducing physical stress, correcting nutritional deficiencies and avoiding injuries. Fish or fish eggs should not be transported from infected geographical areas to non-infected areas. Treatments with Oxytetracycline with 50-70 mg/kg body weight given in feed for 10 days or Sulfamerazine @ 200 mg/kg body weight for 7 days in the feed are suggested to treat the disease. External disinfectants may be used once a week in the water to reduce the population of bacteria.

Edwardsiellosis

The causative organism for this malady is *Edwardsiella tarda,* which produces extreme emaciation, anaemia, loss of skin, peeling off and dropping of skin and gas filled foul smelling abscesses. The disease is termed as "Emphysematous putrefactive disease", aptly describing the gross appearance of infected fish. The organism isa serious pathogen in the hatchery. Contaminated water is the main source of its infection. Gross-changes in the spawn are characterized by deformities in the body and opacity. The spawn become lethargic and show abnormal swimming behaviour. Although the disease can be controlled by antimicrobial compounds, water quality improvement is the single most important factor which can prevent the disease. Iodine preparation in diluted form can cure the disease if applied for 3-4 days.

Bacteria Gill Disease

Bacteria gill disease is attributed to a combination of unfavourable environment condition with infection of gills of myxobacteria. Besides this a large number of gram negative bacteria have been reported in gill diseases. The disease is characterized by proliferation of gill epithelium and in extreme cases fusion and necrosis of the gill filaments occur. The affected fish show sluggish movement and signs of asphyxiation and surfacing. Poor environmental condition and over-crowding are the main triggering factors. Bath in dimethyl-benzyl-ammonium chloride @ 2 ppm or ethyl mercuric phosphate for 1 hour has been used successfully to control the disease.

Haemorrhagic Septicaemia

The aetiology of haemorrhagic septicaemia is under dispute. The disease is clinically indistinguishable from *Aeromonas* infection, although *Pseudomonas fluoroscens* has often been isolated from diseased fish showing septicaemia lesions. The disease is manifested either in acute or chronic form. Large haemorrhagic skin lesions are common signs followed by heavy mortalities. In acute cases severe congestion and haemorrhages are noticed in the visceral organs, whereas in chronic cases the disease is characterized by fibrinous peritonitis. Petechial haemorrhages are seen in the internal wall of the air bladder. Oral administration of oxytetracycline has been reported to give good result.

Vibriosis

This is one of the most importnet diseases of cultured fish usually caused by *V. anguillarum, V. parahaemolyticus* and *V. alginolyticus.* Diseased fish shows haemorrhages in the mouth region, opercula and ventral surface of the body. Hyperaemic intestine, swollen spleen and necrotic kidney are other gross pathological findings. Peritonial and abdominal dropsy may also develop in some cases. Prevention through immunization is the best method to control this disease. It can also be controlled by feeding a diet containing 0.02% furazolidine for two weeks. Sulfamerazine @80-120 mg/kg body weight is recommended as a suitable control measure.

Common viral diseases

Lymphocystis Disease

This disease is observed in most freshwater and saltwater species. Clinically, fish are presented with variably sized white to yellow cauliflower-like growths on the skin, fins, and occasional gills. Occasionally, this virus may go systemic with white nodules on the mesentery and peritoneum. The disease gains entry through epidermal abrasions. The virus infects dermal fibroblasts.

Channel Catfish Virus

Channel Catfish Virus *(Herpesvirus)* is seen in fry or fingerling of channel catfish during the summer when water temperatures are reaches above 22°C. Clinically these fish usually show erratic swimming or spiralling movements followed by terminal lethargy. Haemorrhage at the base of the fins and skins, ascites; exophthalmos, and pale gills are other signs. Mortality is very high. Infection is direct with transmission of the virus in water or feed. Piscivorous birds, snakes, or turtles may mechanically carry the virus from pond to pond.

Herpesvirus cyprini

This is a non-fatal disease, commonly known as '*Fish Pox*' observed in carp and other cyprinids. Elevation of the epidermis with the formation of white to yellow plaques over the body of the fish is seen. Healed lesions usually turn black.

Infectious Hematopoietic Necrosis

The disease is observed in the fry of trout (rainbow) and salmon (Chinook and sockeye) with mortality up to 100%. Fish become lethargic or hyperactive, become dark due to increase in pigmentation, exophthalmus, abdominal distension, and faecal cast seen Haemorrhage on skin and viscera primarily at base of fins, behind the skull, and above the lateral line are also observed.

Viral disease management

Specific drugs for viral disease treatment in fishes are not available or difficult to be developed since virus is host cell dependent for all its metabolic machinery. Virucidal chemicals capable of killing virus outside the host are available like chlorine, iodine, ozone and UV rays. Vaccines in general are not found to be effective in fish viral disease management. Poor immune system of the fish and young age at infection are some of the contributory factors. So, avoidance of the virus in culture system is the best strategy. This can be achieved by proper screening of brood, seed and certification programme.

Parasitic diseases

The parasite itself is the primary factor responsible for some epizootics and hence is a primary stressor. Parasitic forms commonly associated with diseases in fish are *Ichthyophthirius, Ichthyobodo, Cryptobia, Oodinium, Eimeria, Trichodina, Trichodinella, Tripartiella, Glossatella, Microsporidia, Myxosporidia, Gyrodactylus, Dactylogyrus, Sanguinicola, Posthodiplostomum, Diplostomum, Ligula, Ergasilus, Lernaea* and *Argulus.*

Ichthyophthiriasis

This disease is caused by *Ichthyophthirus multifilis*, which is a ciliate protozoan. If burrows into the skin and gills and causes pin-head size spots producing the while spot disease or Ich disease. The parasite penetrates the mucus coat and the upper layer of the dermis causing hyperplasia of the epidermal cells around the site of infection. The parasite feed on RBCs of the host. The mature parasites live in cysts of the hypodermis and gills. The parasitic cysts on the gills affect respiration to a great extent the fish becomes extremely emaciated and may finally die. The trophozoite is oval to round in shape and it uniformly ciliated around the body. There is a crescent-shaped macronucleus. The mature parasite leaves the host and by rapid division produces about 250-1000 ineffective young parasites in about 12-18 hours. After about 36 hours these young parasites (about 0.03-0.04 mm in size) swim freely in search of new hosts if they do not find a host and they die in a few days. The tomites and trophozoites are pear shaped causing mild to severe inflammation and epithelial erosion. Ichthyophthiriasis decreases haemoglobin concentration and death is probably due to osmo-regulatory failure. Fingerlings are more susceptible to mortality due to Ich infection.

