ANNUAL REPORT
2018-19

ICAR-National Bureau of Fish Genetic Resources
Canal Ring Road, P.O. Dilkusha, Lucknow-226 002, INDIA

Front cover


Green damsel, *Chromis viridis* with Acropora coral at Agatti island, Lakshadweep


Model of a traditional passenger vessel of Lakshadweep at Bangaram island


Under water view of *Lutjanus* sp. in Bangaram island of Lakshadweep


Amphiprion clarkii at Kavaratti island of Lakshadweep


Under water view of *Lutjanus* sp. in Bangaram island of Lakshadweep

Inner cover

1. Fishermen carrying a traditional fish cage at Eruvadi, Tamil Nadu
2. Under water view of *Amphiprion nigripes* with *Heteractis magnifica*
3. *Stenopus hispidus* with Boyprid parasite *Argeiopsis inhacae* from Lakshadweep, First report in India
4. *Thor hainanensis* Xu & Li, 2014, First record from Indian waters at Lakshadweep
5. View of Acropora coral during low tide at Bangaram island, Lakshadweep

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ICAR-National Bureau of Fish Genetic Resources

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Published by : The Director, ICAR-National Bureau of Fish Genetic Resources, Lucknow-226002 (UP), India

Citation:
Anonymous (2019). Annual Report 2018-19, ICAR-National Bureau of Fish Genetic Resources, Lucknow-226002 (UP), India

Designed & Printed at :
M/s Royal Offset Printers, A-89/1 Naraina Industrial Area, Phase-I, New Delhi 110 028, Ph.: 9811622258

PREFACE

ICAR-National Bureau of Fish Genetic Resources (NBFGR), is an institute under the Indian Council of Agricultural Research (ICAR), Department of Agricultural Research and Education, Ministry of Agriculture and Farmers' Welfare, Govt. of India. The bureau is entrusted to address the researchable issues relevant to aquatic genetic resource management and utilization and provide technical support to various departments for fulfilling national and international obligations of the country. The bureau's research programs envision "National Actions and Global Relevance" stems upon the conviction that all aquatic genetic resources are linked to each other at evolutionary level and therefore, knowledge adds to global information systems. The bureau is also looking at establishing working models for harmonizing conservation with livelihood through use of aquatic genetic resources. The steady acceleration of this institute is due to the continuous molding in the need-based research and adapting new technological advancements keeping with the pace of global scientific fraternity. Apart from the strategic research in the field, ICAR-NBFGR has formulated several multi-dimensional programs to support the national visionary plans like "Blue Revolution" and "Climate-resilient Aquaculture". Further, the institute is continuously providing technical impetus to several national bodies/departments such as DADF, NBA, MPEDA (Ministry of Commerce) and international organizations such as FAO, OIE and NACA.

During the reporting period (2018-19), the bureau has been making immense efforts through various programs in exploring and cataloguing native germplasms from different rivers, wetlands, lakes and marine ecosystems. Several exploratory surveys have been made to the major river systems such as Ganga and its tributaries, Cauvery, Mahanadi and Godavari; different brackishwater lakes of Kerala and marine islands including Andaman & Nicobar and Lakshadweep islands for documenting the germplasms with aquaculture potential or ornamental value. Genetic characterization is another focused area of the institute; hence genome sequence and transcriptome data are being generated for important aquatic germplasms to identify efficient traits in culture point of view or potential molecules in fish pathogens for designing efficient control strategies. Apart from identifying and characterizing the important aquatic genomic resources, the institute is also have targeted strategies through development and preserving the cell lines and generating viable progeny through surrogacy for *ex-situ* and *in-situ* conservation of threatened and economically important aquatic germplasms. Further, in this line a new database named as "Aquatic Genetic Resource Information System of India" has been launched and a new "National Fish Museum & repository" is in the phases of development. One among the management aspect of aquatic germplams is to address the production loss in aquaculture; in this direction the institute is involved in targeted activities through research on diagnosis,

surveillance and reporting of economically important trans-boundary aquatic animal diseases and emerging diseases. Further, several comprehensive programs are being undertaken by the institute to develop therapeutic and preventive measures against these pathogens and addressing the global concern of antimicrobial resistance. The institute has also formulated plans for documenting the genetic losses in farmed stocks especially Indian major carp and use of cryopreserved sperm to alleviate such issues.

On behalf of the institute, I express my deep sense of gratitude to Dr. Trilochan Mohapatra, Secretary, DARE and Director General, Indian Council of Agricultural Research (ICAR), New Delhi for his continued guidance and support. I am grateful to Dr. J.K. Jena, DDG (Fisheries Science), ICAR for his dedicated efforts and guidance along with Dr. P. Pravin, ADG (Marine Fisheries). I also acknowledge Principal Scientists Dr. Yasmin Basade and Dr. Prem Kumar at Fisheries Division of ICAR for their cooperation.

I take this opportunity to thank Secretary, DADF, Shri Tarun Shridhar and Joint Secretary (Fy.), Dr. J. Balaji for involving ICAR-NBFGR in various programs of National Importance. I am thankful to Chief Executive, NFDB, Ms. I. Rani Kumudini for the support to this institute. I also acknowledge with gratitude Chairman of Research Advisory Committee (RAC), Dr. George John and all the esteemed members.

I place on record my thanks to different organizations, DBT, DST, Mangrove Cell, Maharashtra and Bioversity International for supporting some of the new initiatives taken by this institute. I also acknowledge Network of Aquaculture Centers in Asia-Pacific (NACA), Bangkok for their engagement with this institute in various programs and consultations.

I express my heartfelt thanks to the entire publication team of the institute for their efforts and commitment in timely publication of the Annual Report 2018-19.

June 20, 2019

(Kuldeep K. Lal)
Director

CONTENTS

EXECUTIVE SUMMARY

Program: Exploration, species characterization and cataloguing of fish genetic resources

- **Godavari basin**

  Under the new collaborative project of ICAR-NBFGR with Bioversity International, the quantification of agrobiodiversity and ecosystem services in the river Godavari basin, was done. Three districts selected for the purpose were Adilabad, Karimnagar and West Godavari. GIS mapping was used to analyse landscape changes. A total of 204 villages (2nd tier) were selected while 147 for 1st tier. Villages were selected through stratified random sampling and proportional allocation. A total of 46 species were documented which included both brackish water as well as freshwater ecosystems. Planktons were collected and observed which revealed a dominance of group Chlorophyta among phytoplanktons followed by bacillariophyta and cyanophyta, while among zooplanktons, rotifera dominated followed by copepod and cladocera.

- **Lower Mahanadi Basin**

  An exploratory survey was conducted for documentation of fish diversity and habitat parameters in lower Mahanadi basin during September, 2018. Total 13 sites of river Mahanadi and its two main tributaries (Tel and Ong) in lower basin were explored for fish and tissue collections during survey. A total of 120 finfish and two shellfish species belonging to 14 orders, 43 families and 85 genera have been recorded. Cyprinidae (39%) was the most predominant family followed by Bagridae (6%). Site-wise and season-wise fish diversity data was analysed for lower Mahanadi and its tributaries Tel and Ong which indicated low species dominance, high diversity and high evenness across all major sites of rivers explored in the lower Mahanadi basin.

- **Tributaries of river Ganga**

  Conducted exploratory surveys and sampling of the rivers - Gandak, Burhi Gandak, Baghmati and Saraiyamaun wetland of North Bihar. Samplings was carried out at 7 selected sites of the rivers. Due to habitat similarity, fish diversity of the rivers was also similar with some site specific minor variations. A total of 85 fish species were observed from the rivers under 9 orders, 23 families and 64 genera. The number of species observed from the rivers Gandak, Burhi Gandak and Bagmati were 71, 61 and 67, respectively. A total of 45 fish species were recorded from Saraiyamaun wetland comprising 7 orders, 18 families and 34 genera.

- **Cauvery River Basin**

  Exploratory surveys were conducted in the middle and upper reaches of the Cauvery (6 stations) in Karnataka and Kerala (5 stations). The survey yielded an addition of 18 more species of freshwater fish bringing a total of 110 species, belonging to 8 orders, 25 families and 66 genera, including 18 endemic species, 78 native species, 4 stocked and 10 exotic species. Cyprinidae is the most abundant family, contributing 49 % of the fish fauna of the Cauvery followed by family Bagridae, second most abundant with 7% of the total species.

- **Andaman and Lakshadweep Islands**

  Exploratory surveys were carried out at the tidal pools of Chidiya Tapu region, Andaman. Three species belongs the family Gobiidae, one species each from Blennidae and Labridae were obtained. A total of 91 species of marine fishes belonging 8 orders, 42 families and 71 genera from Andaman Islands has been collected, so far. In Lakshadweep, surveys were conducted at Agatti, Bangaram, Thinnakara, Parali I and Parali II islands during January and February, 2019. A total of 49 species of marine fishes belonging to 5 orders, 24 families and 36 genera were collected.

- **Ramsar sites in Kerala**

  Explorations were continued in Ramsar sites of Kerala, *viz.* Vembanad and Ashtamudi Lake and 187 species were recorded. Collections were made from 2 sampling sites of Ashtamudi Lake and 3 sampling sites of Vembanad Lake. 31 and 12 additional species were collected from Vembanad and Ashtamudi Lake, respectively. *Scylla olivacea, Portunus reticulatus, Thalamita cranata* and *Charybdis variegata* are the new records of crabs from the Ashtamudi region. Partial sequence information of 655 bp regions of COI were generated for 72 species from Ashtamudi lake, 15 species from Sasthamkotta and 112 species from Vembanad lake for assessing phylogenetic relationships among various species.

- **North-Eastern Region of India**

  NBFGR under ICAR-North East (NE) component, is implementing 'Collaborative Research Programme on fish germplasm exploration, characterization and development of Live Fish Germplasm Resource Centers in North-eastern Region of India' involving collaborators from various institutions of the NE region in selected parts/rivers of the NE region. The objective is development of regional live fish germplasm resource centers of indigenous food and ornamental fishes for resource enhancement and sustainable livelihood generation and cytogenetic characterization of endemic fishes of North Eastern, India. Number of explorations were conducted in the state.

- **Species Characterization**

  A total of 15 species of the families Conidae (12) and Strombidae (3) were collected from six sites along the Andaman Nicobar islands. Specimens were identified based on shell morphology; morphometric and meristic data were recorded. Sequencing of mitochondrial COI, 12s rRNA, 16s rRNA and nuclear H3 genes of all the specimens were carried out for phylogenetic analysis of the species. 390 sequences were generated for the specimens collected from the South East & South West coasts, Andaman & Nicobar and Lakshadweep islands.

  A total of 183 tissue samples of 14 fish species belonging to 9 genera of 4 families of Clupeiformes were collected from Veraval, Mangrol and Porbandar area of Gujarat and identified based on morphomeristic characters. A total of 190 tissue samples of 19 fish species belonging to 12 genera of 4 families of Clupeiformes were collected from Odisha during the exploration. DNA isolation and PCR amplification of mitochondrial gene Cytochrome c oxidase I (COI) was carried out for all 533 samples for assessing phylogenetic relationships.

  Marine ornamental shrimps, *Stenopus hispidus, Periclimenes brevicarpalis, Saron marmoratus, Lysmata amboinensis* and Sea anemone, *Heteractis magnifica* were collected from Agatti island of Lakshadweep for broodstock development and captive propagation in captivity in order to establish the DBT - NBFGR germplasam resource centre for marine ornamental invertebrates at Agatti Island. Captive spawning of *S. hispidus* and *Periclimenes brevicarpalis* was achieved.

  A new species, *viz. Channa stiktos*, was discovered from Mizoram in collaboration with Pachhunga University College, Aizawl, using morphological and molecular (COI) markers.

  Live specimens of *Tor putitora* were collected from the River Mahanadi (Jharpada and Lankeswari site) and tissues were preserved in RNAlater® and stored at −80 °C. The samples of *Tor putitora* were collected from Nayar, Bhagirathi and Ganga rivers in Uttarakhand state during October, 2018. Molecular identification of fish specimen was completed based on COI sequencing and it has been confirmed that all samples were *Tor putitora* based on COI data.

Program: Characterization and evaluation of genetic resources, intra-specific diversity and genetic stocks

- **Stock Characterization**

  Genetic variability in *Chitala chitala* was inferred from mitochondrial genes, i.e., Cytochrome *b* (Cyt *b*) and ATP*ase* 8/6. A total of 421 *C. chitala* individuals from 12 rivers of 5 different river basins were analyzed. The alignment of the sequences revealed 26 different haplotypes for ATPase 6/8 and 31 for Cyt *b*. For ATPase 6/8 gene, haplotype diversity ranged from 0.000 (Mahanadi) to 0.692 (Gandak), while 0.000 (Mahanadi) to 0.808 (Bhagirathi) in Cyt *b*. The mean nucleotide diversity was 0.0008 and 0.0019 for two genes, respectively. The mean F_{ST} was found to be 0.340 and 0.282 for ATPase 6/8 and Cyt *b* genes, respectively.

In flathead grey mullet, *Mugil cephalus*, ATPase 6/8 genes were amplified for 429 individuals collected from 26 locations and analyzed. Clustal alignment of the sequences revealed 34 different haplotypes. The overall haplotype diversity was 0.4174, for all populations, whereas nucleotide diversity was 0.00067. Hierarchical partitioning revealed that variation was low 0.53% among the groups. The genetic variation pattern in *M. cephalus* (n=438) was also assessed, based on full length cyt *b* (1141 bp) gene which revealed 62 haplotypes with overall haplotype diversity (h) 0.6835, whereas the nucleotide diversity was 0.00097.

In *S. silondia*, a total of n=247 individuals were sequenced and analyzed for both mitochondrial genes, individually. The sequence alignment of Cyt *b* and ATP*ase* 6 & 8 genes revealed 17 and 12 distinct haplotypes, respectively. Haplotype diversity ranged from 0.67-0.73 for Cyt *b* and 0.60-0.74 in ATPase 6/8 genes, whereas nucleotide diversity ranged from 0.00146-0.00257 for Cyt *b* and 0.00146-0.00291 in ATPase 6/8 genes. The analysis of molecular variance (AMOVA) results indicated that 78-79% of total variation was within populations.

A total of n=209 individuals of *Systomus sarana sarana*, collected from six different riverine locations, *viz.*, Hooghly, Betwa, Mahanadi, Godavari, Krishna and Bramhaputra (Guwahati) were investigated. The analysis of ATPase 6/8 genes revealed 28 different haplotypes with overall haplotype diversity 0.6391 for all populations, whereas overall nucleotide diversity was 0.00214.

Sequence analysis of n=82 individuals of *Anguilla bengalensis* from seven locations, revealed 24 different haplotypes. Nucleotide sequences of ATPase 6/8 were A+T rich (59.0%). Haplotype diversity ranged from 0.674 to 1.000, whereas nucleotide diversity 0.0014 to 0.0024. AMOVA analysis revealed that out of total variation, majority (98.76%) was attributed within population.

Analysis of two genes (cyt *b* and ATPase 6/8) in n=140 samples of *Tor tor* from 6 riverine localities revealed 12 different haplotypes for cyt *b* and 7 for ATPase 6/8. For cyt *b* gene, haplotype diversity (Hd) ranged from 0.000 to 0.666, while in ATPase 6/8 ranged from 0.000 to 0.590.

- **Validation of microsatellite markers**

A total of 20 polymorphic microsatellite loci were used to genotype n=140 samples from 6 riverine populations. The observed and expected heterozygosities ranged from 0.2256 to 0.3834 and 0.1690 to 0.3537, respectively. The pair wise F_{ST} value ranged from 0.097 to 0.29. Significant genotypic heterogeneity and F_{ST}=0.182 over all loci.

A total of 166 tissue samples of *Litopenaeus vannamei* individuals from 5 different farms were assayed using 9 polymorphic microsatellite markers. A total of 70 alleles were identified across all loci in all populations. The number of alleles per locus (Na) ranged from 3 to 14. The PIC values ranged from 0.401 to 0.879 with an average of 0.668.The observed heterozygosity ranged from 0.044 to 0.724.

Genetic stock identification of *Sillago sihama* was estimated using 16 microsatellite loci from four locations along the west coast of India, *viz.*, Ratnagiri, Goa, Mangalore and Cochin. The total no. of alleles per locus ranged from 6 to 30 and with the allele size range of 108 to 310bp. Mean value of observed heterozygosity (Hobs - 0.601) for all populations was low compared to the expected heterozygosity (Hexp - 0.705).

Population structure and genetic differentiation of *Perna viridis* in Indian waters were investigated using microsatellite marker panels with 15 loci. The total no. of alleles per locus ranged from 11 to 33 and with the allele size range of 120 to 390 bp. Mean value of observed heterozygosity (Hobs - 0.741) for all populations was low compared to the expected heterozygosity (Hexp - 0.75).

Upon sequencing of 1.5Kb library, the reads were assembled into 1,478 contigs different SSR's repeats in 524 contigs of *Tor putitora* were identified. Out of which, 356 SSR repeats were observed in these sequences. 52 were found to be polymorphic, repeatable ones were 30. Two populations Kosi, Ramnagar and Mahanadi rivers were genotyped with 30 microsatellite loci. Two and four genes associated with microsatellites were found to be under positive and balancing selection, respectively.

Development of Microsatellite marker panels were initiated in *Scomberomorus commerson* and *Thunnus albacares* in PacBio RSII. Sequencing 1.5

kb library (for each species) resulted into 472 and 150 contigs containing perfect repeat sequences in *S. commerson* and *T. albacares* respectively. Primers for 203 microsatellite loci were designed in *S. commerson* and 100 microsatellite loci for *T. albacares*. Testing these primers on 12 individuals, 30 and 25 primers were found to be polymorphic in *S. commerson* and *T. albacares*, which can be used for developing marker panels for utilization in genetic variability and structure analysis of the selected fish species.

- **Evaluation of Prioritized Fish Genetic Resources**

  Under CRP-Agrobiodiversity, work was carried out at three locations, NBFGR at Lucknow, Nagarjunasagar, Telangana and PMFGR center of NBFGR at Kochi, as part of live germplasm resource centers network. The aim was to conserve and propagate the indigenous fish species. On Farm evaluation of *Clarias magur*, *Ompok bimaculatus*, *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala* is being carried out at NBFGR at Lucknow; *Pangasius silasi* (a new fish described by ICAR-NBFGR) at Nagarjunasagar, Telangana and *Clarias dussumieri*, *Horabagrus brachysoma, Labeo dussumieri*, *Hemibagrus punctatus* at PMFGR center of NBFGR at Kochi.

  Assessment of genetic introgression and variation in hatchery bred Indian major carps has been done. Samples collected from six different hatcheries of Uttar Pradesh, Madhya Pradesh and West Bengal were used. Polymorphic microsatellite loci were optimized and for each species and genotyping was done with fluorescently labelled dyes. Upon analysis, the mean number of alleles were calculated in hatcheries and it was found to be 7.958 in *Labeo rohita* and 4.2 in *Catla catla* from 4 distant hatcheries of Uttar Pradesh and Madhya Pradesh. The mean inbreeding coefficient (F_{IS}) was 0.067 for *L. rohita*. F_{IS} in *C. catla* was 0.155, in hatcheries. In *Cirrhinus mrigala*, a total of 255 individuals are being analysing for 16 polymorphic loci collected from 6 distant hatcheries of Uttar Pradesh, Madhya Pradesh and West Bengal.

Program: Genomic resources for important fishes

Identification of genes involved in adaptability to varying salinity to be carried out in Hilsa, *Tenualosa ilisha*, through differential expression is being done. The gill samples from marine, brackish and freshwater environment were analyzed for differential gene expression in the different environment. It was found that 807 up-regulated and 3080 down regulated genes in marine versus freshwater environment and 661 up-regulated gene and 426 down regulated genes in brackish versus freshwater environment. The GO enrichment analysis revealed that marine versus freshwater, 1829 and 718 genes were up and down regulated, respectively.

A total of 907 BAC clones of *Clarias magur* genome were revived and isolation of BAC insert DNA were accomplished. Further, a total of 1164 forward and reverse end sequences of clones were generated using T7 and pbRP1 primers, respectively. The BAC end sequences were mapped on scaffolds of *C. magur* genome using BACPipe bioinformatics tool, where 933 end sequences were mapped on the scaffolds of genome. A total of 769 genes were mapped on 189 BAC clones, while on the other hand a total of 931 genes were mapped on 281 BAC clones in the new genome assembly of *C. magur*.