Ichthyobodo (Costia nectar)

It is a flagellated, round to kidney-shaped ectoparasite belonging to the class Zoomastigophorea. It has one pair of short posteriorly directed axostyles or flagella. There is also one pair of free moving flagella used for jerky free swimming movements and for attachment to the host body and gills. Ichthyobodo attaches to the host by means of a flat disc from which small bundles of micro tubules extend into parasite as food vacuoles. Reproduction of the parasite occurs mainly by binary fission. It is an obligate parasite and may diet within 30-60 minutes without a host. Icthyobodo has a seasonal incidence in some situations. The parasite cause hyperplasia of the malphigian cells and exhaustion of the epidermal goblet cells beneath infested areas which is followed by intercellular oedema or spongiosis of the underlying epidermis. Severe infestations cause gill congestion and death.

Cryptobia

These are blood parasites (biflagellate) which make the host emaciated with sunken eyes causes "Weakness disease".

Eimeria cyprini

Eimeria cyprini is found in the intestinal mucosa of young carp. This parasite causes enteritis and emaciation. *E. subepithelialis* cause formation of yellowish nodules in the colon and rectum of diseased carp.

Trichodina, Trichodinella, Tripartiella* and *Glossatella

These are ciliate protozoans which infect carp skin and gills. These are easily recognized as spherical organisms (about 40 µm diameter) having miniature spiked wheels with cilia. Due to the sucking action of these parasites the epidermal cells of the host are irritated, secrete a lot of slime and ultimately die. The parasite then feeds on these dead cells. Asexual reproduction of these parasites occurs by binary fission.

Microsporidia* and *Myxosporidia

The spores of Microsporidia are very small with a vacuole at one end opposite to the polar capsule. The spores are gram-positive and at the anterior end the small granule is positive in the periodic acid-schiff reaction. In stained preparations the nuclei appear to lie in a deeply staining girdle at the center of the spore. The cytoplasm occupies the entire intrasporal cavity. The membranous structure of the polaroplast gives the appearance of the anterior vacuole. Infection results in new host by ingestion of mature spores. When an infected adult fish dies, a concentration of spores are released and there is chance of new host getting the infection. Several Microsporidia are parasites of the ovary, testes, gills, kidney, etc. in fishes.

Myxosporidian spores are more frequently found on skin gills, fins, eyes, brain, kidney, gall bladder, etc. Under heavy infection they cause emaciation, hamper gonadal development and may result in dropsy condition along with *Aeromonashydrophila.*

Gyrodactylus* and *Dactylogyrus

These are monogenetic trematodes which infects fishes. *Gyrodactylus* infects both skin and gills whereas *Dactylogyrus* infects only the gills. These parasites feed on the blood and epithelial debris of the host. *Gyrodactylus* is viviparous. Lack of eyespots, presence of two anchors and a larva in utero are diagonostic feature of *Gyrodactylus*.

Sanguinicola

This is a blood fluke, is a serious parasite that causes thrombosis and occulusion of gill capillaries by release of the parasite's eggs. It also causes gill haemorrhage, necrosis, exophthalmos and loss of health.

Posthodiplostomum* and *Diplostomum

These are the digenetic trematodes whose matacercarial cysts are seen as black nodules in the host body. Diplostomum infests the eye and may cause blindness. These parasites cause serious epizootic particularly in young fishes.

Ligula

Ligula intestinalis is a large fleshy tape worm and is an endoparasite. The presence of such large amount of parasitic tissue in the body cavity of the host compresses the visceral organs and gonadal maturation is inhibited.

Ergasilus

This is one of the most problematic parasites fishes which at times cause serious losses. Eragasilids feed on epithelial cells and causes local damage which may lead to secondary infection by fungi or bacteria.

Lernaea

Lernaea is commonly known as the anchor worm. This is also considered as other most problematic parasites of fishes which at times cause serious losses. The head of this parasite has ancho-shaped, chitinous appendages. When the free swimming larvas of the parasite meet a fish it penetrates through the skin of the host into the underlying muscles and only the tail part is visible outside. There is a decrease in the number of red blood corpuscles and of the haemoglobin content of the host due to this parasite.

Argulus

This is an Arthropod parasite which perforates fish skin by its mandibles. It causes severe skin damage and anaemia and also ulcerations, which may lead to secondary infection. Crustacean parasite, *Argulus* is an external parasite can be seen with naked eyes. It can be controlled with common salt @ 3-5 % by dip treatment or Gamaxine @ 1 ppm in pond water could be used and can be treated the infected fish with dip treatment in solution of 2-3 % common salt or potassium permanganate @4 ppm can be used in pond water.

Control measures for parasitic diseases

To control parasitic diseases following treatments are recommended as a suitable control measure.

External protozoa	• 25 ppm of mixture of formalin + 0.1 ppm malachite green; used for upto 6 hours daily in tanks at 3 to 4 days intervals in ponds. • HCHO @ 200 ppm for 1 hour or less daily, 15-25 ppm pond application. • Malachite green (Oxalate) @0.1 to 0.15 ppm at 3-4 days intervals in pond • $CuSO_4$ @ 2ppm mixed with 3 ppm citric acid in ponds with calcium carbonate level above 200 ppm.
Internal protozoans	• Diametridazole@0.15% in food daily for 3 days. • Enheptin @0.2% in food for a day • Furazolidone @1ppm for 1 hour or 25 mg per kg body weight of fish per day for 14 days.
Monogenetic	• HCHO used as against external protozoans.

trematodes	• Dipteryx, neguzon, malathion, chlorophus used in the pond @ 0.25 ppm and repeat if necessary • $KMnO_4$@5-10 ppm for 1-2 hours and 3 to 5 ppm in ponds.
Digenetic trematodes	• Di-n-butyl tin oxide or dibutyltin dilaurate @250 mg per kg of fish or @ 0.3% of food for 5 days.
Cestodes	• Di-n-butyl tin oxide or dibutyltindilaurate @250 mg per kg offish or 0.3% of food for 5 days.
Nematodes (round worms)	• Santonin @0.04% g/fish
Acanthocephalan	• Same as for tematodes
Leeches	• Neguvon, Chlorophus, Malathion: use at 0.5 to 1 ppm pond application.
Parasitic copepods	• For killing the larval stages Malathion, Neguvon or Chlorophus can be used @ 0.25-0.5 ppm, 3-5 times at weekly intervals.