Proteomic profiling of *C. magur* exposed at thermal tolerance limit for 60-days were done. The extracted protein samples were analyzed for peptide finger printing. Thermal tolerance limits of *Ompok bimaculatus*, *Labeo calbasu* and *Channa punctatus* were estimated as 38°C, 40°C and 39°C, respectively. Blood parameters (glucose, cholesterol, serum protein, hemoglobin, creatine, sodium, potassium, chloride, ammonia and nitrous oxide) of control and stressed fishes of *C. magur*, *O. bimaculatus*, *L. calbasu* and *C. punctatus* were estimated.

Clarias magur obtained from the commercial catches were acclimatized in indoor laboratory in FRP tank for one month. The experimental set up consisted of fish exposed to 25 mM NH_4Cl and control for a period of 3 h, 6 h, and 24 h. Temperature: 23.6 to 23.9 °C, pH: 7.2 to 7.3, and DO: 4.5 to 5 mg/l in treatment group. Sampling were done at 3 h, 6 h of exposure to ammonia, however, no survival was found at 24 h. The Hemoglobin, Hematocrit value of blood, Blood Urea Nitrogen, Blood Urea, Serum Creatinine, Serum Protein, Blood Sugar, SGPT, SGOT, LDH and ammonia accumulation in blood plasma

of *C. magur* control and treated samples with ammonium chloride were analyzed.

Program: *Ex situ* and *in situ* conservation

- **Germplasm Resource Center**

  As part of establishing marine ornamental fish village in collaboration with the Mangrove Cell, Dept. of Forests, Govt. of Maharashtra, established a marine ornamental fish hatchery facility at Airoli, Thane, Maharashtra. Nine different species of clown fish and two species of sea anemones were collected from wild and maintained in captivity for broodstock development. *Amphiprion sebae* and *A. percula* spawned in captive condition and larval rearing is in progress.

  As part of establishing Germplasm Resource Center for Marine Ornamental Invertebrates for the Islanders of Lakshadweep for biodiversity conservation and for their livelihood, the ornamental shrimps and sea anemones collected from different islands were stocked in the hatchery facility for broodstock development. 350 individuals of shrimps, which belonged to 7 families, 8 genera and 12 species & 60 individuals of Sea anemone, *Heteractis magnifica* has been collected and stocked in the hatchery. Broodstocks of five species of shrimps were successfully raised under captive conditions and spawning was achieved for three shrimp species and larval rearing is in progress for *L. amboinensis, G. americanum* and *S. hispidus*.

- **National Repository of Fish Cell Lines (NRFC)**

  Attempts were also made to develop new fish cell lines of different fish species. Four fish cell lines using various tissues, viz. ZFM (*Danio rerio*, muscle), SRE (*Schizothorax richardsonii*, eye), BBF (*Barilius bendelisis*, fin) and CMT (*Clarias magur*, testis) were developed. All the four cell lines were characterized using COI sequences and also found negative for mycoplasma. Immuno-phenotyping was performed for these cell lines.

Program: Documentation of fish genetic resources of India

- Aquatic Genetic Resource Information System of India known as AqGRISI is a web based e-product developed from the project entitled "Information-base on Fish Genetic Resources of India". This e-product on the World Wide Web hosted at the institute web server is an information system that provides the ability for user to browse and view the information on different aspects of fish genetic resources native to Indian waters. This resource provides link to the other worldwide available databases like FishBase, NCBI, WORMS, Google Patents and Natural History Museums etc. and other database developed by FAO, IUCN, CMFRI and CIFRI. It is a unique platform included with data and user management capabilities, which can be accessed at URL: http://mail.nbfgr.res.in/agrisi.

Program: Evaluation of fish genetic resources; exotic and health management

- **National Surveillance Programme for Aquatic Animal Diseases**

  Under the External funded NSPAAD-NBFGR Component-Inland shrimp farms in Haryana were surveyed to know the prevalence of shrimp diseases. From the available list of shrimp farms of the state, a total of 45 farms were sampled randomly in different districts of Haryana and shrimp samples were screened for the presence of *Enterocytozoon hepatopenaei* (EHP), White spot syndrome, Hepatopancreatic Parvovirus, Infectious Hypodermal and Haematopoietic Necrosis Virus and Monodon Baculovirus. Out of the 45 farms sampled, 35 farms were found to be positive for EHP infection and all the 45 farms were found negative for rest of the pathogens. In Uttar Pradesh, one hundred forty five Pangas farms were surveyed and their baseline information was collected. Active surveillance of spring viraemia of carp and Koi herpes virus in ornamental fish, a total of 275 ornamental fish samples were collected from 5 districts of Kerala and 2 districts in Tamil Nadu.

- **Antimicrobial resistance in fisheries and aquaculture**

  A Network of all 8 Fisheries Research Institutes established with ICAR-NBFGR as Nodal Centre for AMR surveillance in fisheries and aquaculture under Indian Network for Fisheries and Animal Antimicrobial Resistance (INFAAR). Standardization of procedures (SOP) related to isolation and identification of *Staphylococcus aureus*, *Aeromonas/Vibrio* and *E. coli* from finfish and shrimp samples was prepared and circulated to partners for adoption. A questionnaire developed

for collecting information on farming practices by sampled fish farms and circulated to partners for adoption. A total of 30 fish farms of Maharajganj and Varanasi in Uttar Pradesh were surveyed. During the course of study, a total of 83 bacterial isolates comprising of 26 isolates of *E. coli*, 27 of *Staphylococcus* sp. and 30 of *Aeromonas* sp. *E.coli* were analyzed for AMR for 11 listed antibiotics.

- **Exotic species**

  Explorations were conducted on certain rivers, wetlands and other water bodies in the states of Uttar Pradesh, Rajasthan, Karnataka and Kerala to assess occurrence and status of alien fish species. The rivers Ganga and Yamuna are observed under high invasion of common carp (*Cyprinus carpio*) and Nile tilapia (*Oreochromis niloticus*) at Allahabad stretch. Many exotic fishes were reported after the flood in Kerala. Majority of the fishes were pacu, *Piaractus brachypomus*, which are in culture in Kerala in many places. Apart from pacu, Malaysian Catfish, *Pangasianodon hypophthalmus*, tilapia, *Orechromis niloticus*, were also observed in the natural waters. Occasional reporting of ornamental fishes, like Araipama, *Araipama gigas*, Allegator gar, *Atractosteus spatula*, Gaint gourami, *Osphronemus gorami*, silver arowana, *Osteoglossum bicirrhosum* and Oscar, *Astronotus ocellatus* were also observed. Occurrence of sucker catfish was reported from Periyar River.

- **Vaccines & Diagnostics**

  Efficacy of commonly used aquaculture chemicals and antifungal drugs against *Aphanomyces invadans* was studied *in vitro*. The results indicated that amongst selected drugs, Clotrimazole, Terbinafine, and amongst chemicals, iodine solution, Benzal-konium chloride and formalin were comparatively more effective against production of zoospores, germination of zoospores and growth of hyphae of *A. invadans*.

  Inactivated germinated zoospores of *A. invadans* in combination with adjuvant was found to stimulate good immune responses and confer protection in rohu. To validate the results of immunization with inactivated germinated zoospores of *A. invadans* in conjunction with adjuvant in rendering protection, further experiments are in progress.

  Emerging diseases including, Cyprinus herpes virus-2 (CyHV-2) in gold fish, carp edema virus (CEV) in koi carp and tilapia lake virus (TiLV) in tilapia has been carried out to know the prevalence rate. Infection was confirmed on basis of PCR, histopathology, infection of fish cell lines and bioassay. Disease prevalence rate of CyHV-2 was 22% in gold fish, 21% CEV in koi carp and 20% TiLV in tilapia. Fifty five ornamental fish farmers from Kerala and Tamil Nadu were given consultancy on ornamental fish disease management during 2018-19.

  Methods for isolation of bacteriophages specific to *A. hydrophila* were standardized. Bacteriophages against two strains of *A. hydrophila* were isolated after enrichment from fish tissues using spotting and diffusion method. Studies on determining the host range using five strains of *A. hydrophila* showed that the isolated phages were specific only to the host strains. Phages were purified, propagated to obtain titres of >108 plaque forming units/ml and stored for further characterization.

  Virulent and multiple antibiotic resistance *Aeromonas veronii* was isolated and confirmed from a farmed Nile tilapia, *Oreochromis niloticus* with bilateral exophthalmia in mass mortality. Natural co-infection of Tilapia Lake Virus (TiLV) and Lactococcus garvieae in a farmed Nile tilapia was also confirmed.

Publications

- The Institute published 48 research papers in different peer-reviewed journals, along with various popular articles during the year 2018-2019.

Capacity Building Programs:

Farmers

- **NFDB sponsored Skill Development Programme for Farmers**

  Four residential training programme of 3 days duration for all India fish farmers under NFDB sponsorship were conducted on Skill Development Programme (SDP) on Re-Circulatory Aquaculture System (RAS) for 187 participants.

- **Activities under Tribal Sub-Plan Scheme**

  Under the Tribal Sub-Plan scheme of the Govt. of India, the Institute undertook a variety of extension programmes and activities for the socio-economic development of tribals in various areas of the country. Two training programmes

were organised for tribal farmers including tribal women with total 64 participants. Three awareness programmes were also organised for tribal farmers including tribal women total 244 participants.

- **State Officials**

  Three residential training programmes of 5 days duration under NFDB sponsorship for the state officials were conducted on ToT for Re-Circulatory Aquaculture System (RAS), which was attended by total of 60 participants.

  One five days special training programme was conducted on, "Importance of Feed in Aquaculture Production System and their Availability in Market" for the U.P. state beneficiaries of SAME (ATMA) Rehmankheda, Lucknow, in which 35 candidates attended.

  A Hands-on Training Programme on 'Fish Health Management' was organised at ICAR-NBFGR, Lucknow during October 8-12, 2018 under National Surveillance Programme on Aquatic Animal Diseases with a total of 11 fisheries officers/participants from Haryana.

Youth under Skill Development

Two residential training programmes of 25 days duration for the youth under Agricultural Skill Council of India, New Delhi/ATARI, Kanpur were conducted by ICAR-NBFGR at ARTU, Chinhat, Lucknow on Freshwater Aquaculture for 40 farmers of Uttar Pradesh.

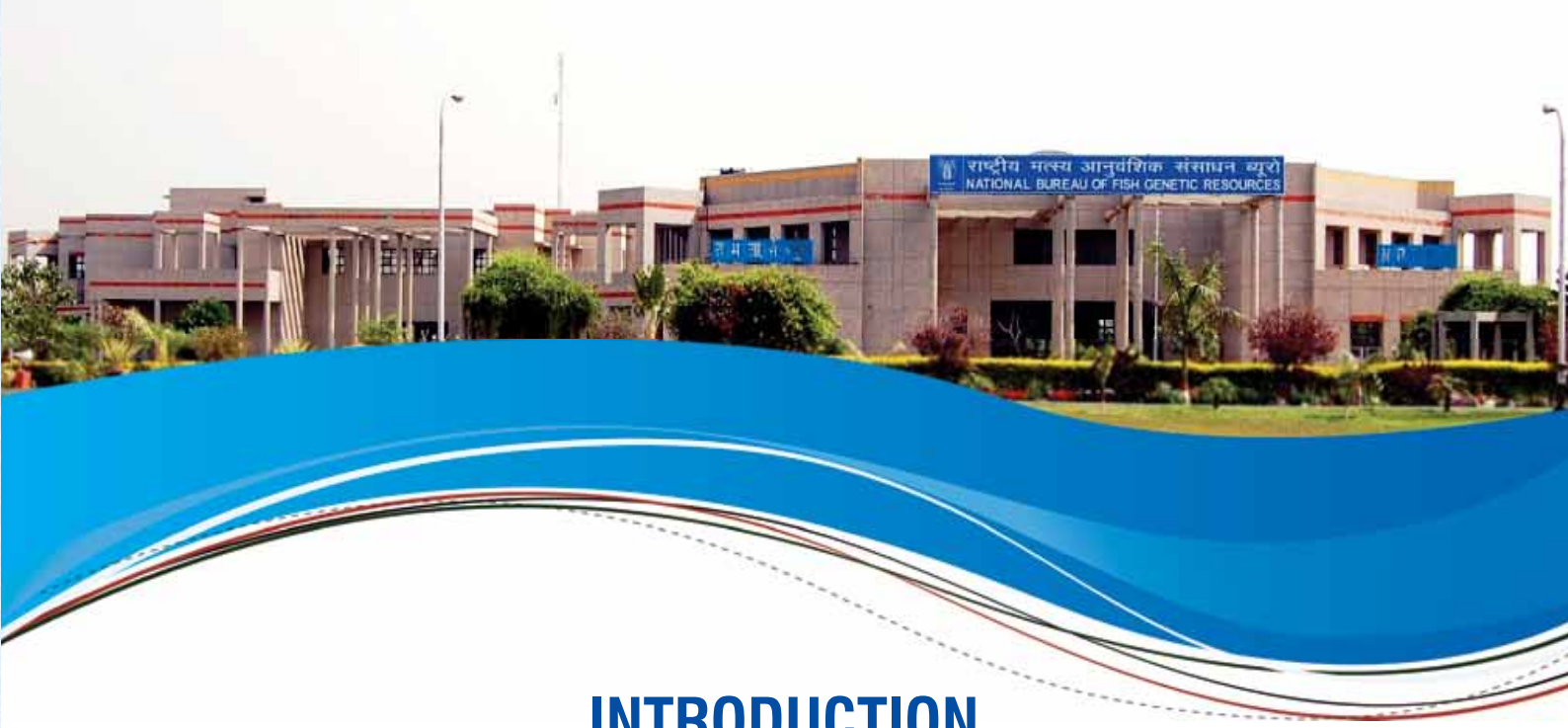
Training of staff

A Short-term Hands-on training course on "Cell Line: Development, Maintenance and Applications" was conducted at ICAR-NBFGR, Lucknow, during September 24 to October 01, 2018 in which there were 11 trainees.

A three-day training on "Human Resource Development for Agricultural Research" was organized during December 04-06, 2018 by by HRD unit of ICAR-NBFGR, Lucknow for the staff.

Farm Activities:

Quality fish seed production is one of the important activity of the institute for societal benefit and livelihood support of the fish farmers of the region. The institute has developed farm cum hatchery facilities at two sites - one at its main campus and another one at ARTU Chinhat, Lucknow. During the reported period institute produced 1076 lakh seed in the form of spawn, fry and fingerlings of Indian major carps & exotic carps. Received a total of Rs. 11.96 as sale proceed of seed.



INTRODUCTION

India is one among the biodiversity hotspot in the world and possesses approximately 9.5% of fish genetic resources spread over different geographical area comprising varied topographical features, which offer immense opportunities for livelihood support, besides maintaining its ecological integrity and valuable gene pool. To manage these vast genetic resources, ICAR-National Bureau of Fish Genetic Resources (NBFGR) was institutionalized in 1983, as a project, which later become one among the seven bureaus under the aegis of Indian Council of Agricultural Research, Department of Agricultural Research and Education, Ministry of Agriculture and Farmers' Welfare Government of India. Aquatic genetic resources have become one of the focussed area globally both from the policy makers and researchers over the last two decades due to its immense unharnessed potential to cater the nutritional security to the ever-growing population. Although, India possesses a huge aquatic resource base spanned over different freshwater, brackish water and marine regions, but majority is unutilized or under utilized. The huge aquatic germplasms inhabiting these ecosystems are facing continuous threat of extinctions due to several anthropogenic and natural environmental changes, precisely, habitat alteration, climate change, establishment of exotic fish species and outbreak of diseases. In this direction, ICAR-NBFGR is contributing since its inception, with several multifaceted programmes boosted with cutting-edge technologies to safeguard and expand the native germplasms.

Since its establishment, ICAR-NBFGR is continuously evolving with the pace of global technological advancement to become a premier institute to address the aquatic genetic resources of the country. In-house capacity to generate knowledge and need-based research are the two main components in the steady acceleration of the institute in this field. Since its journey from Allahabad in 1983, ICAR-NBFGR shifted to the magnificently built administrative and laboratory facilities in Lucknow in the year 1999 and now operating with four divisions (three at HQ and one at Kochi) and a field training unit at Chinhat, Lucknow. Following establishment, several new *state of the art* facilities including indoor hatchery, wet laboratories, public aquarium, national fish museum with different repositories, guest house, staff quarters and above all, experimental tanks and required ponds have been created to serve the differential needs to facilitate research and conservation of live gene-pools. These exemplary facilities and in-house expertise reciprocated in development of several research areas including exploratory surveys to major rivers systems, lakes and marine islands, *ex-situ* and *in-situ* conservation, development of fish databases, genetic characterization, gene banks, fish germplasm and habitat inventory, risk analysis of exotic species, diagnostics for OIE notified and emerging pathogens, development of therapeutic and prophylactic measures for important aquatic pathogens and other areas of germplasm conservation with special focus on prioritized agro-biodiversity species of indigenous origin. Along with these broad researchable areas, several other specialized research programmes including whole genome sequencing, transcriptomics, metagenomics, population genetics, sperm cryobanking, molecular disease diagnostics and therapeutics, national surveillance programme for aquatic animal diseases, antimicrobial resistance in fisheries and aquaculture, exploration of newer geographical areas and unexplored aquatic resources for assessment of fish diversity have been materialized to address diverse fish genetic resources of the country.

VISION

Assessment and conservation of fish genetic resources for intellectual property protection, sustainable utilization and posterity.

MISSION

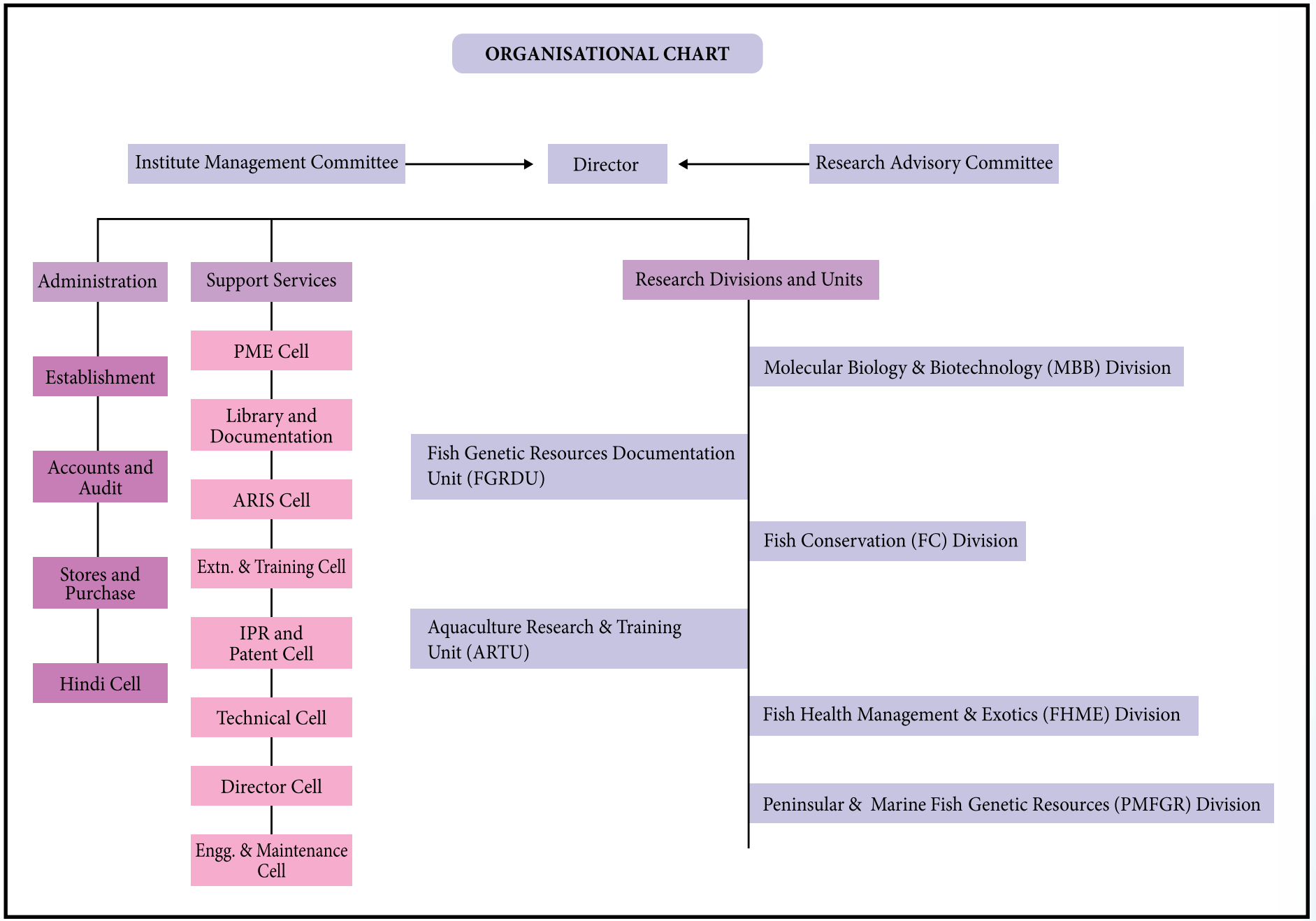
Collection, cataloguing and documentation of fish genetic resources using operational strategies of partnership and cutting-edge technologies

MANDATE

Exploration, characterization and cataloguing of fish genetic resources.