Common fungal disease

Saprolegnia

The most common freshwater fungal disease is cotton wool disease (*Saprolegnia* sp.) which is characterized by the presence of cotton wool like growth on the body surface and also on the eggs. During stress conditions when there is some injury on the fish body this fungal pathogen grows on the dead tissue at the site of the injury and forms a thick layer of fungal hyphae which scatter their spores outside the host. When the fungus grows over the necrotic tissue of the host it imparts a cotton wool like appearance. This fungus causes widespread damage particularly under stress conditions in young fish and in hatcheries. Since *Saprolegnia* is a secondary pathogen improvement of the general sanitation helps in controlling the infection.

Branchiomyces

This fungal pathogen causes "gill rot" in fish resulting in yellow-brownish discolouration and disintegration of gill issue. Infested fishes gasp for air. This fungal pathogen is very serious as it causes high rate of mortality. Large areas of the gill because of the infestation become necrotic and ultimately fall off.

Achlya

This is also a secondary pathogenic fungus. This parasite grows relatively with ease if there are areas of necrotic tissue or inflammation of the skin. Fish are more susceptible to this parasite particularly after breeding. The mycelium grows progressively through the skin of the host. The hyphae sometimes extend deep into the muscles of the host.

Ichthyosporidium

This pathogen belongs to the class phycomycetes and is an endoparasite. The main characteristic of this parasite in the host is numerous small ball-shaped cysts in the liver which damages the organ. It also attacks spleen, heart, kidney, gonads, brain, gills, musculature and nerve tissue behind the eyes of some host species. Patchy skin wounds and hoes in the bones and haemorrhages in the skin of the host are generally caused due to this pathogen.

Aphanomyces

Aphanomyces species are highly pathogenic to fishes and cause mortality. The pathogen grows in the dorsal musculature of tropical freshwater fishes. Death of host occurs when dorsal skin is penetrated from within. Mortality occurs within seven to eight days. Apart from the above common form recently *Aspergillus flavus, A. ochraceous* and *Fusarium moniliforme* were isolated from some of the EUS affected specimens by ICAR-CIFA, Bhubaneswar.

Control measures for external fungi

To control external fungi following treatments are recommended as a suitable control measure: Fish eggs infected with external fungi can control by the application of Malachite green @ 5 ppm as one hour flush used daily, @1500 ppm as 10 dip or Formalin @ 2000 ppm for 15 minutes and Malachite green@0.1 ppm for 1hour flush. For fish infected with external fungi, application of HCHO @50 ppm+ Malachite green @0.1 ppm for very short durations is reported as effective control measures.

The fishes infected with *Saprolegnia* can be given bath with 3-4 % in common salt or infected fish can be removed from the pond to give a bath treatment in a solution of 1- 2 ppm Malachite green for 30 minutes. Formalin @ 20 ppm in pond water also can be used.

Epizootic Ulcerative Syndrome

The primary etiological cause of this disease is still under controversy although some workers in the recent years have reported *Aphanomyces invadans,* a fungus as the primary causative factors of EUS. Application of lime/ bleaching powder, Sokrena WS, CIFAX (a formulation of CIFA, Bhubaneswar), etc. are reported to control EUS disease effectively. The available control measures are as follows:

- ✓ Pond disinfection: Lime @ 60 – 100Kg/ 0.16 ha. (Apply 3 - 4 times at 3 weeks interval).
- ✓ Salt application: Apply Salt @ 200 – 300 Kg/ 0.16 ha when water becomes heavily polluted.
- ✓ Lime & turmeric: A mixture of 16 Kg lime with 1.6 Kg liquid green turmeric or dust turmeric can be spread in 0.16 ha water area.
- ✓ CIFAX: Dilute 160 ml "CIFAX" and spread all over the 0.16 ha water surface.
- ✓ $KMnO_4$ & Lime: A mixture of 500g $KMnO_4$ with 60 – 80 Kg lime spray all over the water surface of 0.16 ha.
- ✓ Alum: Dissolve 500g alum and spray over 0.16 ha water surface uniformly.

Environmental diseases

Water quality in an environment fluctuates as a result of dynamic interactions between several variables. Fluctuations in the physic-chemical parameters are often quite irregular in an ecosystem which needs quick monitoring and careful management so as to maintain a hygienically sound aquatic environment. Dissolved oxygen level below 4 mg/L is stressful and 0.3 mg/L is lethal to most fish species. Similarly low pH can cause bleeding (haemorrhages) on the gills and heavy mortality. pH below 4 and above 11 is lethal to fishes. Optimum temperature is also essential for efficient feed utilization, assimilation and growth. Due to excessive deposition of organic material in the bottom sediment, rapid biosynthesis process occurs in some bacterial community. This leads to development of bloom of certain bacterial and blue green algal species, which increases the biological oxygen demand beyond tolerance limits resulting in decreased quantity of available dissolved oxygen for the fishes. For proper gonadal development and maturity of fishes environmental parameters should be maintained within the optimum range.

Nutritional disease

Malnutrition in presence or absence of toxic materials adversely affects health of fishes resulting in impaired growth, poor food utilization and lowered resistance to diseases. Proper growth and gonadal development is not possible without adequate balanced diet. Liver lipoid disease, pin head disease, scoliosis, lordosis, etc. are some examples of malnutritonal disorders in fishes.

Monitoring and management of fish health

Effective monitoring through regular and frequent sampling and examinations and timely or corrective management measures are important for keeping reared fishes healthy as there is no guarantee about the factors remaining constant over a given period of time. Periodical netting of part of fish population at least once in a month is a good practice that allows checking the growth rate and other defects. All the physico-chemical parameters of the environment should be first observed to detect any changed behaviour e.g., erratic swimming movement, resting near the margins, loss of balance, excessive or lack of mucus secretion, change in normal pigmentation, erosion of scales, fins, lesions on the body etc. and loss of appetite, etc. Adverse physico-chemical parameters of the environment should be corrected through efficient manipulation and management. Through detailed examination of the fish samples we can know the disease problem and accordingly curative measures and treatment can be given.

Fish disease surveillance in Assam

ICAR-CIFRI is part of the "National Surveillance Programme for Aquatic Animal Diseases (NSPAAD)" sponsored by NFDB, Hyderabad and led by ICAR-NBFGR, Lucknow. The surveillance programme was launched in Assam through a Launching workshop on National Surveillance Programme for Aquatic Animal Diseases in Assam jointly organized by the Institute's Guwahati Regional centre and the College of Fisheries, AAU, Raha, Nagaon at the College of Veterinary Science, AAU, Khanapara, Guwahati on January 29, 2014.

Presently, active fish disease surveillance in Assam is being carried out by the Institute in three districts *viz.*, Kamrup, Barpeta and Cachar. Besides active surveillance, passive surveillance is also being carried out in different places of Assam as and when information of fish disease outbreaks/ kills are recieved. To support the fish disease surveillance programme, one fish disease diagnostic laboratory has been established by the Centre under the project.

Conclusion

Success of fish production is directly related to fish health of reared fish stocks. Hence, fish health monitoring and management cannot be ignored at any time. With little care we can observe some of the abnormal signs, symptoms or behavioral changes of fishes at the site itself. Whenever any such abnormality is noticed expert advice should immediately be sought to avoid losses due to ill health and mortality. When the fish the stock is kept healthy returns of aquaculture ventures will be rewarding.

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BEST MANAGEMENT PRACTICES IN FISH CULTURE

A. K. Sahoo and B. K. Das

ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata-700120

Aquaculture sector is contributing considerably towards food security, nutrition and health, livelihood of rural population besides export earnings in all major parts of the world. The most important inputs for this sector are seed, feed and health. However in recent years, the major problem in aquaculture is quality seed and health. The demand for quality and certified aquaculture products is supposed to increase substantially in coming years and the most practical, economical and acceptable way to achieve these goals is for small scale farmers to adopt better/best management practices (BMPs) in all aspects of production systems starting from pond preparation, quality seed to harvesting and post-harvesting processes, collectively as a cluster, in a given locality. BMPs in the aquaculture context outline norms for responsible farming of aquatic animals. BMP's are management practices, and implementation is generally voluntary; they are not a standard for certification. However, implementation of BMPs will help to achieve compliance with standards set by international agencies, certification bodies and trading partners.

Better Management Practices (BMPs) is a term used in the United States to describe a type of water pollution control. Historically the term has referred to auxiliary pollution controls in the fields of industrial wastewater control and municipal sewage control, while in storm water management (both urban and rural) and wetland management, BMPs may refer to a principal control or treatment technique as well. BMPs began in the United Nation's Food and Agriculture Organization (FAO) *International Code of Conduct for Responsible Fisheries* (FAO, 1995).

Definition

BMP is defined as "A schedule of activities, prohibitions or practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States" (definition from the CWA)**.**

BMPs have been determined to be an effective and practical means of reducing point and nonpoint-source water pollutants at levels compatible with environmental quality goals.

The primary purpose for implementation of BMPs is to conserve and protect soil, water and air resources. BMPs for aquaculture operations are a specific set of practices used to reduce the amount of soil, nutrients, pesticides and microbial contaminants entering surface and groundwater while maintaining or improving the productivity of agricultural land. It is a holistic approach for ecosystem management and upkeeping of environment health for optimal critical hazards. It also further emphasizes certified aquaculture products with low levels of risk prescribed for exports and consumption. For fish culture, BMPs are the guidelines mainly to minimize the disease risks and improving quality of product through following culture practices on scientific lines and environment friendly measures. In shrimp farming, this practise has been proven as the successful measures to reduce the risk of disease outbreaks.

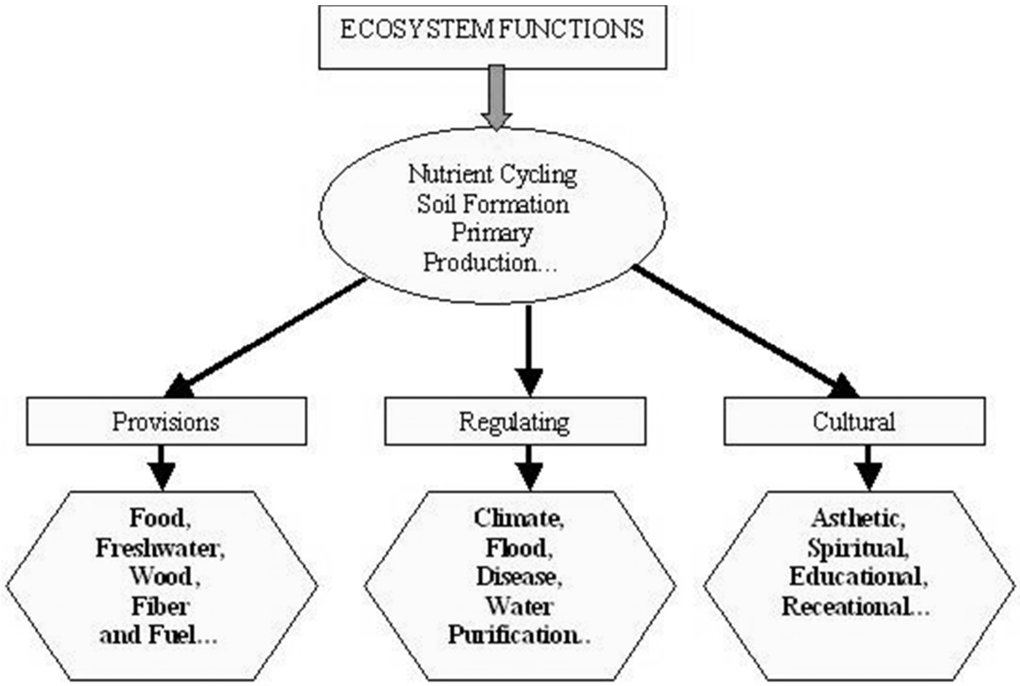
BMPs start from *pond preparation, selection of quality seed, acclimatization of seed, water quality management, feed management, health management as well as harvesting*. Once farmers comply with the BMPs, there is every possibility of reducing the disease risks and the chances for reaping good harvest are quite possible.