Maintenance and preservation of fish genetic resources for conservation and utilization of prioritized species.

Evaluation of indigenous and exotic germplasm including risk assessment and fish health.


ORGANISATIONAL CHART
Institute Management Committee
Director
Research Advisory Committee
Administration
Establishment
Accounts and Audit
Stores and Purchase
Hindi Cell
Support Services
PME Cell
Library and Documentation
ARIS Cell
Extn. & Training Cell
IPR and Patent Cell
Technical Cell
Director Cell
Engg. & Maintenance Cell
Research Divisions and Units
Molecular Biology & Biotechnology (MBB) Division
Fish Genetic Resources Documentation Unit (FGRDU)
Fish Conservation (FC) Division
Aquaculture Research & Training Unit (ARTU)
Fish Health Management & Exotics (FHME) Division
Peninsular & Marine Fish Genetic Resources (PMFGR) Division

RESEARCH ACHIEVEMENTS

Program 4.1: Exploration, species characterization and cataloguing of fish genetic resources

The vast aquatic resources of India are a source of rich biological wealth that provides ample opportunities for development of fisheries sector. India harbours approximately 10% of global fishery resource, which are present in different water bodies, *viz*., sea, rivers, streams, wetlands, reservoirs, lakes, etc. Aquatic germplasm are turning out to be an important genomic resource with lots of commercial, nutritional, pharmaceutical and ornamental values. The appropriate conservation efforts are need of the hour to protect this vast biological wealth for the posterity, and for which explorations is the first and fore most essential component to assess the status of these aquatic resources.

Exploration is an important ongoing activity of the institute, as part of the scientific research on assessment of the aquatic genetic resource as well as their probable management approach. This tool is useful for discovery of new species or to record extension of range of the species from different aquatic resources, which can further be evaluated to ascertain their ecological or commercial importance. The institute has been undertaking systematic explorations, since its inception, to update fish diversity status of the country, including alien species, in various water bodies. The activities on species richness in the waterbody, features of habitat, topology, etc. will help in suggesting appropriate conservation measures and domestication protocols for the species.

Project: Exploration and cataloguing of the fish diversity from marine island ecosystems and Cauvery River basin

Subproject 1: Exploration and cataloguing of the fish diversity from Cauvery River basin

Period: April, 2014 - March, 2019

Personnel: V. S. Basheer (PI) and Charan Ravi

Funding Support: Institutional, ICAR-NBFGR

Exploratory surveys were conducted in the middle and upper reaches of the Cauvery (6 stations) in Karnataka and Kerala (5 stations) (Fig. 1).

Fig. 1 Sampling location in Cauvery River

These regions represent the headwaters of the Kabini, a major tributary of the Cauvery, in Kerala as well as the region below the Kabini reservoir in Karnataka. We also continued sampling the main Cauvery channel between the KRS reservoir and Shivanasamudra falls which was started in 2018. Habitat in the riverine stretches was mostly composed of strong flow over bedrock and boulders, with numerous cascades. The survey yielded an addition of 18 more species of freshwater fish bringing a total of 110 species, belonging to 8 orders, 25 families and 66 genera (Fig. 2), covering 18 endemic species, 78 native

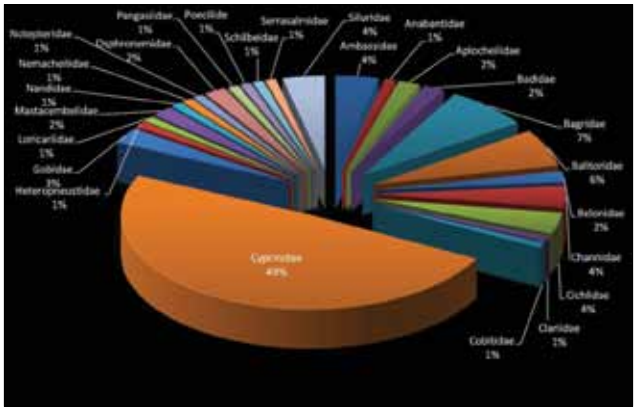


Fig. 2 Percentage of fishes, family wise in the sampling

species, 4 stocked and 10 exotic species. Cyprinidae is the most abundant family, contributing 49 % of the fish fauna of the Cauvery followed by family Bagridae, second most abundant with 7% of the total species. Majority of the fishes were under status of Least Concern, while four species under critically endangered and 6 species under endangered category as per the IUCN status (Fig. 3).

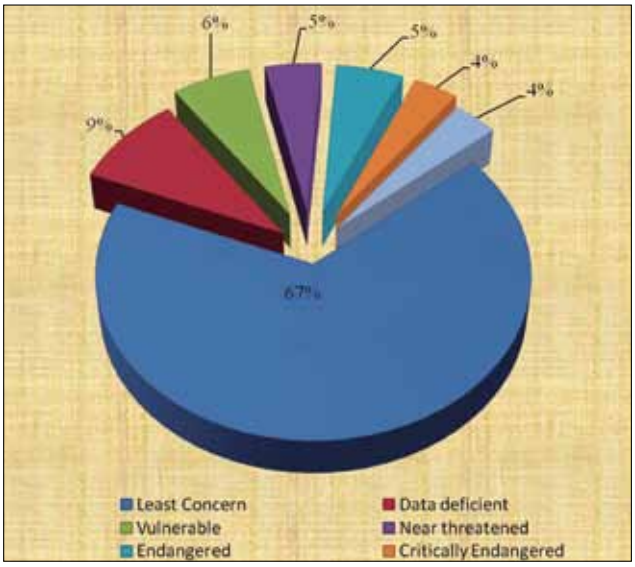


Fig. 3 Conservation status of fishes as per IUCN criteria

Significant Findings

Many of the indigenous fishes were observed first time from the Cauvery River systems. Specimens of *Kantaka brevidorsalis,* an endemic cyprinid species were sampled from the KRS dam, which is the first time we have encountered this species from this location (Fig. 4). Specimens of *Pristolepis marginata* were collected from KRS dam during this sampling. While this species has been previously encountered in Coorg, this is the first time we have come across individuals downstream. Fishermen, who refer to the fish as "native tilapia", say the species is rarely encountered there. Few specimens of *Osteobrama sp.* were collected from Hemmige and according to local fishermen this is the first time, this species has been encountered in their fishing activity. This probably due to the heavy rains and water release from Kabini dam. Specimens of the critically endangered catfish *Hemibagrus punctatus*, including sexually mature individuals of both sexes, were obtained from Hemmige (above the dam), Shivanasamudra and KRS. Some specimens were with oozing eggs in September, indicating the spawning season commences with the onset of the monsoons and extends for a few months after. There is a good market for this species, and

Fig. 4 Collection of *K. brevidorsalis* for the first time from KRS Dam

8-10 specimens were encountered daily at all landing centers. A gravid female specimen of *Hypselobarbus micropogon*, oozing eggs, was encountered at KRS in September, suggesting this species spawns in the post-monsoon period. Specimens of *Amblypharyngodon mola* were encountered at Hemmige and KRS dam. This is for the first time we have encountered this species from Cauvery in Karnataka. Specimens of the endemic *Neolissocheilus wynaadensis*, *Pterocryptis wynaadensis* and *Pethia nigripinna* were collected from the headwaters of the Kabini in Wayanad (Fig. 5).

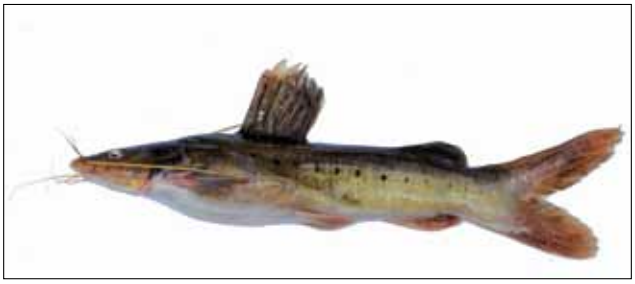
P. wayandensis

P. marginata

Osteobrama sp.

N. wynaadensis

K. brevodorsalis



H. puctatus

H. micropogon

A. mola

Fig. 4 Collection of fishes from Kabini in Wayanad

Presence of exotic fishes

The Nile tilapia was observed at most landing centres, and was the most commonly encountered tilapia species, replacing the Mozambique tilapia in the fish catch. It is observed and also got information from fishermen that after appearing Nile tilapia, *Oreochromis niloticus,* the mossambique tilapia, *O. mossambicus* is totally washed out. The invasive African catfish were also collected from Mananthavady river, tributary of Kabani River, for the first time following the monsoons in 2018. It was earlier only reported from the river at Panamaram. It was told that after the last flood in Kerala, African catfish, *Clarias gariepinus* spreaded to most of the rivers in Wayanad. A gravid individual of the invasive suckermouth catfish, *Pterygoplichthys sp.* was encountered at Shivanasamudra, indicating this species is reproducing in the wild and it might be established in the Cauvery basin in Karnataka. Heavy silt deposition was observed in the upper reaches of the Kabini and the water was still turbid in January. Further observations will reveal whether this will have any long term impact on the aquatic fauna and this will be more helpful invasive species to spread in these rivers.

Project: Exploration and Cataloguing of the Fish Diversity from Marine island Ecosystems and Cauvery river basin
Sub-project 2: Survey and Collection of fishes from Marine Islands (Andaman & Lakshadweep)
Period: April, 2014 - March, 2020
Personnel: T. T. Ajith Kumar (PI), A. Kathirvelpandian and Teena Jayakumar T. K.
Funding Support: Institutional, ICAR-NBFGR

Exploratory surveys were carried out at the tidal pools of Chidiya Tapu region, Andaman. Three species belongs the family Gobiidae, one species of each from Blennidae and Labridae were obtained. Adding this with earlier collection, 91 species of marine fishes belonging 8 orders, 42 families and 71 genera from Andaman Islands were collected.

Among the collected fishes, a single individual of the wrasse, *Leptojulis lambdastigma* was obtained from Chidiyatapu (Fig. 6). The species is widely distributed in Western Pacific; Taiwan and the Philippines and the present specimen represents the first record of the species from Indian Ocean, suggesting the range extension of the species in Indian waters.

In Lakshadweep, surveys were conducted at Agatti, Bangaram, Thinnakara, Parali I and Parali II islands during January and February 2019 (Fig. 7 a & b). 49 species of marine fishes belonging to 5 orders, 24 families and 36 genera were collected, besides live Tilapia specimen were collected from the Bangaram lake. Occurrence of Red blotch Razorfish, *Lniistius twistii* was found in Agatti, which is the first occurrence of the species in Lakshadweep waters.

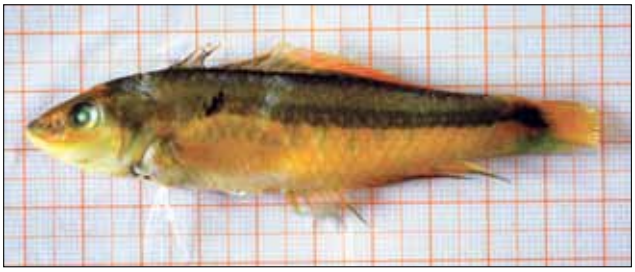


Fig. 6 *L. lambdastigma,* collected from the Andaman Sea, first record from the Indian waters

Fig. 7a Exploring marine biodiversity at Bangaram island of Lakshadweep

Fig. 7b Exploration at Bangaram island, Lakshadweep

Project: Exploration for fish diversity assessment and traditional ecological knowledge in lower Mahanadi basin
Period: April, 2016 - March, 2019
Personnel: Lalit K. Tyagi (PI), Sangeeta Mandal, Trivesh S. Mayekar, Rejani Chandran, Amit S. Bisht and Sanjay K. Singh
Funding Support: Institutional, ICAR- NBFGR

Exploration and assessment of fish diversity is a prerequisite for sustainable management and protection of biodiversity. Project aims at exploring and assessing the fish diversity and traditional ecological knowledge in the lower Mahanadi basin and its associated important tributaries that join it in the lower basin, namely, Tel, Ib, and Ong. Six primary exploratory surveys has been undertaken, since the inception of project in 2016 covering 28 sites of river Mahanadi and its tributaries. One focused exploration survey was conducted in lower Mahanadi and its tributaries during this year and 13 sites were explored for fish diversity and tissue collections (Fig. 8 & 9). Focus was on estuarine region of Mahanadi river and selected less explored sites of Tel and Ong tributaries. Data (length and truss image) on a total of 482 fish samples were recorded during exploration.

A total of 120 finfish and two shellfish species belonging to 14 orders, 43 families and 85 genera have been recorded so far from explorations. Cyprinidae (39%) was the most predominant family followed by Bagridae (6%) (Fig. 10). In addition to the 112 species recorded in the first two years, 10 additional species were identified during the exploration this year. Site-wise and season-wise fish diversity data was analysed for lower Mahanadi and its tributaries Tel and Ong. Results indicated low species dominance, high diversity and high evenness across all major sites of rivers explored in the lower Mahanadi basin across three seasons (Fig. 11, 12 & 13).

In lower Mahanadi river, total species recorded were 116. Maximum site-wise catch was recorded from Sonepur (1149) followed by Sadakghat (502), where as maximum species recorded were from site

Fig. 8 & 9 Explorations for fish diversity in lower Mahanadi basin.

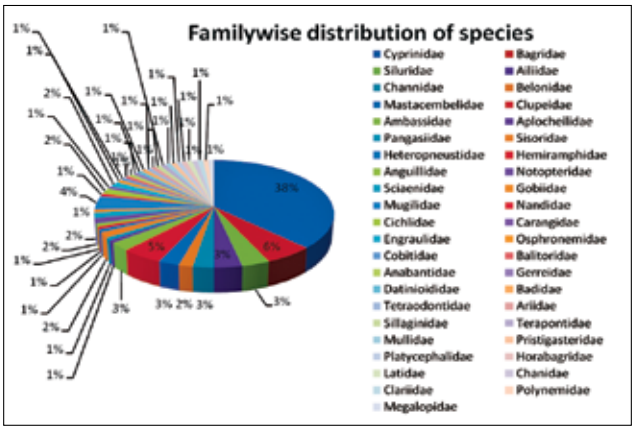


Fig. 10 Family-wise distribution of fish species in lower Mahanadi basin

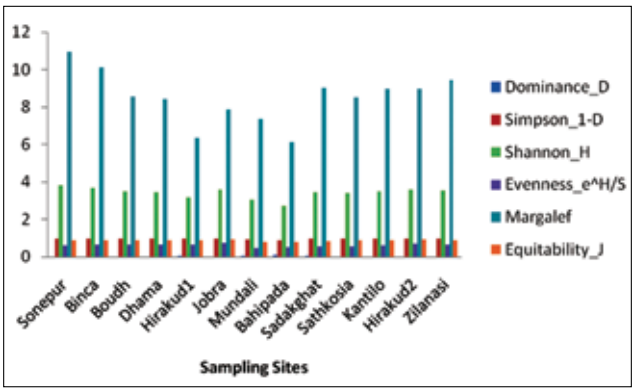


Fig. 11 Sitewise diversity indices observed along various sites of Lower Mahanadi

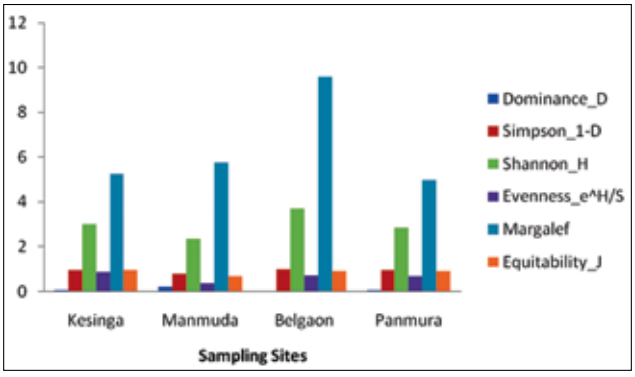


Fig. 12 Sitewise diversity indices observed along various sites of Tel tributary

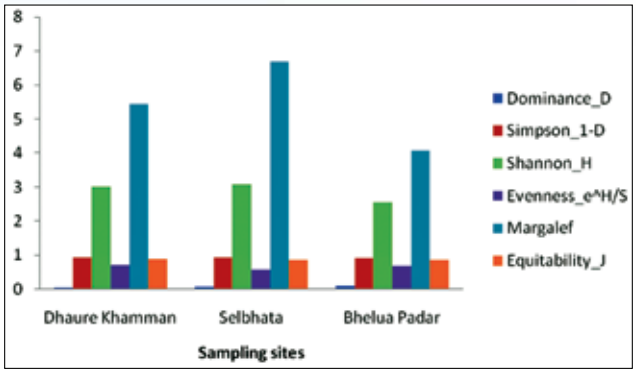


Fig. 13 Sitewise diversity indices observed along various sites of Ong tributary

Sonepur (78 species), followed by, Binka (62 species). Most relatively abundant species was *Cirrhinus reba* (6.25%), followed by *Rita chrysea* (4.39%) of total catch. Seasonal diversity was highest in post-monsoon, followed by, monsoon and pre-monsoon, respectively.

In Tel river, total species recorded were 72. Maximum site-wise catch was recorded from Belgaon, followed by Manmuda where as maximum species recorded were from sites Belgaon (59), followed by, Manmuda (31). Most relatively abundant species was *Chelon parsia* (10.17%), followed by *Cabdio morar* (5.47%), of total catch. Seasonal diversity was highest in post monsoon, followed by, monsoon and pre-monsoon, respectively.

In Ong river, total species recorded were 63. Maximum site-wise catch was recorded from Selbhata, followed by Dhaura Khaman where as maximum species recorded were from sites Selbhata (37), followed by Dhaura Khaman (29). Most relatively abundant species was *Puntius sophore* (10.1%), followed by *Barilius bendelisis* (6.55%). Seasonal diversity was highest in monsoon followed by post monsoon.

Habitat parameters, i.e., micro-habitat type, riparian and aquatic vegetation, dominant substratum were recorded from all the surveyed sites along with water parameters, like, temperature, DO, salinity, TDS and turbidity. Data on perceptions of fishing communities about fish diversity, associated socio-economic aspects and traditional ecological knowledge, from 450 fishermen/ women from 45 villages of the four rivers (lower Mahanadi - 25 villages, Tel - 7 villages, Ib - 10 villages and Ong - 3 villages), was analysed.

Project: Exploration and assessment of fish diversity of mid Himalayan tributaries and wetlands of Ganga river System

Period: April, 2017 - March, 2019

Personnel: Kripal Datt Joshi (PI), Ajey K. Pathak, Santosh Kumar, Rajesh Dayal, Ajay K. Singh and Ravi Kumar

Funding Support: Institutional, ICAR- NBFGR

Conducted exploratory surveys and sampling of the rivers - Gandak, Burhi Gandak, Baghmati and Saraiyamaun wetland of North Bihar during the period. Conducted summer and winter samplings at 7 selected sites of the rivers at Valmikinagar, Dhanaha Bridge & Dumariyaghat in Gandak river; Lalbaghiya & Scinghiyaghat in Burhi Gandak; Belwaghat & Kewatsa in Bagmati river (Table 1 & Fig. 14). The rivers are almost in similar geographic region so vital water quality parameters and substratum conditions were also in almost similar ranges. The substratum profile gradually changes from gravel, sand & silt laden in up-stream segments to sand, silt and clay towards mid and downstream stretches of the rivers.