What are BMPs ?

- BMPs are practices used by agricultural producers to control the generation and delivery of pollutants from agricultural activities to water resources of the state and thereby reduce the amount of agricultural pollutants entering surface and ground waters.
- Each BMP is a culmination of years of research and demonstrations conducted by agricultural research scientists and soil engineers.
- BMPs for one ecosystem may not be the same for another ecosystem and depends on the functions and utility of the system.

Where to use BMPs?

The schematic diagram is provided to use the BMP practices at various stages of aquaculture practices**.**



(Source: Millennium Ecosystem Assessment)

Fig 1: Ecosystem functions where BMP implementation is required

BMPs for fish and shellfish culture systems: Case studies

BMPs for Indian Shrimp farming

In Andhra Pradesh, until the mid-1990s shrimp farmers earned good returns but investment in technologies for good management practices were generally ignored. As a result, shrimp farming in Krishna district failed to withstand the impact of viral disease outbreaks in the mid-1990s and a large number of farmers abandoned shrimp farming.

NaCSA has organized more than 100 farmers societies, 30 of them are in Krishna District of Andhra Pradesh. There were 164 farmers involved in shrimp farming owning 384 ponds in 600 acres farming area. Out of which 63 farmers (84 ponds, 67 ha area) formed into three societies in the village and agreed to follow the better management practices (BMPs). A mutual agreement has been formed between the selected hatchery and three societies. The agreement included:

- Screening brood-stock for disease.
- Using only disease free broodstock for seed production.
- Single spawner systems.
- No use of banned antibiotics.
- Good feeding practices.
- Getting disease free seed through contract hatchery system 45 days in advance of the planned stocking date.

Positive outcome of this demonstration

- No disease incidence.
- Increased confidence in contract hatchery system.
- Reduced cost production.
- Production of safe shrimp.
- Motivated farmers in abandoned areas.

Positive impact of this success was evident as new societies implemented BMPs and more societies were organized in Krishna District. This paved the way for full-scale revival of most of the abandoned ponds in Krishna and other places.

BMPs for catfish aquaculture in the Mekong delta, Vietnam

Catfish farming in the Mekong Delta, the bulk of which is still undertaken by relatively small-scale producers, is one of the largest and most rapidly growing freshwater aquaculture industries in the world. The sector has already reached the forecast for 2010 of a production of 1 million tonnes with export value of 1 billion US$. The issues impacting the viability and development of catfish farming in the delta include

- poor husbandry practices
- low quality seed
- excessive dependence on trash fish as a feed resource
- inadequate planning in site selection
- food safety and market access
- environmental degradation

These issues were addressed through the development and adoption of Better Management Practices (BMPs), implemented through collaborative groups of small-scale farmers in conjunction with those from large-scale farmers. The resultant output of which are:

- Brood-stock management in hatcheries and grow-out practices (in ponds) reviewed and documented.
- Development of BMPs for catfish farming in Mekong Delta including guidelines for hatchery (husbandry and brood-stock management) and grow-out (health, feeds and feedings) developed.
- Skills-based training in Vietnam, Australia and Thailand to facilitate implementation of BMPs and associated practice change in fish farming in the Mekong Delta.
- Dissemination and implementation of BMPs to farmers and other stakeholders in the Mekong Delta.

BMPs for marine finfish aquaculture in the Asia-Pacific region

Marine finfish aquaculture production in the Asia-Pacific region has grown an average of 10% by volume and 4% by value per year over the last decade. Increasing production is attributable to the expanding culture of high-valued marine carnivorous species such as groupers. Development has escalated due to the breakthrough and improvements in hatchery production and husbandry of a range of species including groupers, snappers, cobia, pompano and threadfin. The majority of marine finfish farmed in Asia are cultured in earthen ponds, floating cages or pen systems. Mariculture development has indirectly contributed to:

- The conservation of wild fish stocks and the habitats of many species
- Convert fishery by-catch or low-value fishery products to higher value consumable fish protein for human consumption
- Providing alternative livelihoods for fishers
- An alternate fish supply to the 'live marine food fish restaurant trade', which is now by-and-large dependent on cultured produce.
- But marine finfish aquaculture has been criticized by many for contributing to environmental problems such as:
- coral reef destruction

- high nutrient and organic loadings
- algal blooms
- use of 'trash' /low-value fish as feed
- Contributing to overfishing through the use of wild-caught seed and brood-stock.
- The development of a BMPs-based approach provides a practical and positive mechanism for small-scale farmers to adopt practices that will better support their participation in more formal accreditation / certification schemes in the future.

Assistance of small-scale farmers to maintain market access in the face of increasing consumer demands for environmental and social responsibility in aquaculture.

BMPs for Aquaculture in Philippines

The Philippine Department of Agriculture Bureau of Agriculture and Fisheries Product Standards have developed a Best Aquaculture Practice Program that leads to certification of farms. The objectives of the certification scheme are to assist the Department of Agriculture to:

- Ensure safe and quality aquaculture products
- Facilitate fish farmers/ aquaculturists adoption of responsible, ecologically and economically sustainable aquaculture practices
- Uplift BMP farmers' profiles as members of the nationally recognized list of fish farmers/ aquaculturists that is setting the benchmark for the aquaculture production of safe and quality fishery products
- Enable consumers to exercise the option of buying quality aquaculture products from traceable and certified sources
- Increase the market access of safe and quality aquaculture products both in the local and foreign markets

BMPs should be developed depending on species, culture system and geographical location. The planning and management of aquaculture should adhere to a maximum production below the estimated carrying capacity.