Table 1. Locations of the sampling sites on different rivers

S.N.	Centres	Longitude	Latitude
River Gandak			
1	Valmikinagar	E 83°54.555’	N 27°26.194’
2	Bagaha (Dhanaha bridge)	E 84°09.960’	N 26°58.088’
3	Dumarigaon	E 84°45.796’	N 26°46.825’
River Burhi Gandak			
1	Tharghatwa-Lalmania, Mahuagaon	E 85°00.755’	N 26°39.570’
2	Singhiya Ghat	E 85°59.556’	N 25°45.122’
River Bagmati			
1	Belwaghat	E 85°00.829’	N 26°39.222’
2	Kewatsa	E 85°44’6.69”	N 26°12’11.80”

The water temperature during winters varied between 18.01°C (Bewaghat, Bagmati) and 18.7°C (Valmikinagar, Gandak). The water was alkaline in nature (pH 8.23 - 8.46) with low to moderately high dissolved oxygen content (4.88-8.13 mgl^{-1}). Values of total dissolved solids (TDS) and conductance were between 138.0 to 199.0 mgl^{-1} and 260.0-383.0 µmhos, respectively.

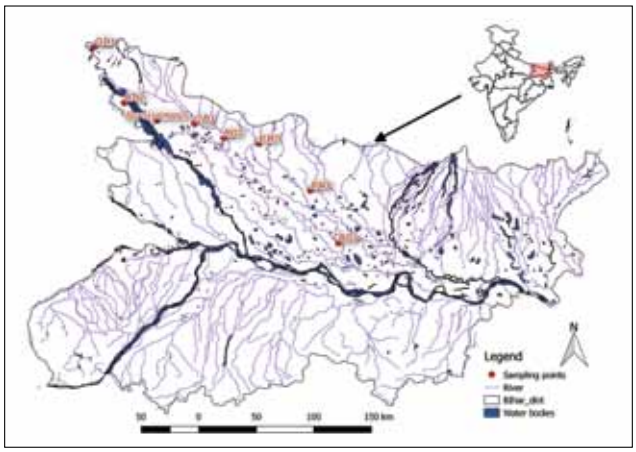


Fig. 14 Map of the sampling sites on the rivers of North Bihar

Due to habitat similarity, fish diversity of the rivers is also similar with some site specific minor variations. A total of 85 fish species were observed from the rivers under 9 orders, 23 families and 64 genera. The number of species observed from the rivers, Gandak, Burhi Gandak and Bagmati were 71, 61 and 67, respectively. The rivers are highly exploited as evidenced by operating fishers' population and availability of smaller sized fishes only in the catches. Lesser flow and depth particularly during lean season, dearth of deep pools and over-fishing are some of the reason could be attributed for poor fishery in the rivers. However, a giant catfish, *Sperata seenghala* (body length - 110 cm, weight - 8100 g) was observed at Valmikinagar in the river Gandak, indicate rare occurrence of some large sized fishes in the river (Fig. 15). The upstream stretches of all three rivers mainly dominated by small sized cyprinids. Small sized minnows, like *Salmostoma bacaila* and *Securicula gora* form sizeable fishery at Valmikinagar and Dhanaha bridge sites of the river Gandak. Despite the small size, these fishes has immense importance as table fish in nearby road hotels. Minnows form 60-70% of total fish catch (by weight) at these stretches. *Hara hara* (Fig. 16) and *Barilius barna* (Fig. 17) were collected for the first time from the rivers of North Bihar (Fig. 18). Stray samples of alien fishes - *Ctenopharyngodon idella* and *Cyprinus carpio* were caught from downstream stretch of Burhi Gandak river.

Fig. 15 A giant catfish, *Sperata seenghala* observed at Valmikinagar

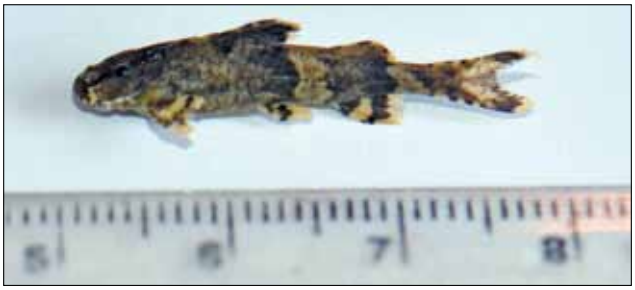


Fig. 16 *Hara hara* collected for the first time at Belwaghat in Bagmati river

Fig. 17 *Barilius barna* collected for the first time at Belwaghat in Bagmati river

Fig. 18 Fishing at Belwaghat, river Bagmati

Studies on Saraiyamaun wetland

Saraiyamaun (E 84° 26.112', N 26°48.798') is a ring shaped wetland located about 15 km from Bettiah town, in West Champaran district of Bihar. The wetland is spread over 319 ha area, the water spread area is approximately 15 km in length and 270 to 550 m in width at different places. It is situated at an elevation of 65 m from sea level. The main source of water is precipitation and runoff from the catchment area. The wetland is connected to river Gandak through a man-made canal which has a sluice gate. The excess flood water of the river is allowed to enter in the wetland. One seasonal stream connects the wetland to river Gandak.

A total of 45 fish species were recorded from Saraiyamaun wetland comprising 7 orders, 18 families and 34 genera (Fig. 19). The maximum weight of the samples caught during the sampling varied from 5.23 gm (*Parambassis ranga*) to 137.42 gm (*Channa striatus*).

The past record reveals that the wetland had been leased during 1983 at the amount of Rs. 13,000.00. There are also record of depleting fishery of the wetland in the past, therefore, 80,000 fingerlings were reportedly stocked in the wetland by forest department in the year 1963. The wetland periphery is densely populated with fishers population. A total of 12 fishers' hamlets/ villages are situated on periphery of the wetland. It was observed during the study that 200-250 fishermen with boats operates in the wetland on daily basis and fish catch of the fishers varied from 0.5 to 1.5 kg/day. The total fish production of the wetland is estimated to 228 kg/ha/year and 73.0 t/year. The fish catch mostly comprised of small sized omni-carnivorous fishes dominated by *Channa* species. Stray samples of *Ctenopharyngodon idella* and *Cyprinus carpio* collected from the wetland evidenced presence of alien fish.

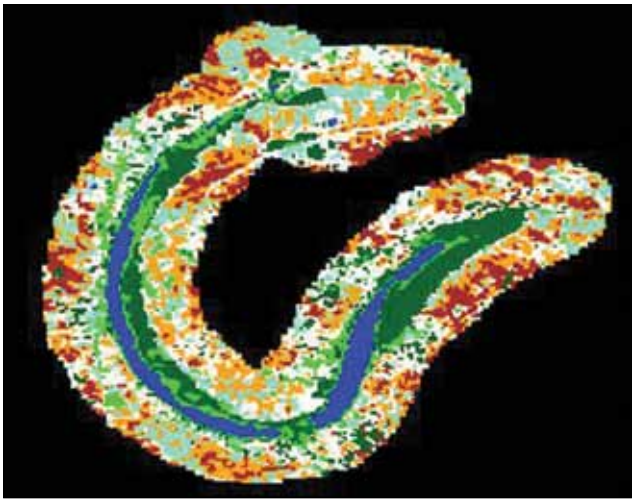
Assessment of socio-economic profile and livelihood issues of 50 fisher families of Bind Tola depend on the wetland has been done. The fishers of Bindtola and Majhariya colony situated at the bank of Saraiyamaun wetland were studied to assess some socio-economic attributes. The fishers are of 22 to 88 years of age, but mostly are between 35-60 years. The most of the fishers belong to OBC class and are landless, however, the maximum land holding was up to 1.6 ha, hence, the source of livelihood of the fishermen families is fishing. A few only engaged in agriculture, horticultural crops and cattle rearing. The fish catch mostly comprised of small sized omni-carnivorous fishes dominated by *Channa* species. Stray samples of *C. idella* and *C. carpio* collected from the wetland evidenced presence of alien fish.

Fig. 19 Fish sale site at Majhariya, Saraiyamaun wetland

Changes in wetland habitats

Land use/ cover map of Saraiyamaun for time duration of 2013 & 2018 were evaluated to understand the time scale changes. Landsat 8 satellite data of 30 meters resolution of above years was downloaded to assess the change in different landscape classes of the wetland. To study the wetland and its riparian corridor, a buffer of 0.5 km was created around the lake and the area for each geographical entity was calculated for the estimated wetland area of 4.5 km^2. The buffer area around the wetland is 12.786 km^2 and total area under the study is 17.286 km^2. For assessment of each landscape class, unsupervised and Principal Component 4 (PC4) classification techniques with unsupervised learning were used.

Map of 2018



Map of 2013

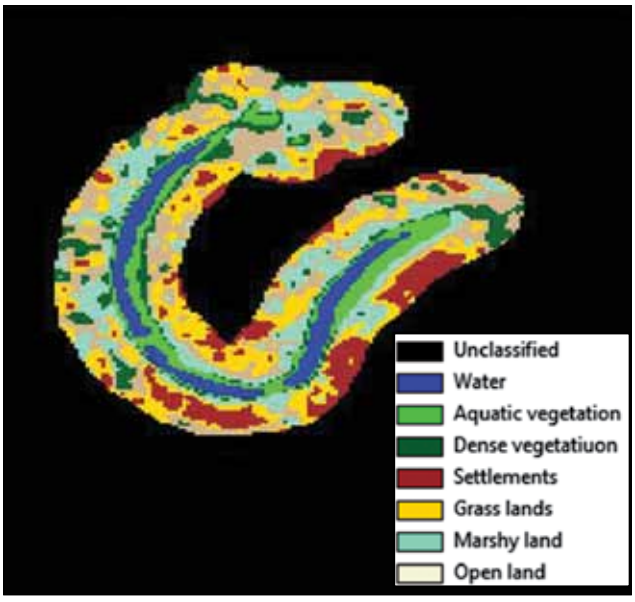


Fig. 20 Land use/ Land cover classification map using unsupervised classification

Based on the landscape geography of the study area, seven classes were prepared using the above classification techniques. Sizeable decrease in the area under 'Water', 'Settlements', 'Aquatic vegetation' and 'Open land' was observed during 2013 to 2018 (Fig. 20). On the contrary, the area under 'Dense vegetation', 'Grass lands' and 'Marshy lands' increased during the same period. Comparison of the changes in land use patterns as mentioned above, indicate rapid succession of the wetland from aquatic to terrestrial habitat during the study period.

Unlike river Ganga, established alien species were not observed from any of the river and wetland sites. However, stray samples of *Ctenopharyngodon idella* and *Cyprinus carpio* were observed from downstream stretch of Burhi Gandak river and also from Saraiyamaun wetland. Owing to low lying area along the river banks and course diversion trend of the rivers, there are ample chance of escape of farmed fishes to the nearby rivers and wetlands.

Project: **Exploring our wetlands: Establishing DNA barcodes for finfishes and shellfishes of Ramsar sites in Kerala.**

Period: **January, 2016 - December, 2019**

Personnel: **P. R. Divya (PI)**

Funding Support: **Kerala State Council for Science Technology and Environment, Govt. of Kerala**

Collection of fish and shellfish samples from Ashtamudi and Vembanad lake, their identification, maintenance of tissue and voucher specimens and generation of barcodes was the main objective assigned for 3rd year. Two collections were made from 2 sampling sites of Ashtamudi lake, *viz.*, Sakthikulangara and Kavanad. Collections were also made from 3 sampling sites of Vembanad lake, *viz.*, Murinjapuzha, Vaikom and Kalamukku. 31 species were collected from Vembanad Lake comprising 23 genera of 18 families. 12 additional species were collected from Ashtamudi lake, comprising 11 genera of 9 families. Crabs including *Scylla olivacea, Portunus reticulatus, Thalamita cranata* and *Charybdis variegata* and fishes, *Aesopia cornuta, Chaetodon collare, Scarusiseri, Saurida cf. micropectoralis, Trachinotus bailloni* are new records from the Ashtamudi lake. Voucher specimens are tagged and maintained in NBFGR repository. Photographs were taken for all the species. DNA extraction was completed from all the specimens collected during study. Secondary information is being collected for the voucher specimens with a view to prepare a complete handbook on the fishery resource of Ramsar sites.

Phylogenetic relationships among various species of Vembanad Lake were assessed by analyzing COI gene using the Bioedit and MEGA 5.0 software. The overall mean distance among the species of Vembanad was found to be 0.248. Generated 655 bp regions of cytochrome oxidase I region (DNA Barcodes) of 72 species of Ashtamudi lake, 15 species from Sasthamkotta and 112 spp of Vembanad lake. Phylogenetic relationships among various species of Ashtamudi lake were analyzed using the Bioedit and MEGA 5.0 software and the mean genetic distance within fish species, genera, families and orders were calculated to be 0.26 %, 6.6 %, 9.8 % and 15.8 %. Mean genetic distance among the genus *Portunus, Charybdis* and *Scylla* were 0.14, 0.04 and 0.036, respectively. Phylogenetic analyses among crabs of Ashtamudi (Fig. 21) were done and the evolutionary tree inferred using the Maximum Likelihood method based on the Tamura-Nei model is given in Fig. 22.

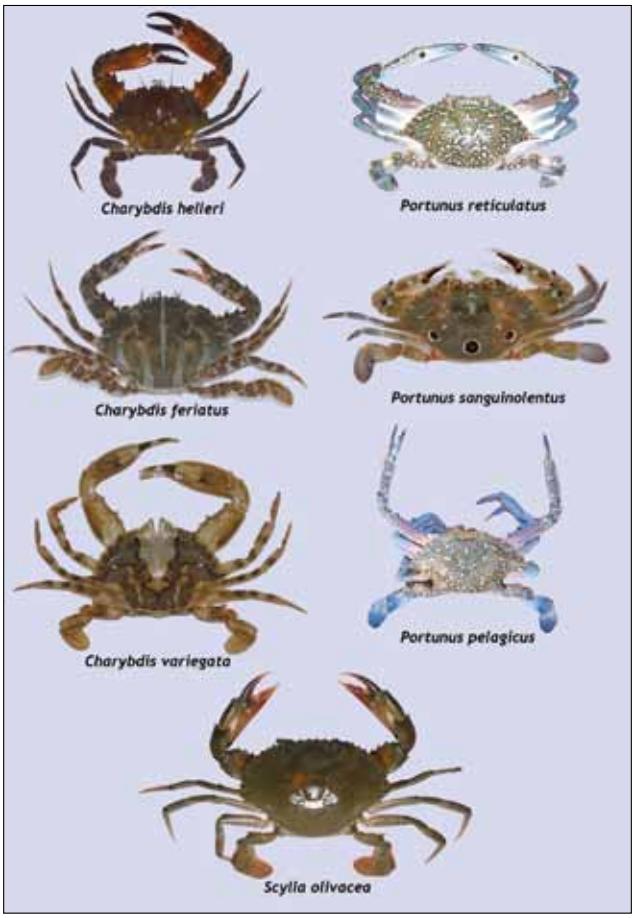


Fig. 21 Images of crabs collected from Ashtamudi estuary

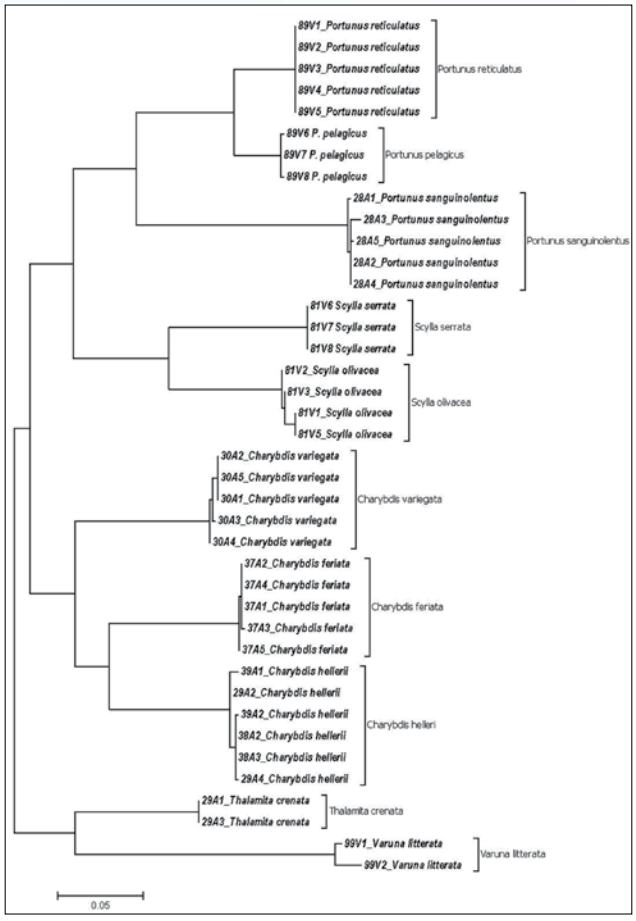


Fig. 22 The evolutionary tree inferred among crabs of Ashtamudi using the Maximum Likelihood method based on the Tamura-Nei model

Photographs were taken for all the 187 species recorded from Ramsar regions in Kerala. Secondary information is collected for the voucher specimens with a view to prepare a complete handbook on the fishery resource of this region.

Project: Molecular taxonomy and phylogeny of Cones (Cone, snails) and Strombs (Mollusca, Gastropoda) of the Indian coast.
Period: November, 2015 - November, 2018
Personnel: Laxmilatha P. (PI), Ranjith L. (ICAR-CMFRI, Kochi) and A. Kathirvelpandian (ICAR-NBFGR, PMFGR Centre, Kochi)
Funding Support: Department of Biotechnology, Govt. of India

In total, 45 individuals from 15 species of the families Conidae (12) and Strombidae (3) were collected from six sites along the Andaman Nicobar islands (South Andaman - Bermenella, Wandoor, Havelock Middle Andaman - Mayabandhar, North Andaman - Diglipur, Areal Bay) and Mandapam, Gulf of Mannar, South east coast of India. Specimens were identified based on shell morphology; morphometric and meristic data were recorded. Muscular tissue from the foot or mantle of the *Conus* and strombid specimens were used for total genomic DNA extraction. A customized marine animal kit, premium according to the manufacturer's instructions (Origin) was used and the DNA isolation was standardized to obtain optimum quality DNA.

Fragments of the mitochondrial genes, 12S rRNA, 16S rRNA, cytochrome oxidase subunit I (COI) and nuclear H3 gene were amplified using universal primers 12S1/12SB (Simon, Franke & Martin, 1991; Palumbi, 1996), 16Sar/16Sbr (Palumbi, 1996), LCO1490/HCO2198 (Folmer *et al.*, 1994), H3a/H3B (Colgan *et al.*, 1998), respectively. PCR amplification of 45 individuals from 15 species of the families Conidae and Strombidae for all the four genes were completed. The product size of 640 bp (COI); 420 bp (12s rRNA), 510 bp (16s rRNA) and 320 bp (H3) were obtained.

Molecular confirmation of phenotypic plasticity in *Conus catus*

Integrated taxonomy reveals the exceptional phenotypic plasticity in *Conus catus* among the Andaman and Lakshadweep archipelagos. Species delimitation in the cone snails has long been difficult, because of its extraordinary taxonomic and ecological diversity. Shell characters and primarily colour patterns are the basic taxonomic. Molecular sequence data from three mitochondrial gene regions (16S rRNA, 12S rRNA and cytochrome oxidase subunit I) and one nuclear gene (Histone3) were used to resolve phenotypic plasticity among the *C. catus* in varying ecosystems of Andaman and Lakshadweep archipelagos.

Project: Systematic review and evolutionary study of Indian Clupeiform fishes
Period: April, 2017 - March, 2020
Personnel: Mahender Singh (PI), T. T. Ajithkumar, Murali S., Teena Jayakumar T. K. and Akhilesh K. Mishra
Funding Support: Institutional, ICAR-NBFGR

The fishes of order Clupeiformes are commercially important in terms of food, forage and pharmacological uses. Their catch, from Indian marine fish landing centres, steadily declined from 27.89% (total catch of 3.78 MMT in 2013) to 20.46% (total catch of 3.73 MMT in 2016). The successive annual decrease might be due to overexploitation (FAO, 2010) and rising ocean temperature. The location of India is nearly in the centre of World's richest ichthyo-diversity hotspot, i.e., Indo-West Pacific (IWP) region, for marine fishes, including Clupeiformes. India has major stake in IWP region and great potential for enhancing Clupeiform fish landing from EEZs. The aim of the project was to assess the species-wise genetic diversity present in the fishes of this order, which will help in sustainable management of capture fisheries.