Planning and sitting BMPs

- Environmentally suitable areas.
- Water supply sufficient and suitable for aquaculture.
- Minimize impact to sensitive habitats.
- Long-term sustainability.
- Avoid conflicts with other coastal users.
- Avoid navigational routes.
- Avoid sites with fluctuating water quality.
- Integrated with local community.

BMPs for cage and pens in Philippines

- The sustainable carrying capacity for fish production should be calculated for zones
- The number of cages in a zone should be capped to ensure sustainable production
- Fish cages, floating or stationary, should be installed and kept at least one meter between units with a maximum of 10 in a cluster and at 20 meters between clusters of small cages and a 20 meters gap between large cages to provide water exchange.
- Fish pens should be spaced 200 meters apart.
- The construction should not damage aquatic life and habitat.
- Site improvement, grow out equipment and structures should be capable of withstanding adverse weather conditions.
- All construction should be completed with a minimal disturbance to the aquatic environment.
- Construction waste and other deleterious substances should be disposed of properly.
- Undertaking an Environmental Impact Statement for zone.
- Monitoring of impact inside and outside zones.

- Encourage fallowing of sites within the zone.
- Encourage coordinated fish treatment for disease.

Major issues and challenges to be addressed for formulating BMPs

- Development of BMPs according to the requirement of the producer/ processor/ industry
- Social equality
- Focus on small-scale farmers
- Environmental sustainability
- Food safety aspects of aquaculture
- Role of aquaculture in food security

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Annexure-I

Base line data of the farm

Date: ____________________________

Name of the State:	
Name of the District:	
Name of selected village	
Name of the farm	

TO BE FILLED FOR EACH SELECTED FARM (code details to be provided as separate note)

1. Contact details and geographical location of the Farm	
Name of the farm	
Since how long the farm has been operational	
Owner of the farm	
Name of the contact person	
Village	
Block	
Pin code	
Mobile/Ph. No.	
GPS Coordinates	
Details of the any license, if available (shrimp farm)	

2. Details of the farm	
Ownership (Owned/Community pond/leased/state farm)	
Type of farm (Freshwater/Brackishwater/Mariculture/Cold	

water)	
Hatchery/Nursery/Fingerling pond/Growout	
Monoculture/Polyculture/Integrated	
Water spread area of the farm	
Number of ponds	
Seasonal/ Perennial	
Source of water (Groundwater/canal/creek.....)	

Pre-stocking pond preparation	
Drying	
Ploughing	
Lime/bleaching treatment (If yes, dose and method)	
Any other	

Stocking details of the Farm	
Species under culture	
Number of crops/year (in case of shrimps)	
Source of seed (own hatchery/State hatchery/other)	
Seed quality (in case of shrimps ,PCR tested or not, if PCR tested, name of pathogens)	
Stocking date	
Stage of stocking (Fry/Fingerling/Post-larvae/juveniles etc.)	
Average size at stocking (Length/weight)	
Stocking density (No./ha)	
Present size (Length/weight)	
Age (days of culture)	
Standing biomass (Kg)	

Input usage	
Fertilizer (kg/ha)	
Organic fertilizer (cow dung/poultry manure/pig manure)	
Inorganic manure (urea/super phosphate etc.)	
Disinfectants/probiotics//Drugs/antibiotics and any other chemicals or biologicals …used	
Feed (kg/ha/day)	
Oil cake	
Rice bran	
Pellet feed	
Feeding method (Bags/Trays/Broadcasting etc.)	
Estimation of feed requirement (approximation/feeding to satiation/body weight basis/others)	
Any other	

Water Quality Parameters	
Water exchange (% /month)	
Temp (^{0}C)	
pH	
Dissolved Oxygen	
Salinity (ppt)	
Total hardness (ppm)	
Alkalinity	
Phosphate	
Turbidity	
Any other important/essential parameters (ammonia/nitrite/nitrate)	

Disease History	
Which are the diseases observed by the farmer	
When did the disease occur?	
Species affected	
Species not affected	
Age/size affected	
Major Clinical signs	
Mortality/morbidity (%)	
Any other imp. information	
Treatment	
Medicine used (composition)	
Trade name	
Dose	
Method of application	
Biosecurity measures followed (for shrimp farms)	

Any other qualitative information related to fish health management practices of the farmer

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Annexure-II

Biological sample collection – Finfish*

Date	
Name of farm with address	
Contact person's name and phone number	
GPS Coordinates	

Farm/pond details			
Type of system • Hatchery • Nursery • Fingerling pond • Grow-out • Integrated • Village Pond • Any other	**Fish species in the system** IMCs • Catla • Rohu • Mrigal Chinese Carps • Silver • Grass • Common Ornamental fish Any other • Sea Bass • Pearl spot • Catfish • Murrels	**Culture information** Pre-stocking pond preparation (drying/liming/MOC...)	
		Monoculture/Polyculture	
		Stocking date	
		Stocking Density	
		Source of seed	
		Mode of transport	
		Avg. size at stocking	
		Present avg. fish size (Length/Weight)	
		Age	
		Standing biomass (kg)	
		Type of feed used	
		Feed source	
		Daily Feed intake	
		Water source	
		Any recent interventions (water exchange/lime /cow	

		dung)	
		Any new introductions	

Disease history			
Species affected		Morbidity (%)	
Species not affected		Mortality (%)	
Avg. size and/age affected		Duration	
Total area of farm		Type: Mass mortality/ Continuous small-scale mortality	
Affected area			
Any other nearby farm affected			

Medication		
Medicines already used Drug/chemical/ Probiotics/Disinfectants / immunostimulants	Dose/quantity	Application method (through feed/water...)
Medicines used now Drug/chemical/ Probiotics/Disinfectants /immunostimulants	Dose/quantity	Application method (through feed/water...)