During the year, marine waters in five states, namely, Tamil Nadu, Maharashtra, Kerala, Gujarat and Odisha and Union Territory of Lakshadweep were explored and 533 tissue samples and voucher specimens of 38 Clupeiform species were collected. In Tamil Nadu, Cuddalore coast was explored and 24 tissue samples of five species, namely, *Ilisha melastoma, Sardinella fimbriata, Sardinella melanura, Thryssa mystax* and *Thryssa* sp. were collected. Seven samples of *Sparatelloides* sp. were collected from Suheli island of Lakshadweep. In Maharashtra, 30 tissue samples of eight species, *viz., Coilia dussumieri, I. megaloptera, Ilisha* sp., *S. fimbriata, Tenualosa toli, T. hamiltoni, T. mystax, Thryssa* sp. were collected from Thane district, whereas, 20 tissue samples of 7 species, *viz., Dussumieria acuta, I. melastoma, I. sirishai, S. longiceps, Sardinella* sp., *T. toli, Thryssa* sp. were collected from Alibag district. In the same exploration, 20 samples of *Chirocentrus nudus, Hilsa kelee, I. melastoma, Opisthopterus tardoore, S. albella, T. dussumieri, T. setirostris, Thryssa* sp. from Anjarale and 20 samples of *Sardinella* sp., *Sparetelloides* sp., *T. mystax*, *Thryssa* sp. were collected from the landing centres of Mirkarwada region of Ratngiri district. From the landing centres of Kochi, 38 tissue samples of 5 species, namely, *Dayella malabarica, Ehirava fluviatilis, Stolephorus commersonii, S. waitei* and *T. hamiltonii* were collected.

A total of 183 tissue samples of 14 fish species belonging to 9 genera of 4 families of Clupeiformes were collected from Gujarat and identified based on morphomeristic characters. Further, specimens from *Sardinella* and *Ilisha* genus are under study for confirmation of species. *Amblygaster clupeoides, Anodontostoma chacunda, C. dorab, C. nudus, Coilia dussumieri, Dussumieria acuta, Hilsa kelee, T. toli, Ilisha* sp., *Opisthopterus tardoore, S. longiceps, Sardinella* sp., *T. dussumieri, T. hamiltoni, T. mystax* and *Thryssa* sp. were collected from Veraval, Mangrol and Porbandar area of Gujarat.

A total of 190 tissue samples of 19 fish species belonging to 12 genera of 4 families of Clupeiformes were collected from Odisha during the exploration and identified based on morphomeristic characters. Due to overlapping characters among congeners, specimens from *Sardinella* and *Ilisha* genera are under study for species confirmation. *Anodontostoma chacunda, C. dorab, C. nudus, C. dussumieri, Escualosa thoracata, Gudusia chapra, Goniolosa manmina, T. ilisha, H. kelee, Ilisha* sp., *Nematolosa nasus, O. tardoore, S. longiceps, Sardinella sp., Setipinna phasa, S. taty, S. commersonii, T. dussumieri, T. malabarica, T. mystax, T. setirostris* and *Thryssa* sp. were collected from Asthran, Chilka lake, Cuttack, Gopalpur, Manglajodi, Paradeep, Puri and Rambha landing centres/areas of Odisha coast. The photographs of fish were taken on graph paper as well as the morphomeristic characters were recorded. Length-weight relationship analysis was carried out for *Amblygaster indiana* species (Table 2 and Fig. 23).

DNA isolation and PCR amplification of mitochondrial gene Cytochrome c oxidase I (COI) was carried out for all 533 samples. Sequencing of COI gene was carried out following the di-deoxynucleotide chain termination method, using an automated ABI 3500 sequencer. The edited sequences were blasted in NCBI GenBank for the nearest similar sequence matches. Sequences were analysed by multiple sequence alignment using MEGA 7 software for nucleotide composition, number of polymorphic sites (S), pairwise genetic distance, and phylogenetic analysis based on Maximum likelihood. COI-DNA sequence analysis was performed for getting the inter-species genetic distance and phylogenetic analysis showed that the congeners are claded together. The interesting finding is that sub-clad formation within species, *viz., D. acuta* and *T. setirostris,* will be resolved after thorough morphomeristic analysis. These two cases are being studied with collection of more samples, additional morphomeristic characters and re-sequencing of COI gene. The genetic distance

Table 2. Length-weight relationship and condition factor of *A. indiana*

Sex	N	Total Length		Total Weight (g)		K	a	b	r^2
		Min-Max	Mean±SD	Min-Max	Mean±SD				
Combined	82	20.9-25.72	23.89±0.9	82-194	158.76±21.04	1.15±0.08	-2.43	3.36	0.73
Male	26	20.9-24.87	23.23±0.93	82-185.5	139.65±21.65	1.16±0.1	-2.89	3.68	0.71
Female	56	22.3-25.72	21.19±0.70	131.5-194	167.63±13.65	1.18±0.06	-0.88	2.24	0.62

N=Number of individuals, K=Mean Condition Factor, a=Regression constant, b= coefficient, r^2= Correlation coefficient

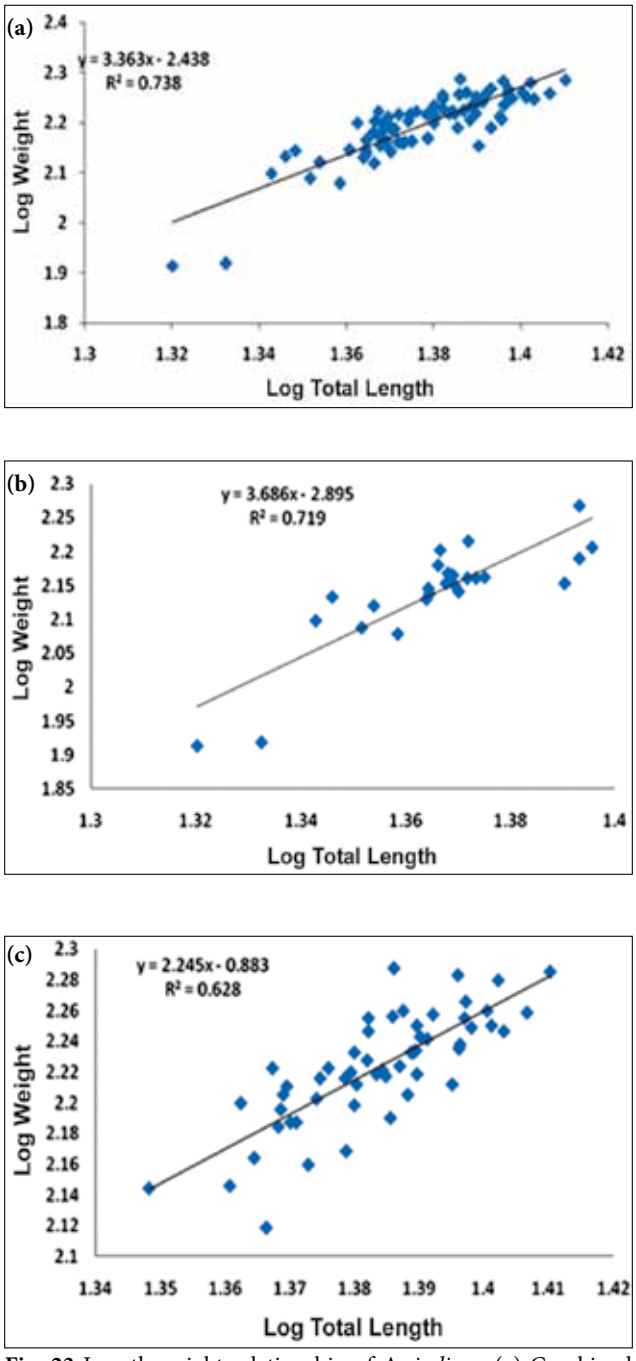


Fig. 23 Length-weight relationship of A. *indiana* (a) Combined sexes (b) Males (c) Females

between *C. dorab* and *C. nudus* was 20.97%, *D. acuta* and *D. elopsoides* was 14.35% and *T. dussumieri* and *T. mystax* was 19.64%.

Project : Quantifying Agrobiodiversity and Ecosystem Services in Godavari River Basin Landscape

Period: February, 2018 - July, 2019

Personnel: Kuldeep K. Lal (Coordinator), Rajeev K. Singh (PI), L. K. Tyagi, Achal Singh, Rejani Chandran and Kantharajan G.

Funding Support: Bioversity International

GIS mapping and hydrology analysis

GIS mapping was used to analyze landscape changes occurred during last 4 decades using remote sensing. The boundary/village/LULC map of three selected districts, *viz.*, Adilabad, Karimnagar and West Godavari, were prepared. LULC map of these sites were prepared to understand how development has affected the land use pattern in these three districts (Fig. 24 a & b). For the non-point source pollution assessment, In Vest and HSPF models were used in the watersheds.

Selection of villages and finalization of survey formats

Adilabad (dominating reserve forest zone) area with minimal human intervention, Karimnagar (intensive paddy production area of Telangana) and West Godavari (intensive shrimp farming zone) were the target areas for survey and documentation of agrobiodiversity. A total of 204 villages (2nd tier) were selected (95% confidence interval with error margin of 5) while 147 for 1st tier. In Adilabad (1st tier 54; 2nd

tier 77); Karimnagar (1st tier 52; 2nd tier 72), and West Godavari (1st tier 41; 2nd tier 55) villages were selected through stratified random sampling and proportional allocation. For collection of biophysical and socio-economic data from the selected area, five formats were prepared in consultation with Bioversity International. The survey was done in 9 villages of Andhra Pradesh and Telangana to interact with farmers, fishermen and other stakeholders.

Documentation of Aquatic diversity

Fish diversity

A total of 46 species were documented which included both brackish water as well as freshwater ecosystems. Planktons were collected from sieved water (200L) from these locations (Fig. 25). Observations revealed a dominance of group Chlorophyta among phytoplanktons followed by bacillariophyta and cyanophyta, while among zooplanktons, rotifera dominated followed by copepod and cladocera. Gut samples of few commercially important species occupying different trophic levels, like, *Pangasianodon hypophthalmus, Labeo rohita* and *Notopterus notopterus* collected and analysed.

Water analysis

Water samples were collected during this pilot study from 2 riverine locations, namely, Soan and Rajaram. Water sample analysis was carried out at NABL accredited laboratory of CSIR-Indian Institute of Toxicology Research, Lucknow. Liquid Chromatography-Mass spectrometry and Gas Chromatography-Mass spectrometry methods were used to quantify pesticides, fertilizers and other chemicals present in the water. The antibiotics were assessed through LC-MS/MS (AB Sciex, API-4000) and found to be below detection limit, in both localities.

Socio-economics and people's perception

Baseline data was collected on village profile & resources, farmer households profile and agricultural, livestock and aquaculture practices, through the questionnaires developed. Interactions with farmers, fishermen and other stakeholders (including state fisheries and agriculture department officers, agro-chemical shopkeepers, etc.) focused on trends and perceptions on agricultural practices and aquatic resources over the years (Fig. 26). A total of 17 stakeholders and 62 fishermen and farmers were interviewed during this survey belonging to 9 villages.

Based on the pilot study results, the necessary modifications were incorporated in the survey formats. Further, based on the experience gained, during the preliminary study and inputs received from partner's institutes, a modified proposal with title and objectives will be submitted by ICAR-NBFGR to Bioversity International.

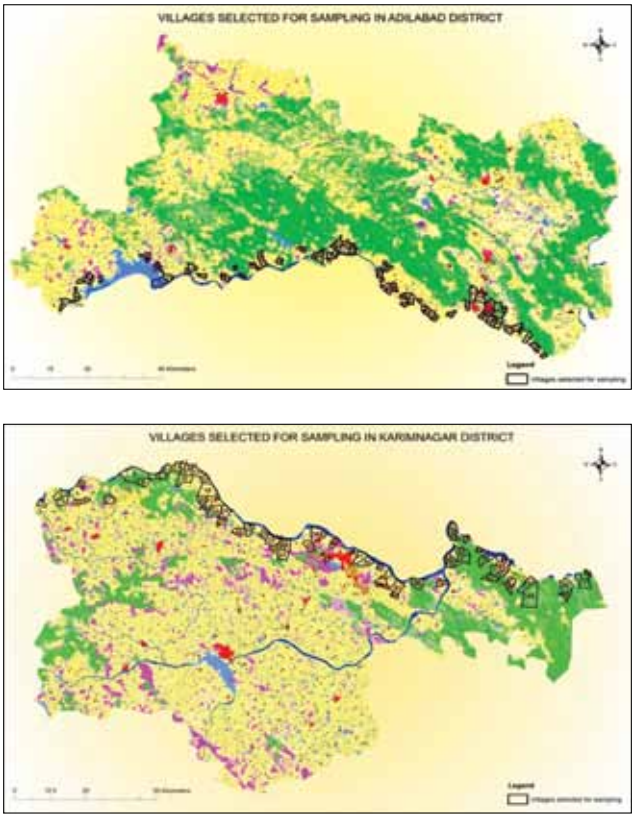


Fig. 24 Land use/land cover pattern in district Adilabad (a) and Karimnagar (b)

Fig. 25 Collection of planktons in Godavari river water

Fig. 26 Interaction with farmers and stakeholder in West Godavari

Project: Fish diversity pattern of fish communities from Luni river basin, Rajasthan, India
Period: April, 2018 - March, 2021
Personnel: A. K. Pathak (PI), Rajesh Dayal and Ravi Kumar
Funding Support: Institutional, ICAR-NBFGR

Survey and sampling for collection of data on fish and habitat

The river Luni is one a major non-perennial river of Rajasthan flowing from Rajasthan to Gujarat that presently starts from Kotaki Village in Aliyaniwas, Govindgarh, Rajasthan. The river Luni after flowing through different cities of Rajasthan, the river flows between the state borders of Rajasthan and Gujarat and thereafter in its lower basin, it completely flow in Gujarat state. In the Gujarat state, the river finally meets into Gulf of Kutch. During its flow regime, the rive Luni forms two sub basins; Luni upper and Luni lower. The Luni basin totally covers an area 87393 Km^2, of which the Luni upper sub basin entirely lies in Rajasthan and covers 57454 Km^2 area formed by 31 streams of the river Luni. The Luni lower basin partially lies in between Gujarat and Rajasthan and thereafter in Gujarat covers 29399 Km^2 area formed by 15 streams of the river Luni. To assess the fish diversity pattern of fish communities in the river Luni; the entire river with selected tributaries were surveyed from 22 to 28 October, 2018. At origin point of the river Luni at Kotaki Village in Aliyaniwas, Govindgarh, very few fragmented water spills of negligible water depth (water touching the river bed) were noticed (Fig. 27). No fishing was observed in the river at this location and no locality of fisherman was noticed in the vicinity of the river. The water colour was found greenish and the bottom substrate of the river was found completely sandy with pebbles and cobblestones. Babool trees and long height wild type grass were observed as vegetation cover in the riparian corridor of the river at this point. Sand and stone mining were observed at few locations in the corridor of the river. The geographical position coordinate of this location was noted by using GPS and pictures of this location were captured. The water and soil samples from this location were collected and labelled.

After surveying the river Luni at origin point, the main channel of this river was surveyed in Kankani about 40 km away from Jodhpur (Fig. 28). In this region, again few fragmented water spills of very low depth were noticed. Further, the bottom substrate of the river was found sandy, mixed with salt. Few juveniles of fish were noticed in few water spills whose water colour was green. No fishing was noticed in these water spills and in the vicinity of the river corridor. No locality of the fisherman was found. The water and soil samples from this point were collected and labelled. The pictures of this area were captured and the geographical position coordinate of this point was noted by using GPS.

At Sirohi district of Rajasthan, one of the major tributary of the river Luni named Jawal was surveyed. The tributary was found completely dry. The bottom substrate of the river was found completely sandy with pebbles, cobblestones, boulders and rocks. No fisherman locality was observed in the vicinity of the river corridor. The geographical position coordinates of this area was taken and pictures were captured. Further, in Jalor district the another tributary of the river Luni named as Bandi was surveyed and same condition was observed in this tributary, which was observed earlier in Jawal at Sirohi district. The geographical position coordinates of this area was taken and pictures were captured. Again near Bhilwara in Pali, another tributary of the river Luni named as Sukri was surveyed and similar conditions were observed in this tributary also. The geographical position coordinates of this area was taken and pictures were captured.

After surveying the tributaries, *viz*., Jawal, Bandi and Sukri, the main channel of the river Luni was again surveyed at Sindhari district, where fragmented large water spills of low depth and deep pools were noticed (Fig. 29). No fish of any life form was observed in these water fed areas and no fishing was observed. The data on topography and habitat structures were documented. The water with soil samples were collected from this place and labelled. The photographs and geographical position coordinates of this area were taken. The water colour was found greenish in colour and in the vicinity no fisherman locality was found. The riparian corridor of the river was full of Babool trees and long height grasses of wild type. The bottom substrate of the river was found sandy, full of pebbles, cobblestones, boulders and rocks. Further, on the way to Payla, same situation was observed in the main channel of the river Luni.

On the way to Bakasar on Sindhari-Payla route, the main channel of the river Luni was observed at 'Kakoda Ka Pulia (Fig. 30). Here plenty water was observed in the river with high degree of salinity because on the water surface white patches of salt were observed. Here, fishes of different life stages were observed. Fishing effort was done but due to scarcity of manpower, absence of suitable gear, no support and knowledge on the river by the local community, fish specimens could not be captured. The data on topography, habitat structures and water colour were documented. The water sample was collected and labelled. The photographs of this area were taken along with geographical position coordinates. In the vicinity of the river corridor, neither fishing nor locality of fisherman was observed. Further, the lake named as 'Sayar ka Kocheta' originated and regulated by the river Luni was surveyed. No fishing was observed in this lake and here the lake water was found more salty. Finally, the main channel of the river Luni was again surveyed in Bakasar before meeting into Gulf of Kutch. Many large fragmented water spills of low depth and deep pools were noticed in this area. The river bed was found highly salty. Juveniles and fingerling life stages of fish were seen in few deep pools and water spills. Fishing effort was done and some fish were captured. The water and soil samples were collected from this place and labelled. In addition, the photographs and geographical coordinates of this area were taken. In the vicinity of river corridor, neither fisherman locality nor fishing was observed.

Land use and land cover analysis

To analyse the land use and land cover changes of the Rajasthan state in order to have understanding on riverine landscape features and their change over years, the thematic services of Bhuvan 2D were used. This analysis provided the baseline information on trend of change in different land use/ land cover type over a period of 5 to 6 years. The six type of land use and land cover types, *viz.,* Agriculture, Barren, Built-up, Forest, Sparse vegetation and Waterbody were used for assessing change. The comparative analysis between 2011-12 and 2005-06 provided decrease in area of all land use/ land cover type in the year 2011-12 except increase in area of built up (Fig. 31 and Fig. 32). This understanding reveals that area under all land use/ land cover type except built-up is decreasing drastically where attention of resource planners and managers are required for formulating strategies to sustain these resources for well beings of human, riparian cover in the river corridors and aquatic organisms.

Physico-chemical analysis of water samples

The analysis of the water samples collected from the different location of the river Luni were analysed and Table 3 presents the details on different physico-chemical characteristics of the water samples:

Table 3. Key water anality parameter of Luni

Physico-chemical characteristics of water	Range values
pH	(7 - 9)
DO	(0.9 - 2.9) ppm
Conductivity	(21 - 113) S/m
TDS	(10 - 58.1) ppm & ppt
Salinity	(12.5 - 71) ppt
Water temperature	(31.8 - 32.7) °C

The collected fish specimens were preserved in formalin for identification and reference (Fig. 33).

Fig. 27 River Luni at Kotaki village

Fig. 28 Kankani

Fig. 29 Kakoda ka Pul

Fig. 30 Sindharia

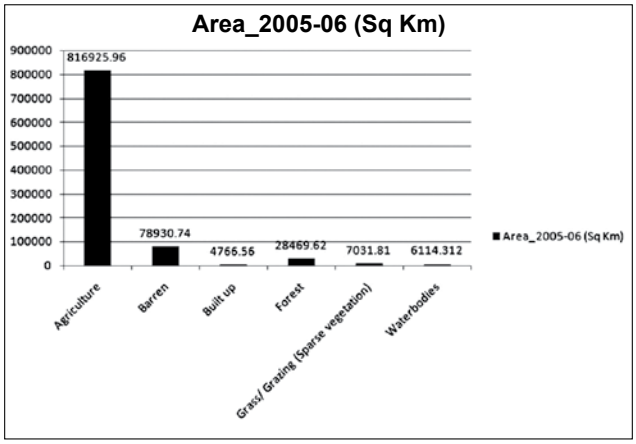


Fig. 31

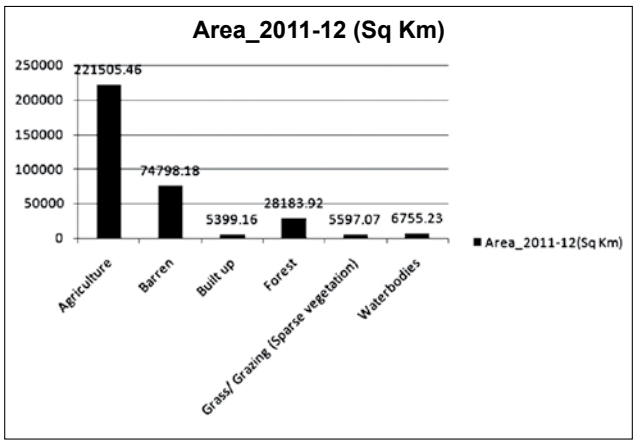


Fig. 32

Fig. 33

Project: ICAR-NBFGR Collaborative Research Programme on Fish Germplasm Exploration, Characterization and Development of Live Fish Germplasm Resource Centers in North-Eastern Region of India

Period: November, 2017 – March, 2020

Personnel: L. K. Tyagi (Coordinator), Vindhya Mohindra and Rajeev K. Singh (Co-coordinators)

Funding Agency: ICAR-NE Component

NBFGR under ICAR-North East (NE) component, is implementing 'Collaborative Research Programme on Fish Germplasm Exploration, Characterization and Development of Live Fish Germplasm Resource Centers in North-eastern Region of India' involving collaborators from various institutions of the NE region (Table 4). The major themes of the programme are: Exploration and documentation of fish germplasm resources and indigenous knowledge from selected parts/rivers of the NE region; development of regional live fish germplasm resource centers of indigenous food and ornamental fishes for resource enhancement and sustainable livelihood generation and cytogenetic characterization of endemic fishes of North Eastern, India.