Salinity		Algal bloom		Nitrate	
pH		Transparency		Nitrite	
Dissolved Oxygen		Alkalinity		Ammonia	
Temperature		Water level		Phosphate	
Water color		Water exchange		Any other	

Abnormal pond environment	
Black pond bottom	
Algae on pond bottom/algal bloom	
Acid soil	
pH drop	
Temprature drop	
Foam on surface	

Source of Sample			
Sick fish		Cast net	
Moribund fish		Any other	
Check tray			

Clinical signs					
Lethargy		Cork-screwing		Darkening of skin	
Reduction in feeding		Protruding vent		Sinking to the bottom	
Off-feed		Erratic/abnormal swimming		Swim near surface	
Loss of balance		Dropsy		Air gulping	
Other abnormal behavior					

External lesions			
Body surface (Skin and fins)			
Damage/ Erosion of fin		Wound/ ulcers	
Red spot/		Parasites	

hemorrhages			
Abnormal growth/ White spots/ Wooly or cottony appearance		Protruding scales	
Loss of scales		Any other	
Eye			
Cloudiness		Sunken	
Hemorrhages		Any other	
Protruding			
Gills			
Red spots/ hemorrhages/ Pale color		Fouling	
Degeneration /Erosion of gills		Parasites on the gills	
Mucous build up in the gills		Abnormal gill cover	
Any other			
Internal lesions			
Body cavity and muscle			
Accumulation of fluid		Necrotic musculature	
Hemorrhages		White /black cysts in muscle	
Parasites		Any other	
Organs (Swelling/white-gray patches/ hemorrhages /mucous build-up/ liquefaction/inflation....)			
Liver		Spleen	
Kidney		Heart	
Swim bladder		Gonad	

Peritoneal cavity/Visceral fat		Pancrea s	
Stomach/intestine		Brain	

Samples collected					
Bacterial swab/bloo d tissue/ cultures taken	Tissues preserved for histology	Tissues preserved in ethanol for PCR	Tissues preserved in RNA later	Live specimen /preserved in ice	Water sample collected

**** - While filling the form either make tick mark or write as it is necessary***

Annexure-III

Biological sample collection – Shellfish*

<table>
<tr><td colspan="2">Date</td><td colspan="2"></td></tr>
<tr><td colspan="2">Name of farm with address</td><td colspan="2"></td></tr>
<tr><td colspan="2">Contact person's name and phone number</td><td colspan="2"></td></tr>
<tr><td colspan="2">GPS Coordinates</td><td colspan="2"></td></tr>
<tr><th colspan="4">Farm/pond details</th></tr>
<tr><td rowspan="16">Type of system
• Hatchery
• Nursery
• Grow-out
• Culture with shrimp
• Any other</td><td rowspan="16">Shrimp species cultured
• Penaeus monodon
• Litopenaeus vannamei
• Other
Prawn
• Macrobrachium rosenbergii
Molluscs
• Mussels
• Oysters
• Others</td><td>Culture information
Pre-stocking pond preparation (drying/liming...)</td><td></td></tr>
<tr><td>Stocking date</td><td></td></tr>
<tr><td>Stocking Density</td><td></td></tr>
<tr><td>Source of seed</td><td></td></tr>
<tr><td>Biosecurity measures (net cover, crab fencing, disinfection etc.)</td><td></td></tr>
<tr><td>Pathogen screened</td><td></td></tr>
<tr><td>Pathogens detected</td><td></td></tr>
<tr><td>Mode of transport (Air/Train/Road)</td><td></td></tr>
<tr><td>Avg. size at stocking</td><td></td></tr>
<tr><td>Present avg. size (Length/Weight)</td><td></td></tr>
<tr><td>Age</td><td></td></tr>
<tr><td>Standing biomass (kg)</td><td></td></tr>
<tr><td>Type and quantity of feed used</td><td></td></tr>
<tr><td>Water source (Creek/borewell/Seawater)</td><td></td></tr>
<tr><td>Any recent interventions</td><td></td></tr>
</table>

		• water exchange (interval & %) • lime • other	
		Any new introductions	

Disease history			
Species affected		Morbidity (%)	
Days of culture (DOC)-problem noticed		Mortality (%)	
No. of ponds at farm		Duration	
No. of ponds affected		Mass mortality/continuous small scale mortality	
Whether informed to fellow farmers/authorities			

Medication		
Medicines already used Drug/chemical/ Probiotics, Immunostimulants/ feed/water supplements	Dose/quantity /how many days	Method (through feed/water…)
Medicines used now Drug/chemical/ Probiotics/ Immunostimulants/feed/water supplements	Dose/quantity	Method (through feed/water…)

Water Quality variables					
Source of water: creek/canal/tube well/sea water /other pl specify					
Water treatment: yes / no					
Salinity		Algal bloom		Nitrate	
pH		Transparency		Nitrite	

Dissolved Oxygen		Alkalinity		Ammonia	
Temperature		Water level		Phosphate	
Water color		Water exchange (interval and %)		Any other	

Abnormal pond environment			
Black pond bottom		Acid soil	
Algae on pond bottom		Temprature drop	
Foam on surface		pH drop	
Any other			
Practices			
Disinfectant used in last 3 days			
Addition of water in last 3 days			
Use of cast net in last 3 days			
Sampling method			
Sick shrimp		Cast net	
Dead shrimp		Check tray	
Any other			
Clinical signs			
Lethargy		Brown /black/ Pink/red gills	
Increasing mortality		Aggregation at water inflow	
Swim near surface		Size variation	
Shrimp on the edge		White/ Red feces	
Other shrimp and crabs die		Slow growth	
Abnormal gill cover		Shrimp glowing in dark	

<table>
<tr><td>Feeding behaviour (↑/↓/cessation)</td><td colspan="2"></td><td colspan="2">Moulting difficulty</td><td></td></tr>
<tr><td>Dead shrimp on the pond bottom</td><td colspan="2"></td><td colspan="2">Empty gut after feeding</td><td></td></tr>
<tr><td>Other abnormal behavior/Specific signs observed</td><td colspan="5"></td></tr>
<tr><th colspan="6">External lesions</th></tr>
<tr><td colspan="6">Shrimp</td></tr>
<tr><td>Damaged/dirty/soft/ abnormal/wrinkled/loose shell</td><td colspan="2"></td><td colspan="2">Yellow head</td><td></td></tr>
<tr><td>Dark/marble /pale/yellow/red/blue color</td><td colspan="2"></td><td colspan="2">Abnormal shape</td><td></td></tr>
<tr><td>White cotton-like/opaque muscle</td><td colspan="2"></td><td colspan="2">White spots/black spots</td><td></td></tr>
<tr><td>Any other</td><td colspan="2"></td><td colspan="2">Cutaneous ulcers</td><td></td></tr>
<tr><td colspan="6">Bivalve</td></tr>
<tr><td>Shell discolouration / abnormalities</td><td></td><td>Lesions on mantle</td><td></td><td>Ecto parasites in mantle</td><td></td></tr>
<tr><td>Fouling</td><td></td><td>Retracted mantle</td><td></td><td>Gaping in bivalves</td><td></td></tr>
<tr><td>Mantle tissue watery/pale/ discoloured</td><td></td><td>Burrowers (channels/ holes in</td><td></td><td>Any other</td><td></td></tr>
</table>

			the shell)			
Appendages						
Damaged antennae				Bending of appendages, antennae or rostrum		
Damaged legs				Necrosis of appendages		
Cut or swollen tail				Any other		
Internal lesions						
Black/brown spots in muscle						
Hepatopancreas (Shrunken/swollen)						
Hepatopancreas (Pale/yellow)						
Samples collected						
For bacterial isolation	Tissue for RFTM culture	Tissues preserved for histology	Tissues preserved in ethanol for PCR	Tissues preserved in RNA later	Live specimen/ preserved in ice	Water /soil sample collecte d

<u>* - While filling the form either make tick mark or write as it is necessary</u>

Annexure-IV

QUARTERLY AQUATIC ANIMAL DISEASE REPORT- 2016

Institute:_______________ **Period: _______________**

Sl. No.	**Item**	**Disease status**			**Level of Diagnosis (Level II/Level III)**	**Epidemiological comment numbers**
		June	**July**	**August**		
DISEASE PREVALENT IN THE REGION						
FINFISH DISEASES						
1	Epizootic haemotopoetic necrosis					
2	Infectious haemotopoetic necrosis					
3	Spring viremia of carp (SVC)					
4	Viral haemorrhagic septicemia (VHS)					
5	Epizootic ulcerative syndrome (EUS)					
6	Koi herpesvirus disease (KHV)					
7	Grouper iridoviral disease					
8	Viral encephalopathy and retinopathy					
9	Enteric septicemia of catfish					
10	Infectious Pancreatic Necrosis					
11	Infection with *Saprolegnia parasitica*					
12	Infection with *Aeromonas hydrophila* (only in outbreak cases)					
13	Infection with *Edwardsiella tarda* (only in outbreak cases)					
14	Infection with *Vibrio anguillarum* (only in outbreak cases)					
15	Infection with *Flavobacterium columnare* (only in outbreak cases)					
16	Infection with *Streptococcus iniae* (only in outbreak cases)					

17	Infection with *Myxobolus* spp.					
18	Infection with *Ichthyophthirius multifilis*					
19	Infestation with *Argulus* spp.					
20	Infestation with *Dactylogyrus* spp.					
21	Infestation with *Lernaea* spp.					
22	Infestation with *Caligus* spp.					
MOLLUSC DISEASES						
1	Infection with *Bonamia exitiosa*					
2	Infection with *Perkinsus olseni*					
3	Infection with *Bonamia ostreae*					
4	Infection with *Marteilia refringens*					
5	Infection with *Perkinsus marinus*					
6	Infection with Ostreid herpes virus					
CRUSTACEAN DISEASES						
OIE listed diseases						
1	Taura syndrome (TS)					
2	White spot disease (WSD)					
3	Yellowhead disease (YHD)					
4	Infectious hypodermal and haemotopoetic necrosis (IHHN)					
5	Infectious myonecrosis (IMN)					
6	White tail disease (MrNV)					
7	Necrotising hepatopancreatitis (NHP)					
8	Monodon slow growth syndrome					
9	Acute hepatopancreatic necrosis disease (AHPND)					
10	Spherical baculovirosis					
11	Loose shell syndrome					
12	Soft shell syndrome					
ANY OTHER DISEASES OF IMPORTANCE						
1						

2						
3						
4						

Signature of Principal Investigator

Epidemiological comments:

Comments should include: Affected area/region; Species affected; Disease characteristics (clinical signs or lesions); Pathogen (isolated/detected); Mortality rate (high/low; decreasing/increasing); Death toll (economic loss, etc.); Preventive/control measures taken; Samples sent to national laboratories for confirmation.

Comment No.	**Details**
1	**Location:** **Period**: **Species Screened**: **Clinical signs**: **Mortality rate**: **Economic loss:** **Laboratory Diagnosis:** **Publication:**

Annexure-V

Contact details of personnel of ICAR-CIFRI, Regional Centre, Guwahati associated with NSPAAD

Name	Mobile No.	E-mail ID
Dr. B. K. Bhattacharjya, HRC	09435553274	bkbhattacharjya@yahoo.com
Dr. Pronob Das, Scientist	08473001970	pronobjaan80@gmail.com
Mrs. S. Sahoo Das, Research Scholar	09957080740	swagatikasahoodas@gmail.com
Dr. A. B. Gohain, Research Scholar	09613479379	arupgu@gmail.com

Postal address

ICAR-Central Inland Fisheries Research Institute
REGIONAL CENTRE,
HOUSEFED Complex, 4th Floor, Central Block,
Guwahati- 781006, Assam
Tele-fax: 0361-2228486
Office e-mail: cifrighy@gmail.com
Website: www.cifri.res.in

The Assam Tribune

TUESDAY, OCTOBER 20, 2015

8 THE ASSAM TRIBUNE, GUWAHATI

Workshop on aquatic animal diseases held

STAFF REPORTER

GUWAHATI, Oct 19: The ICAR-Central Inland Fisheries Research Institute, Regional Centre, Guwahati, organised a sensitisation workshop on 'Aquatic Animal Dis- ... scientist, Dr BK Behera, senior scientist and PI, NSPAAD, Dr B Kalita, Professor, College of Fisheries (AAU), Raha, Dr D Debnath and AK Yadav, scientists deliberated on various activities of NSPAAD.

Fishery officials working in ... cussed about the ways for jointly contributing for successful completion of the surveillance programme in Assam by involving the fish farmers.

The valedictory session was attended by Hemanta