1. Exploration and characterization of fish germplasm resources, and indigenous knowledge of traditional fishing practices of Dikhu river in Nagaland

The Dikhu River is a perennial river and one among the prominent rivers of Nagaland. The River Dikhu originates from the Hills of Nuruto, Zunheboto and flow westward to join the Brahmaputra basin. It stretches as long as 170 km and in Mokokchung, the river divides into one of its major tributaries, the Nanung, which flows through the Langpangkong hill range of the district. Explorations were carried out at 6 sites (Yimlu, Kumpangziv, Chakba, Dikhu, Kumongkumzu and Chetaizu) for fish germplasm resources. A total of 28 fish species belonging to 18 genera of 9 families under 4 orders were recorded during the explorations (Fig. 34). Maximum species recorded were from Order Cypriniformes (71.43%), followed by Siluriformes (14.28%). Water samples were collected for physico-chemical and biological analysis. Information on ten local fishing gears and practices was also collected, namely, Talu-Tatu kago, akatsu, Hooks and lines, Angu makang, Local bamboo raft and Zura fishing. Details of destructive fishing methods practiced in the studied river basin were also recorded, namely, dynamites, bleaching powder and electro-fishing. Physico-chemical parameters of water were collected and analysed monthly for all the studied sites.

Table 4. Collaborating partners from NE region of India

Sl. No.	Principal Investigator	Title of Project
1.	Dr. Pranay Punj Pankaj Nagaland University, Lumami	Exploration and characterization of fish germplasm resources, and indigenous knowledge of traditional fishing practices of Dikhu river in Nagaland
2.	Mr. Ratul Chandra Bharali Udalguri College, Udalguri, Assam	Exploration and evaluation of fish diversity and habitat ecology of Namora and Dikal rivers of Arunachal Pradesh
3.	Mr. Hrishikesh Choudhury Gauhati University, Guwahati	Exploration & Evaluation of ichthyofaunal diversity of Khri River, Meghalaya and Subansiri River, Arunachal Pradesh
4	Dr. Sarbojit Thaosen Haflong Govt. College	Exploration and Evaluation of Fish Faunal diversity, Distributional pattern and Habitat Ecology of Langting River, Dima Hasao and Dhansiri River, Karbi Anglong, Assam
5	Mr. D. Khlur Baiaineh Mukhim Lady Keane College, Shillong	Exploration & Evaluation of Fish Faunal Diversity of Wahrew River, East Khasi Hills, Meghalaya
6	Dr. D. Sarma Gauhati University, Guwahati	Development of live germplasm resource center for indigenous food and ornamental fishes for resource enhancement and sustainable livelihood generation in Assam
7.	Dr. Y. Bedajit Singh, CAU, Imphal	Diversity and germplasm conservation of fishes of river basins in Manipur
8.	Dr. Banasri Mech Gauhati University, Guwahati	Cytogenetic study of certain selected endemic fishes of North East, India

P. arunachalensis

P. homaloptera

T. latius

K. indicus

A. apangi

P. conchonius

D. assamila

N. hexagonolepis

Fig. 34 Few fish species recorded from Dikhu river in Nagaland

2. Exploration and evaluation of fish diversity and habitat ecology of Na-mora and Dikal rivers of Arunachal Pradesh

Explorations were undertaken in river Na-mora and Dikal originated from the eastern Himalaya covering East Kameng and Papum P which are districts of Arunachal Pradesh. These two rivers formed through a number of tributaries from the lesser Himalayan ranges. The rivers confluence near Duimukh in Assam and meet Brahmaputra in the name of Bargang. The total length of this river system consisting of river in Assam and Na-mora, Arunachal Pradesh is approximate 95-110 kms, of which, 75-85 kms is in Arunachal Pradesh. Experimental fishing was carried out monthly basis with the help of local fishers.

In the first stage, six sampling sites were identified which were increased to eight, at an approximate distance of 10-15 Kms (Fig. 35). Out of the eight

Fig. 35 Explorations in Dikal river

sampling sites, two are located in Dikal river, i.e., Upper Dikalmukh and No.1 Dubi; two in Nomara river, i.e, Namora and Keyrlull which fall within Arunachal Pradesh and the rest 4 sampling sites are located in Assam. The distance between two sampling sites has been found to be 10-15 Kms.

A total of 46 fish species of 28 genera under 12 families have been identified, so far, where as, 4 species are yet to be identified. Relative abundance of family Cyprinidae shows dominance (20 - 64.7) over the others while Sisorids represents 4.76 - 14.29 % in Dikal river. Family Cyprinidae represents all the sampling sites of Namora and Dikal rivers. Significant abundance of family Sisoridae is observed in Upper Dikalmukh sampling site of Dikal River. Cyprinidae is found to be the largest family represented by 23 species, followed by Nemacheilidae (5 species), and Sisoridae (4 species). *Neolissochilus hexagonolepis, Barilius bendelisis, Labeo dyocheilus, Garra annadalei, Glyptothorax striatus* are abundant species in lower stretch of the river. *Botia almorhae* was abundantly reported from the sampling site in the upper stretches of the river.

Seasonal analysis of physico-chemical water parameter was carried out for all the sampling sites of both the rivers to throw some light on the habitat attributes of the river. The mean values of the parameters revealed that both the rivers could harbor a wide variety of fishes, which is also evident from the samples collected during the survey. However, a slight decrease in the diversity of fishes could be seen with the increasing gradient of the river.

The fishing method used by the local people is by building a barricade with the chepas in the river. The fishes are being trapped in the barricade and are collected in a basket. The chepas are used only once and then those are disposed. Hooks and lines are also one of the preferred gears for the local people. The practice of any destructive mode of fishing is considered as a crime, therefore, the use of any such malpractices in the region is almost negligible.

The IUCN status of the studied ichthyofauna revealed that 69.39% of the total species were categorized as Least Concern, 10.86% as Near Threatened, 2.17% as Endangered, 2.17% as Vulnerable, and 2.17% as Data Deficient. Thus, about 15.2% of the fish species recorded are under the threatened categories.

3. Exploration & Evaluation of ichthyofaunal diversity of Khri River, Meghalaya and Subansiri River, Arunachal Pradesh

The Khri river system comprises of three main rivers, namely, Khri, Krisiniya and Um Siri, originating from the West Khasi Hills and flow north. It is known as Kulsi River when it enters Assam and flows further northwest for about 90 km before joining the Brahmaputra as a south bank tributary. The river is joined by various small rivulets and streams throughout its course along Assam and also has connections with various beels and/or floodplain wetlands.

Explorations were carried out in 10 sampling sites covering the entire length of nearly 220 km of the Khri/ Kulsi river drainage in Meghalaya, as well as, Assam. A total of 72 fish species under 20 families were collected from the Khri River basin (Fig. 36). The sites, Ukium and Nagarbera were the most species-rich areas. The presence of exotic species, *viz., Ctenopharyngodon idella*, *Cyprinus carpio* and *Hypophthalmichthys molitrix* were although quite significant, however, their actual population trend needs further study to calculate their impact (if any) on the native species. The presence of the Near Threatened freshwater pipefish, *Microphis deocata*, along the Khri River in site S1 (Ukium, Meghalaya) is very significant.

The water quality parameters did not fluctuate significantly in different sampling sites, except, lower DO values and higher conductivity values along the middle and lower stretches of the river in Assam. Extensive fishing practices were lacking along the upper stretches of Khri. Moreover, there is lack of any traditional fishermen. The local people (Khasi/Garo) catch fish only for their consumption or as per their

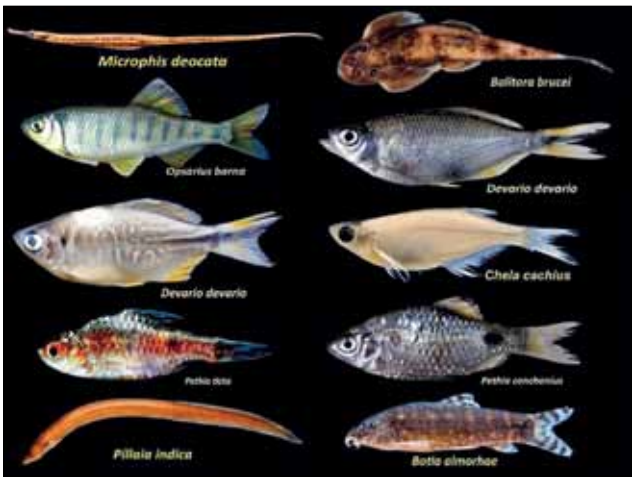


Fig. 36 Few fish species of the Kulsi/Khri river basin

need. Besides, handpicking practice of fish catching by traditional Garo and Khasi community at Ukium (S1) village, Assam-Meghalaya border was also performed to catch fish. Hammering, a unique technique to catch fish by hitting hard on rocks, to make the fish unconscious could also be seen as well as performed. However, the fish catch per unit effort was very less. Electrofishing, liming, dynamiting, poisoning, etc. or any other destructive fishing gears along the upper stretch is banned based on the community rules and regulations to protect the biodiversity.

4. Exploration and Evaluation of Fish Faunal diversity, Distributional pattern and Habitat Ecology of Langting River, Dima Hasao, Assam

Langting is an important tributary of Diyung river in Dima Hasao district of Assam. It further has sub-tributaries on the eastern bank, namely, Digerma, Path, Langao, Llongren, Gangdang and Lalbong, while on its western bank sub-tributaries are: Sherdisa, Dhurun, Dhrang, Lahong and Dihakho. The majority of Dimasa tribal people have settled there and have been practicing wet paddy cultivation. Nothing has been reported regarding the fish faunal diversity of Langting River, Dima Hasao district.

Explorations were conducted at eight sites (Didambra, Hajadisa, Digerdzi, Nobdi, Wajao, Langaobra, Langting Wari Giding, and Langting station) of Langting river (Fig. 37). A total of 46 fish species of 11 families were recorded from these explorations. Maximum species richness was recorded at sites Langting Wari Giding (46 species), followed by Digerdzi (42 species) and Didambra (41 species). Seasonal analysis of physico-chemical water parameter was carried out for all the sampling sites of the river.

Fig. 37 Explorations in Langting river, Assam

Organized fishing was absent along the stretches of the river. No exotic fish species were encountered in the present study. At site Langting station, no. of fish species collected are very few compared to other sites, this is because the site falls at a township Langting and the habitat or the river bottom is sandy. Some stretch of the river could not be covered due to inaccessibility of the area for varied reasons.

5. Exploration & Evaluation of Fish Faunal Diversity of Wahrew River, East Khasi Hills, Meghalaya

The River Wahrew flows in East Khasi Hills district of Meghalaya with its source located high up in the sub-temperate mountain of Pomlum village. It flows southwards down the mountain to the deep valley below where it roughly takes the east-west direction till it turns south towards Bangladesh. Recent quarry of rocks and sand on the catchment areas, road construction and other developmental works pose a big threat to the faunal biodiversity of this important river that has been a perennial source of fish to several villagers. Hence, there is an urgent need to survey the various species of fish present in this river to assess the need for conservation. Explorations were undertaken at seven sites of River Wahrew, with altitude ranging from 21 m to 1811 m. Total 10 fish species were recorded from the explored sites.

6. Development of live germplasm resource center for indigenous food and ornamental fishes for resource enhancement and sustainable livelihood generation in Assam

The work aims at wild collection, brooders management, breeding and larval rearing of selected indigenous food and ornamental fishes of NE region. Efforts are also made to create awareness about the benefit of ornamental fish breeding and culture of certain indigenous and exotic ornamental fishes, and also to train selected rural beneficiaries of Goalpara district of Assam. The selected beneficiaries has been provided training and demonstration in various aspects related to ornamental fish breeding and rearing in aquarium to enhance their sustainable livelihoods.

Indigenous Ornamental Fishes:

Breeding of Pipefish (*Microphis deocata*) in Aquarium

M. deocata (Hamilton, 1822), also known as Deocata pipefish, Indian Royal Green Pipefish or

Rainbow Belly Pipefish, is a freshwater fish species found in rivers and streams. It is categorised as "Near Threatened" species in IUCN Red List (2017). Two different experimental units were used to rear bloodstock. The brooders of *M. deocata* were collected from Manas River. Male and female of *M. deocata* were kept in rectangular 90 l glass aquaria in groups, where females were kept twice the number of males. Gestation time varied from 15-22 days. Brood size varied from 16 to 18 juveniles per brood. Before releasing the juveniles, the male was generally inactive, hiding in the darker areas of the tank and attached to the plants. During release of juvenile, the male widened up the brood pouch opening and juvenile were then released one by one.

Natural Breeding of *Channa stewartii* in Cistern as well as in Aquarium

C. stewartii is a species endemic to Brahmaputra (upper, middle, lower) River basin and native to Nepal and Indian states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland and Tripura. Over the last 10 years, the wild population of snakehead species has undergone a steady decline mainly because of over exploitation and various anthropogenic stresses.

Brood stock of *C. stewartii* in 120 number (60-269 mm of TL) were caught with the help of local fishermen using cast nets (mesh size: 10-20 mm), scoop nets (mesh sizes: 05-20 mm) and bamboo traps, i.e., Sepa, Dingora, etc. on monthly basis. The study was conducted in natural environment to determine the breeding pattern of *C. stewartii*. The successful breeding performance of the species with detailed behaviour of male and female broodstock was documented.

Breeding performance of *Channa andrao* Britz, 2013

C. andrao is endemic to the Brahmaputra River basin in Northeastern India and in habitat in swamp in the vicinity of Brahmaputra River. Fishes were collected from Manas River basin bordering West Bengal. Breeding of *C. andrao* was recorded in the month of March. Male and female were showing breeding behavior from the month of February. The male showed more active participation in mating. Both parents were involved in parental care from egg to fry stage. It was observed that a female lays approximately 50-60 eggs in one attempt.

Breeding & larval rearing of *Garra annadalei*, Hora, 1921

The fishes were collected from their natural habitat in Dhansiri River at Bhairabkundo in Assam-Arunachal Pradesh border. Complete experiment of brood stock management including feed & feeding, breeding and larval rearing was successfully conducted and documented. Fecundity recorded ranged 800-900 (854.8±78.6).

Induced breeding & larval rearing of *Devario aequipinnatus*, McClelland, 1839

The fishes were collected from their natural habitat in Dhansiri River at Bhairabkundo in Assam-Arunachal Pradesh. Complete experiment of brood stock management including feed & feeding, breeding and larval rearing was successfully conducted and documented. In the spawning tank, one gravid female was released along with a mature male and then their behaviour was observed. It was observed that this fish is sexually mature when they are about 7 cm in length. Fecundity recorded ranged 200-300 (251.8±52.6).

Food fishes: *Clarius magur*

Wild collection of Magur initiated since December, 2017 and was continued during the year under report. Magur was collected from six different places of Assam and stocked separately in cistern at Aquaculture and Biodiversity Centre, Department of Zoology, Gauhati University. Samples were also sent to ICAR-NBFGR, Lucknow in the Month of November, 2018. Six breeding trials were performed in the breeding season of 2018-19, but failed. Breeding of *C. magur* has been carried out by stripping the eggs from female and sacrificing the male to collect the milt in last breeding season, but eggs were not fertilized. To collect the milt, testis was dissected out and a homogeneous mixture was prepared using saline water. It was then poured onto the eggs and slowly stirred so that the eggs get fertilized. But in this trial, the eggs did not get fertilized.

Ompok pabda

Total 130 *O. pabda* brooders which were collected from Goronga beel, Morigaon in the Month December, 2017, were maintained in the small ponds of Aquaculture and Biodiversity Centre, Department of Zoology, Gauhati University with live feeds (earth worm) and godrej brand feed (Fig. 38). Six breeding

trial were practiced in the last breeding season but they failed. In October, 2018 again 400 fingerlings were collected from Raniganj fish farm, Siliguri and are being maintained in addition to the earlier stock with live feed. Effort were also made to collect brooders from wild but failed as wild population of pabda in Goronga beel has drastically reduced. Brooders of pabda are being maintained at the Aquaculture and Biodiversity Centre, Department of Zoology, Gauhati University. Breeding trials will be carried out in upcoming breeding season. More brooders have already been collected around 115 from three locations of Assam in the month of March, 2019. Wild collection and stocking is still going on and breeding can be carried out from next month onwards. However, 70% mortality encountered within seven days of collection. Mortality was high because of disease infection. Remaining brooders are being maintained with live feeds, like, earthworm, tubifex, etc.

Fig. 38 Broodstock of *O. pabda* maintained at Aquaculture and Biodiversity Centre, Department of Zoology, Gauhati University

Selection of beneficiaries for promotion of indigenous ornamental fish rearing

Ten women beneficiaries were selected from village Velakhamar, Krishnai, Goalpara district, Assam to promote indigenous ornamental fish rearing as an impetus for livelihood enhancement. Ten cisterns (size: 5x2.5x2.5), one for each beneficiary as rearing tank was constructed and accessories like under gravel filter, submersible pump, heater, etc. are being provided to the beneficiaries. Rearing of ornamental fishes by selected beneficiaries will be initiated in April, 2019.

Diversity and germplasm conservation of fishes of river basins in Manipur

Five explorations were conducted, during the year under report, for collection of fish species of Chindwin and Barak-Surma-Meghna drainages (Table 5):

Table 5. Exploration conducted in Manipur

S.N.	River	Site	Fish species collected
1	Imphal	Chanoubung, T. Khullen	*Devario acuticephala, Devario naganensis, Lepidocephalichthys berdmorei, Schistura khugae*
2	Barak	Karong, Senapati	*Lepidocephalichthys berdmorei, Channa gachua, Channa punctata, Garra* sp., *Schistura* sp., *Esomus dandrica, Devario acuticephala*
3	Lokchao	Tengnoupal	*Xenentondon cancila, Mastacembelus armatus, Channa gachua, Osteobrama belangeri, Osteobrama feae, Osteobrama cunma, Ompok pabo, Lepidocephalicthys berdmorei, Neolissochilus stracheyi, Opsarius ngawa*
4	Khuga	Churachandpur	*Schistura khugae, Devario acuticephala, Lepidocephalicthys berdmorei, Puntius sophore, Puntius chola*
5	Khordak	Bishnupur	*Lepidocephalicthys berdmorei, Puntius sophore, Pethia manipurensis, Mystus ngasep, Trichogaster fasciata, Clarias magur, Glyptothorax ngapang*

Broodstock management:

One pond of the size 72.9m x 17.8m x 1.5 m have been renovated for broodstock management of *C. magur, Bangana devdevi, O. bimaculatus* and *Neolissochilus stracheyi. B. devdevi* and *C. magur* are kept in the brood stock pond and bred during the breeding season. *Neolissochilus stracheyi*, which is an endemic hill stream fish, has been kept for acclimatization in aquariums and stocked in the brood stock pond. Total 1000 numbers of *Ompok bimaculatus* were stocked for preparation of brood stock, which will be used for induced breeding in the coming season.

Induced breeding of *Bangana devdevi*

B. devdevi locally known as Khabak in Manipuri is a much demanded fish in Manipur, India, yet the absence of a standardized method to induce breeding remains a major constraint in the development of aquaculture of this species. In the present study, breeding was induced using 0.1, 0.2, or 0.3 ml/kg body weight of the synthetic hormone Gonopro - FH and compared with fish injected with 30 mg carp pituitary extract (CPE) per kg body weight or 0.5 ml saline (control) for female and male brooders were injected with the dose of half the female dose and left to spawn at a ratio of 2:1. Hormone dose was given once for both male and female. No breeding occurred in the saline-injected control fish. There was partial spawning in the 0.1 and 0.3 Gonopro - FH treatments and complete spawning in fish injected with 0.2 Gonopro - FH. Spawning and number of eggs in fish injected with 0.2 Gonopro - FH did not differ statistically from results in fish injected with CPE ($p \geq 0.05$). The present experiment suggests that Gonopro - FH 0.2 ml/kg body weight is optimal for seed production of Khabak held in captivity and can be used for species restoration. However, the same study will be repeated again in the coming season for confirmation of results. Induced breeding of *Clarias magur* was done last year but it was partially successful. Hence, it will be conducted in the coming season.

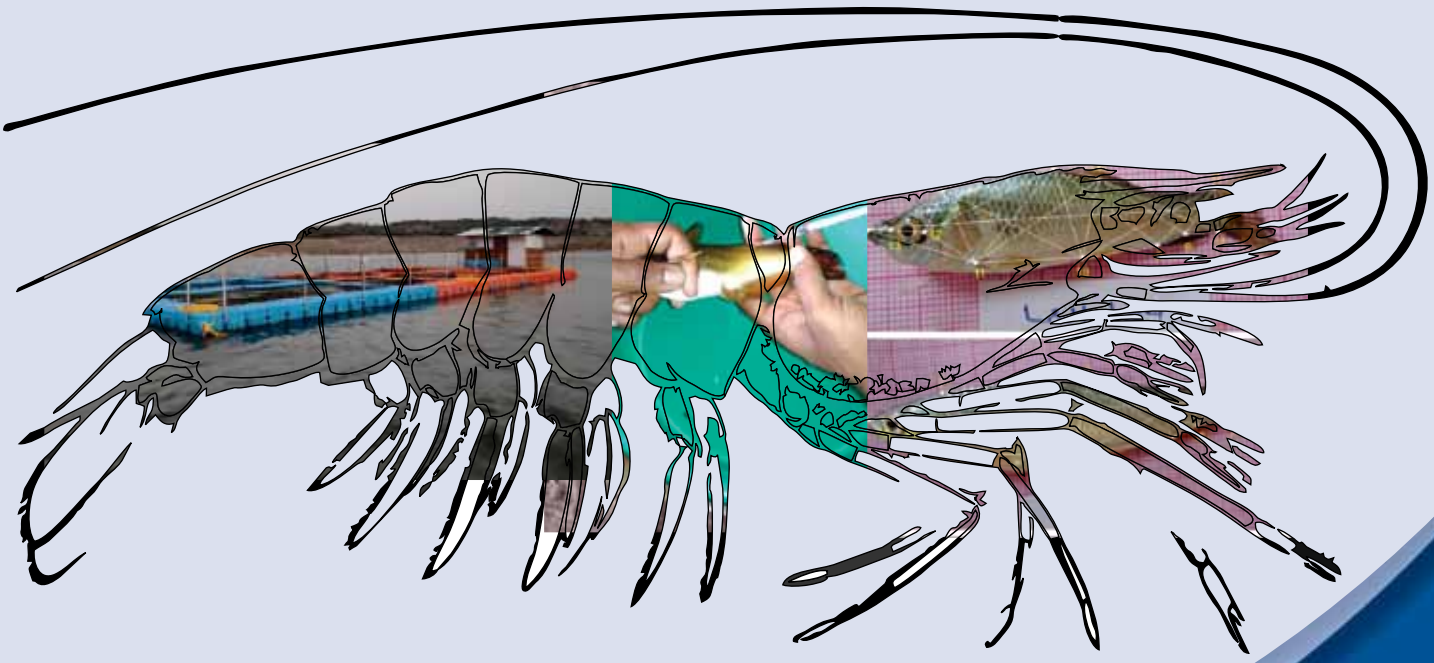
Cytogenetic study of certain selected endemic fishes of North-East, India

The cytogenetic study of certain endemic fishes of North East India has not been performed till date. Therefore, this study intends to provide a complete report on chromosomal and karyotype knowledge in selected species. The fishes were collected from different location sites. Chromosome preparation were stained with 5% Giemsa and observed under a Leica DM300 microscope. The best metaphase spreads were identified and selected. For each fish specimen, at least 50-100 metaphase spreads were studied (Table 6). Chromosome complements of well spread were measured individually and their centromeric indices and arm ratio were determined to assign the respective morphology as per Levan *et al.* (1964).

Table 6. Karyological data for selected fishes

S.N.	Species name	Collection locality	Karyoype formula
1	*Garra annandalei*	Bhairabkunda, Indo-Bhutan Border, Dhansiri river (Brahmaputra drainage)	2n= 50 (14m+12sm+12st+12t)
2	*Garra cf. quadratirostris*	Kameng river, near Seppa, Arunachal Pradesh	2n= 50, (12m+6sm+6st+26t)
3	*Pseudecheneis sulcata*	Bhairabkunda, Indo-Bhutan Border, Dhansiri river (Brahmaputra drainage)	2n= 50, (12m+8sm+8st=22t)
4	*Pethia shalynius*	Umngot river at Mawkynrew, E. Khasi Hills, Barak river drainage	2n= 52, (14m+20sm+6st+12t)

Program 4.2: Characterization and evaluation of genetic resources, intra-specific diversity and genetic stocks



Information on genetic diversity is of great importance for fisheries conservation and management. Genetic variance is responsive to evolutionary forces, such as, migration, mutation, selection in large population, and also genetic drift in small population. Scientific knowledge on various genetic stocks of the species and their production descriptors are important for genetic improvement programs as well as for assessing the potential of the species for its inclusion in the aquaculture system. It is always important to unravel the genetic variability of the species to resolve the issues related to establishing base population for genetic selection programs, breeding nucleus for hatchery populations, genetic erosion in cultured species, IPR protection etc.

ICAR-NBFGR has been working on research related to inter- and intra-specific genetic variation focused on important prioritized species that are cultivable, potentially cultivable or important exploited stocks from freshwater, brackish water and marine ecosystems. Institute is also working on Indian fish population genetics using standardized molecular markers and related biological tools. Such studies are essential to identify stocks of natural populations, their genetic status and to identify stocks that need conservation measures.

Project: Outreach activity on fish genetic stocks (Phase II)
Period: April, 2014 - March, 2020
Coordinator: Kuldeep K. Lal
Co-coordinator and Lead Centre PI: Rajeev K. Singh
Personnel (HQ): Rajeev K. Singh (PI), Vindhya Mohindra, Sangeeta Mandal, Rejani Chandran, Achal Singh, Amar Pal, Rama Shankar Sah and Rajesh Kumar
Personnel (PMFGR): P. R. Divya (PI), V. S. Basheer, A. K. Pandian and Charan Ravi
Funding Support: Institutional, ICAR-NBFGR

Genetic variability in *Chitala chitala* inferred from mitochondrial genes

A total of 421 *C. chitala* individuals were analyzed for two mitochondrial genes (Cytochrome b and ATPase 8/6). The samples were collected from 12 rivers of 5 different river basins. The alignment of the sequences revealed 26 different haplotypes for ATPase 6/8 and 31 for Cytochrome b. For ATPase 6/8 gene, haplotype diversity ranged from 0.000 (Mahanadi) to 0.692 (Gandak), while 0.000 (Mahanadi) to 0.808 (Bhagirathi) in Cytochrome b. The mean nucleotide diversity was 0.0008 and 0.0019 for two genes, respectively. The mean F_{ST} was found to be 0.340 and 0.282 for ATPase and Cytb genes, respectively. Analysis of molecular variance (AMOVA) for both genes revealed that majority of variance was contributed within the population. The inter relatedness and pattern of clustering is illustrated in Fig. 39.

Mitochondrial gene divergence in flat head grey mullet, *Mugil cephalus*

In flathead grey mullet, ATPase 6/8 of mitochondrial genome was amplified and analyzed to determine genetic variation from 429 individuals collected from 26 locations. The samples comprised of six groups, *viz.*, East Coast I, East Coast II, West Coast I, West Coast II, Mahanadi and Hooghly estuary. Clustal alignment of the sequences revealed 34 different haplotypes. The overall haplotype diversity was 0.4174, for all populations, whereas, nucleotide diversity was 0.00067. Hierarchical partitioning revealed that variation was low 0.53% among the groups. The coefficient of genetic differentiation (F_{ST}) was highest at 0.2600 ($P<0.05$) between West Coast I and Hooghly estuary and lowest at 0.0518 ($P<0.05$) between Mahanadi and Hooghly. The dendrogram is illustrated in Fig. 40.

The genetic variation pattern in *M. cephalus* (n=438) was also assessed, based on full length cytochrome b (1141 bp) gene. The sequence analysis revealed 62 haplotypes with overall haplotype diversity (h) of 0.6835, whereas the nucleotide diversity was 0.00097. Hierarchical partitioning revealed that the populations of flathead grey mullet were weakly sub structured.

Genetic diversity in *Silonia silondia*

In *S. silondia,* a total of n=247 individuals were sequenced and analyzed for both genes individually. The sequence alignment revealed 17 and 12 distinct haplotypes, respectively. Haplotype diversity ranged from 0.67-0.73 for Cytb and 0.60-0.74 in ATPase 6/8 genes, whereas nucleotide diversity ranged from 0.00146-0.00257 for Cytb and 0.00146-0.00291 in ATPase 6/8 genes. The analysis of molecular variance (AMOVA) results indicated that 78-79% of total variation was within populations, whereas 21-22% from variation attributed to differentiation between populations. The dendrogram based on cytb gene is presented in Fig. 41.

Mitochondrial genetic divergence in *Systomus sarana sarana*

A total of n=209 individuals of *S. sarana sarana,* collected from six different riverine locations, *viz.*, Hooghly, Betwa, Mahanadi, Godavari, Krishna and Bramhaputra (Guwahati) were investigated. The analysis of ATPase 6/8 genes revealed 28 different haplotypes with overall haplotype diversity 0.6391 for all populations, whereas overall nucleotide diversity was 0.00214. The coefficient of genetic differentiation (F_{ST}) was highest 0.42236 ($P<0.05$) between Guwahati and Mahanadi and lowest 0.11604 ($P<0.05$) between Godavari and Krishna. The inter relatedness of haplotypes was observed using reduced median-joining network (Fig. 42).

Mitochondrial sequence divergence in *Anguilla bengalensis*

Sequence analysis of n=82 individuals of *A. bengalensis*, collected from seven locations, *viz.*, Krishna, Nagarjunasagar, Nirmal, Dhawleshwaram,

Rajamundry, Ken and Farrakka, was done. The analysis revealed 24 different haplotypes. The average frequencies of four nucleotides for all the samples were A: 31.6%; T: 27.4%; C: 31.6%, G: 12.9%. Nucleotide sequences of ATPase 6/8 were A+T rich (59.0%). Haplotype diversity ranged from 0.674 to 1.000, whereas nucleotide diversity 0.0014 to 0.0024. AMOVA analysis revealed that out of total variation, majority (98.76%) was attributed within population. The inter relatedness of haplotypes is illustrated in Fig. 43.

The genetic variability studies were conducted to infer the population genetic structure of *A. benegalensis* (n=67) collected from five different locations; Chennur (7), Soam (10), Dhwaleshwaram (21), Rajamundry (19) and Nirmal (10) using fifteen polymorphic microsatellite markers. Individual genotype data was generated for each locus and used for genetic analysis. A total of 244 alleles were identified. The *PIC* values ranged from 0.555 - 0.929. No evidences of large allele dropout or band stuttering were detected at any locus. The observed heterozygosity (H_{obs}) ranged from 0.187 to 0.791, whereas, the expected heterozygosity (H_{esp}) varied from 0.260) to 0.859, respectively (Fig. 44).

Microsatellite markers analysis in *Tor tor*

A total of 20 polymorphic microsatellite loci were used to genotype n=140 samples from 6 riverine populations. The observed and expected heterozygosities ranged from 0.2256 to 0.3834 and 0.1690 to 0.3537, respectively. The pair wise F_{ST} value ranged from 0.097 to 0.29. Significant genotypic heterogeneity and F_{ST}= 0.182 over all loci indicated that the samples were not drawn from the same gene pool. The *PIC* values ranged from 0.067 to 0.553. No significant linkage disequilibrium was detected among the loci. Five loci showed significant deviation from Hardy–Weinberg equilibrium, but none of them had evidences for null alleles.

Genetic diversity in *T. tor*

A total n=140 samples of *T. tor*, collected through commercial catches from 6 riverine localities of Godavari, Narmada, Madar and Penganga, were analysed for two genes (cytochrome b and ATPase6/8). The alignment of the sequences revealed 12 different haplotypes for cytochrome b and 7 for ATPase6/8. For cyt b gene, haplotype diversity (Hd) ranged from 0.000 to 0.666, while in ATPase6/8 ranged from 0.000 to 0.590. The F_{ST} value was found to be 0.491 and 0.288 for cytochrome b and ATPase6/8 gene, respectively. The dendrogram, depicting the clustering pattern is illustrated in Fig. 45.

Genetic diversity assessment in *Litopenaeus vannamei*

A total of 166 tissue samples of *L. vannamei* individuals, collected from 5 different farms, Cochin, Cuddalore, Kerala, Fatehabad, Hisar, Bhiwani, Rohtak and Nellore, were assayed using 9 polymorphic microsatellite markers. A total of 70 alleles were identified across all loci in all populations. The number of alleles per locus (Na) ranged from 3 to 14. No evidences of large allele dropout or band stuttering were detected at any locus. The *PIC* values ranged from 0.401 to 0.879 with an average of 0.668. The observed heterozygosity ranged from 0.044 to 0.724. No significant linkage disequilibrium and existence of null alleles were observed between pairs of loci, tested for all populations. Significant genetic differentiation ($p<0.05$) between pair wise population were observed for all loci. F_{ST} value ranged from 0.093 to 0.346 with an average of 0.218.

Age, growth and Length-Weight Relationship

The specimens of *M. cephalus* (n=267), collected from locations namely, Puducherry (31), Marakkanam (38), Vellar Estuary (64), Mandapam (52), Coleroon Estuary (21), Thengapattanam (28) and Mahanadi (33) were assessed for length-weight relationships. The regression coefficient ranged from 2.38 to 3.414. Average Fulton's condition factor (K) ranged from 0.91 (Coleroon Estuary) to 1.08 (Puducherry). The back-calculated length for 1+ age class was highest in Thengapattanam and lowest in Mandapam, whereas for 4+ age class, it was highest in Mandapam and lowest in Vellar Estuary. The analysis of the back-calculated results indicated variation at different age

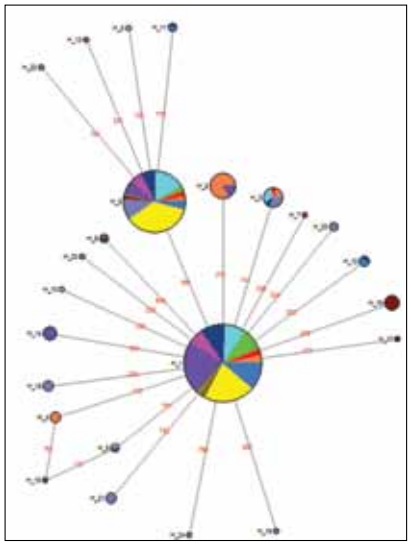


Fig. 39 Networking of haplotypes in *C. chitala*

classes, for all locations. *C. chitala*, n=465 individuals, collected from Satluj (80), Brahmaputra (77), Gomti (27), Ken (25), Son (107), Ganga (46), Bhagirathi (25), Mahanadi (36) and Ghagra (42), were studied for relatedness between length and corresponding weight.

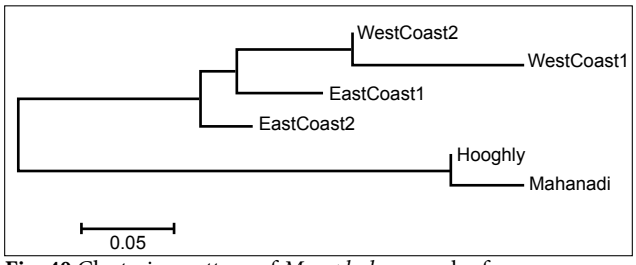


Fig. 40 Clustering pattern of *M. cephalus* samples from

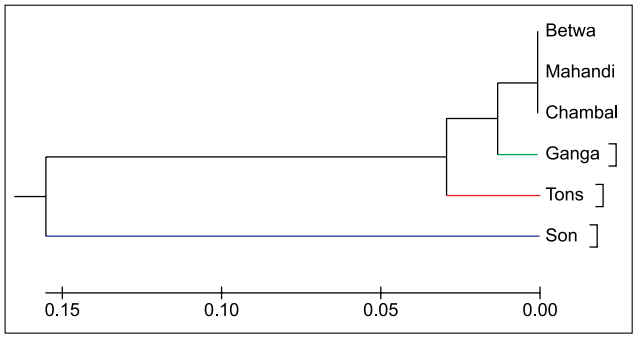


Fig. 41 Dendrogram based on mitochondrial Cyt b gene in *S. silondia*

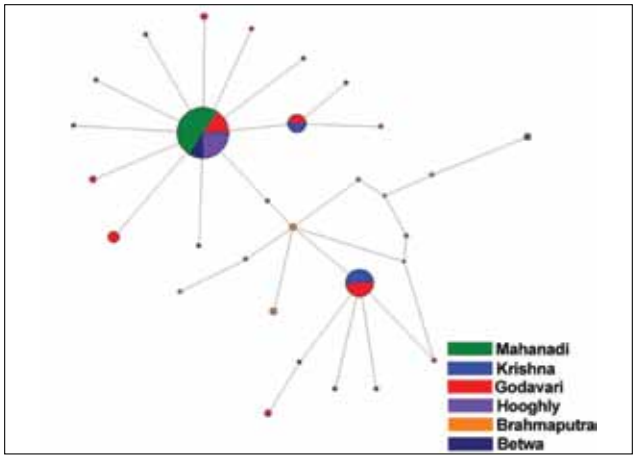


Fig. 42 Inter linking of *S. sarana sarana* haplotypes

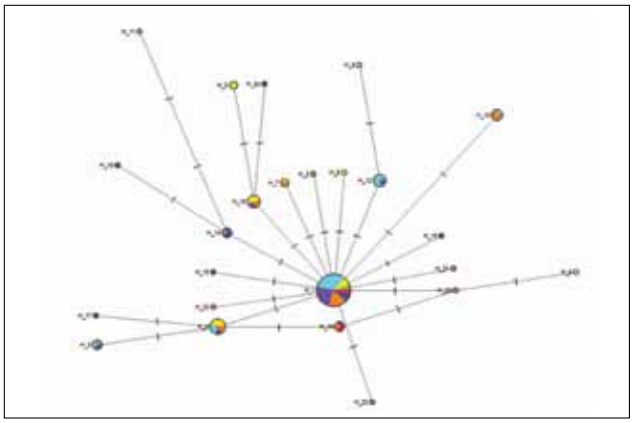


Fig. 43 Reduced median joining network of *A. bengalensis*

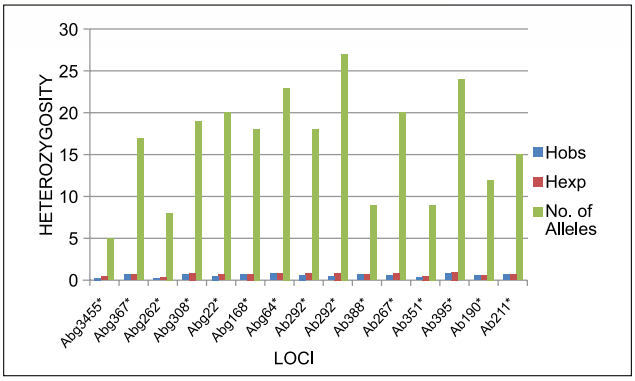


Fig. 44 Graphical presentation of genetic parameters of *A. bengalensis*

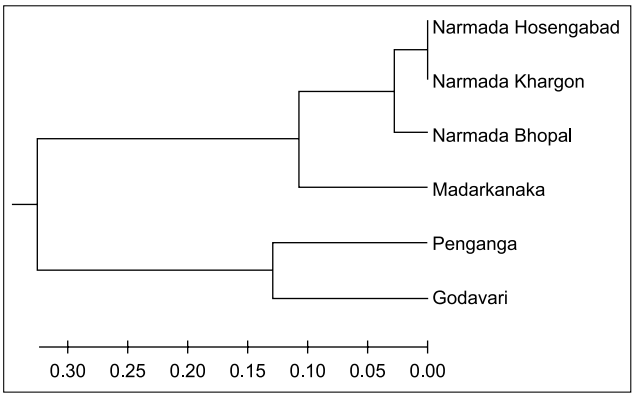


Fig. 45 UPGMA dendrogram of *T. tor*

PMFGR Centre:

Population diversity analysis of *Sillago sihama* using molecular markers from Indian waters revealed that the major fishery of *S. sihama* occurs only along the west coast of India. Populations of *S. sihama* from four locations along the west coast of India estimated using 16 loci exhibited low, but significant genetic differentiation, indicating the existence of distinct management units along west coast. Genetic stock identification in *Perna viridis* using microsatellite markers revealed two separate stocks in Indian waters- one in the west and other in the east coast. Attempt to identify microsatellite markers for stock structure analysis in *Scomberomorus commerson, Thunnus albacares* and *Trachinotus blochi* generated 203,100 and 215 primers in each species respectively, of which, 30 loci in *S. commerson* and 25 loci in *T. albacares* were polymorphic. Genotyping was completed using 20 loci in *S. commerson and* 22 loci in *T. albacares*. 100 Microsatellite primers were screened in *T. blochii* using samples from single location, Mandapam and 35 loci were standardized.

Genetic diversity analysis in *S. sihama*

S. sihama, belonging to the family Sillaginidae,

is a valuable estuarine species with widespread distribution throughout the Indo-West Pacific region and is a candidate species for aquaculture. *S. sihama* exists as a species complex in Indian waters and there is a necessity of species as well as population specific information for sustainable utilization of the species. This is the first comprehensive study to assess the population diversity of *S. sihama* from India, using molecular markers. The present study reveals that the fishery of *S. sihama* occurs only along the west coast of India. Genetic stock identification of *S. sihama* was estimated using 16 microsatellite loci from four locations along the west coast of India viz., Ratnagiri, Goa, Mangalore and Cochin. The total no. of alleles per locus ranged from 6 to 30 and with the allele size range of 108 to 310 bp. Mean value of observed heterozygosity (H_{obs} - 0.601) for all populations was low compared to the expected heterozygosity (H_{exp} - 0.705). AMOVA and pair-wise F_{ST} derived using microsatellite markers exhibited low but significant genetic differentiation (P<0.001) among four populations, indicating the existence of distinct genetically structured management units of *S. sihama* along west coast (Fig. 46). Bottleneck analysis using Wilcoxon signed rank tests and Mode shift test indicated lack of recent bottleneck events across populations of *S. sihama*.

Genetic diversity analysis in *Perna viridis*

P. viridis (Linnaeus, 1758) is an economically important aquaculture species. For designing the appropriate fisheries management schemes, genetic information on wild populations is essential. In the present study, population structure and genetic differentiation of *P. viridis* in Indian waters was investigated using microsatellite marker panels with 15 loci. The total no. of alleles per locus ranged from 11 to 33 and with the allele size range of 120 to 390 bp. Mean value of observed heterozygosity (H_{obs} - 0.741) for all populations was low compared to the expected heterozygosity (H_{exp} - 0.75). Populations were found in HW equilibrium for majority of the loci, at P>0.05. AMOVA and pair-wise F_{ST} using microsatellite markers exhibited two distinct stocks - one along west and other along east coast (Fig. 47). Bottleneck analysis indicated lack of recent bottleneck events across populations of *P. viridis* along both the coasts. The findings of the present study strongly indicate the need for adoption of stock specific rehabilitation programmes of the species from Indian waters.

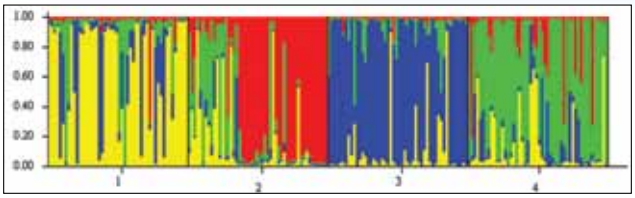


Fig. 46 Plot of K results from the STRUCTURE analysis of *S. sihama*

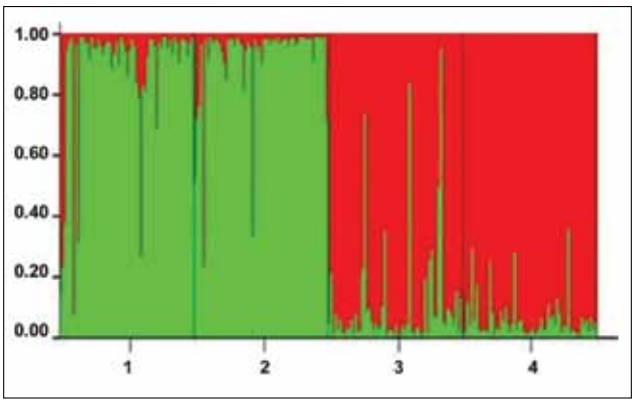


Fig. 47 Plot of K results from the STRUCTURE analysis of *P. viridis*

Development and validation of marker panels in *Scomberomorus commerson*, *Thunnus albacares* and *Trachinotus blochi*

Seer fish, *S. commerson* and yellowfin tuna, *T. albacares* are commercially important marine fishes. The current scenario warrants scientific intervention to utilize the fishery in a sustainable manner for which genetic stock structure information is vital. Attempts to identify microsatellite markers for stock structure analysis in these species, generated 203 microsatellite primers loci in *S. commerson,* 100 in *T. albacares* and 215 in *T. blochi.* Primer pairs were designed through Primer3 software. The secondary structures were checked in Oligo 7/Autodimer Software and oligos were custom synthesized. In order to test the polymorphism, the primer pairs were tested for amplification on unrelated individuals (n=12) of *S. commerson* and *T. albacares.* The amplicons in *S. commerson* exhibited polymorphism at 30 loci, while 25 loci exhibited polymorphism in *T. albacares*. The polymorphic loci were subsequently tested for suitability in population genetics analysis. Individual genotyped data were generated for *T. albacares* samples from Kochi, Visakhapatnam and Andamans (n=20) for each population using 22 primers, with a view to validate the microsatellite marker panels. For *S. commerson* samples (n=20 each) from Kochi, Chennai and Dona Paula, Goa, genotyping were completed using 20 primers. 100 Microsatellite

primers were screened in *T. blochii* using samples from single location Mandapam and 35 loci were standardized.

Project: CRP-Agrobiodiversity: national network on agrobiodiversity management
Project title: On Farm Evaluation of Prioritized Fish Genetic Resources for Conservation Aquaculture
Period: August, 2017 - July, 2020
Personnel: Kuldeep K. Lal (PI), Sullip K. Majhi, Santosh Kumar, Ajay K. Singh, T. T. Ajithkumar, Aditya Kumar and Charan Ravi
Funding Support: ICAR, New Delhi

Collection and broodstock development of Indigenous fishes

The work was carried out at three locations, as part of live germplasm resource centers network. These are NBFGR at Lucknow, Nagarjuna Sagar, Telangana and PMFGR center of NBFGR at Kochi. The aim was to conserve and propagate the indigenous fish species.

The spermatozoa cells ($7.9\pm0.5\times10^8$ per ml) from sexually matured *Clarias magur* (n=10) were partially harvested by surgical interventions (Fig. 48). Ten females were stripped to obtain matured eggs. The gametes were artificially fertilized and reared in flow-through water to produce viable progeny. Using partial harvesting approach, approximately 5000 fry was produced during the year 2018. The induced spawning of *Ompok bimaculatus* was achieved without sacrificing the male. Inducing agent Ovarim was given @ 1.5 ml/kg BW for female and 1.0 ml/kg BW for male intra-muscularly. The injected broods were reared in captivity at 24 - 26°C water temperature under showering condition. The embryonic development was recorded up to hatchling stage (Fig. 49). About 1200 *O. bimaculatus* were collected from Gomti and Sharda rivers at Chhoti dewariya, Sultanpur road, U.P. Nearly 250 *C. magur* were collected from Bihar during the year 2018. Ten *C. magur* each, from Guwahati and Manipur were collected and tagged for performance evaluation. 400 *Labeo rohita*, 200 *Catla catla* and 35 *Cirrhinus mrigala* from Ganga river were PIT tagged for performance evaluation. 300 *L. rohita* from Ghaghra river were also PIT tagged for performance evaluation. All wild stock and farm raised stocks of *C. magur* was PIT tagged and currently reared communally (Fig. 50).

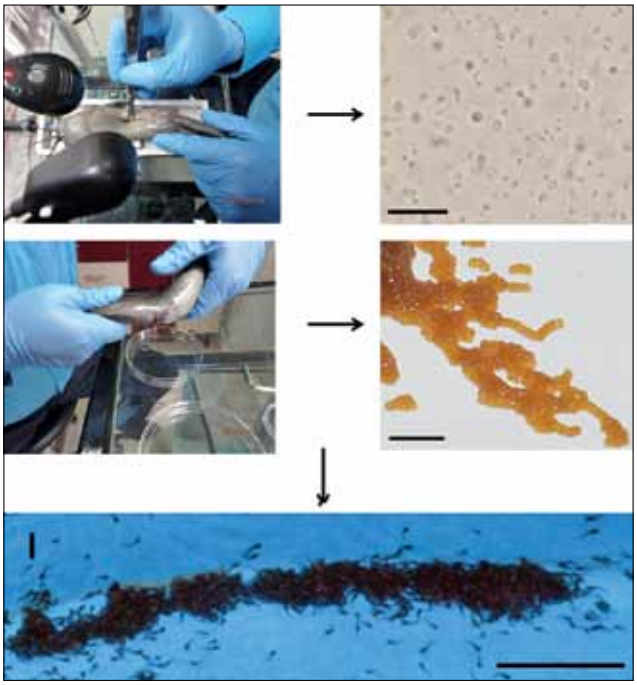


Fig. 48 Harvest of *C. magur* spermatozoa by non-sacrificial approach for mass-scale production of progeny.

Fig. 49 Normal embryonic development of *O. bimaculatus* during incubation at 26°C water temperature.

Fig. 50 PIT tagging of *C. magur* collected from wild.

As the nutritional profile of the *Pangasius silasi* (a new fish described by the ICAR-NBFGR), revealed superiority than *Pangasianodon hypophthalmus* and Basa fillets, much attention was paid for the collection of the fish for broodstock development in cage aquaculture at Nagarjuna Sagar reservoir, Telanagana (Fig. 51). Successfully standardized live fish transportation technique in plastic container / thermacol boxes with coracle. During December, 2017, 30 nos. survived well in the cages, whereas the stock was enhanced with 64 nos. in December, 2018. To monitor the individual growth of a fish, 44 *P. silasi* were tagged during May 2018 and the growth was assessed in December 2018, which gave remarkable results with average monthly length and weight gain of 2.0 cm and 76.22 g. Similarly, 147 nos. of Ompok were tagged to monitor individual growth, which revealed average monthly length and weight gain of 0.5 cm and 4.5 g (Fig. 52).

Fig. 51 View of the cages in the Nagarjuna Sagar dam

Fig. 52 Tagging of fishes in the Nagarjuna Sagar

Indigenous catfish, *Clarias dussumieri* (size range 70-130g) were collected from Thodupuzha, Kerala during 2018-19 and kept in FRP tanks in hatchery and in ponds. 50 fishes collected from wild were tagged for monitoring growth in captivity. The male fishes and female fishes were sorted and kept in separate FRP tanks. The fishes were fed with commercial feed with high protein. Induced spawning trails of *C. dussumieri* were carried out with 6 pairs of brooders, including four pairs of F1 stocks, using WOVA-FH hormone. Since fishes did not spawn naturally, stripping method was carried out. Stripped eggs were fertilised with mashed testis which yielded fecundity of 1500 eggs. The fertilisation rate was about 50% and hatching 25%. Larval rearing was carried out in FRP rectangular tanks, fed with artemia cake for one month and later fry were weaned to commercial feed. After 4 months of rearing fingerlings attained avg. weight of 9 g and avg. length of 8.0 cm.

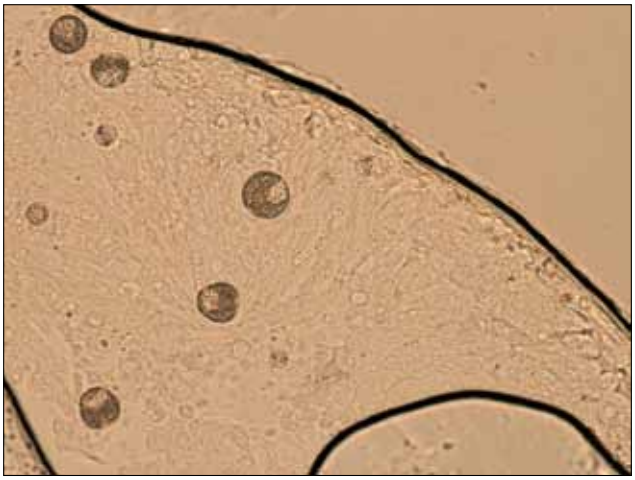


Fig. 53a *Piscinoodinium* parasite from mucus

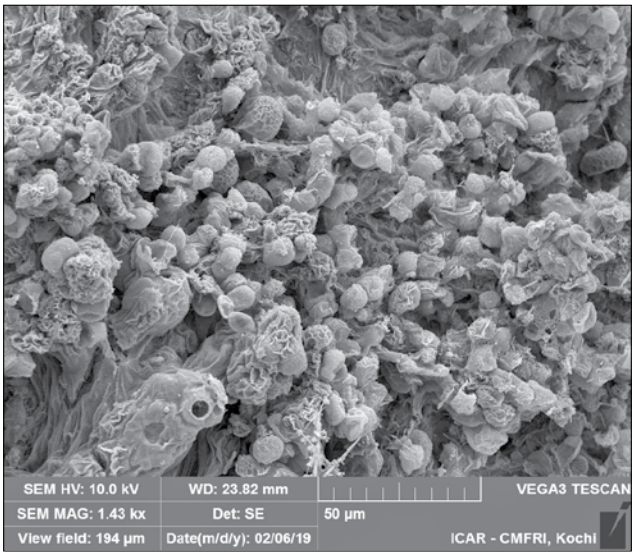


Fig. 53b SEM photo of *Piscinoodinium* parasite

A severe parasitic infection was observed in fingerlings and adults during December, which resulted in high mortality in stocks of *C. dussumieri*. The fishes were examined and the parasite was confirmed as *Piscinoodinium* sp. (Fig. 53a & b). Control measures were taken by continuous treatment with

common salt (5ppt) and FMG (Formalin malachite green) (3ppm) at 3 days interval.

More than 100 numbers of economically important yellow catfish, *Horabagrus brachysoma* were collected from Nandikara, Kerala and stocked in pond for broodstock development and 22 fish were maintained in the hatchery facility and tagged for monitoring individual growth, (avg. length and weight 17.18 cm and 63.0 g). Induced spawning trails of yellow catfish were successfully carried out using WOVA-FH hormone using one female and two male in FRP tubs (Fig. 54a). Female fish was weighing around 70g and male with 90-100g. Naturally ovulated eggs were yellowish in colour with mean fecundity of 4000 eggs per female with 90% fertilisation rate and 70% hatching rate (Fig. 54b). Newly hatched larvae were 3-5 mm in length and 1.0-1.8 mg in weight. Yolk-sac absorption completed in 76-80 hrs and initial feeding was done with newly hatched artemia nauplii.

Fig. 54a Induced Breeding of *H. brachysoma*

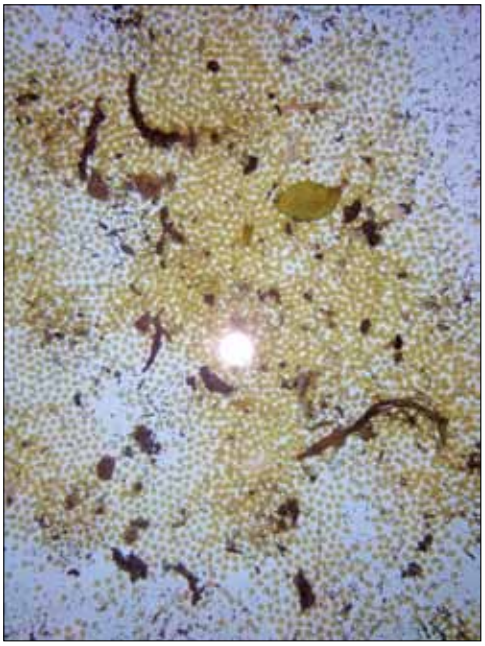


Fig. 54b Fertilized eggs of *H. brachysoma*

Labeo dussumieri commonly called as Malabar labeo and locally known as *Thooli* or *Pullan* were collected from Pampa River, Thakazhi and stocked in the pond for brood stock development (Fig. 55). A total of 100 sub adult fishes of avg. wt 50 g and avg. length 15 cm were collected and stocked in the pond.

Fig. 55 Stocking of *L. dussumieri* in the pond

A critically endangered catfish *Hemibagrus punctatus* (60 no.) endemic to River Cauvery was collected from Thalakkadu, Karnataka, transported to Kochi (more than 400 km) and maintained in FRP tanks (Fig. 56a).

Fishes were showing aggressive behaviour when kept together, hence the tanks were partitioned using nets and fish were separated in the same tanks. 32 fish were tagged for monitoring individual growth of the fish, (avg. length 29.15 cm and avg. weight

Fig. 56a Transporting *H. punctatus* from Mysore

Fig. 56b Gut content analysis of *H. punctatus*

185.73 g). Biology of *H. punctatus* collected from wild was studied. The gut content revealed that fish predominantly eats mollusc, followed by crustacean and fish (Fig. 56b). Gonads were observed and histology of testis and ovaries were done for the collected specimens. From the histology of ovary, it was presumed that the breeding period of *H. punctatus* is October - November.

Infrastructure development

A hatchery shed was constructed (Fig. 57a) and FRP tanks procured for the hatchery. Three nursery ponds (8m x 4m size) with lining were prepared (Fig. 57b) and 4 cages of dimension 4 x 4x 1½ m were installed in the pond for rearing broodstock (Fig. 57c) and two earthen ponds allotted to NBFGR were renovated (Fig. 57d). A wet-lab cum hatchery was set up within CMFRI campus with FRP tanks for breeding and larval rearing of fishes. In this facility, brood stocks of *C. dussumieri, H. brachysoma* and *H. punctatus* are being maintained.

Fig. 57a NBFGR Hatchery at KUFOS Farm

Fig. 57b Nursery pond with lining (8 x 4m)

Fig. 57c Cages installed in KUFOS pond

Fig. 57d Renovated pond

Project: Exploring the variation in immunological and disease susceptibility against *Aeromonas hydrophila* in two different stocks of Indian catfish *Clarias magur*
Period: April, 2017 – March, 2020
Personnel: Gaurav Rathore (PI), Chinmayee Muduli, Anutosh Paria and Ranjana Srivastava
Funding Support: Institutional, ICAR-NBFGR

Molecular characterization of immune genes of *Clarias magur*

Toll Like Receptors (TLR) recognizes the Pathogen-Associated Molecular Patterns (PAMP) and trigger a signaling pathway leading to production of inflammatory cytokines and other effector molecules associated with host immunity. Therefore, studying the expression of innate immune genes related to TLR pathway could serve as important immune mediators for understanding disease resistance in fish population.

Full-length cDNA of three immune genes of TLR pathway of *C. magur* for innate immunity were cloned and sequenced. These were TLR 22, TRAF6 (TNF receptor-associated factor-6) and IRAK-4 (IL-1 receptor-associated protein kinase-4) molecules. Full-length magur TLR22 cDNA comprised of 3597 bp with a single open reading frame of 2901 bp encoding a polypeptide of 966 amino acids. Full-length magur TRAF-6 cDNA comprised of 2383 bp with a single ORF of 1617 bp encoding a polypeptide of 538 amino acids. Full-length magur IRAK-4 cDNA comprised of 1893 bp with a single ORF of 1383 bp encoding a polypeptide of 460 amino acids. In addition, partial cloning and sequencing of TLR 2 molecule was also carried out (Fig. 58).

Four commonly used housekeeping genes, *i.e.*, Beta Actin; (β-actin), Glyceraldehydes Phosphate Dehydrogenase (GAPDH), Elongation Factor-1 alpha (EF-1α), 18S Ribosomal RNA (18S) were evaluated in Indian catfish, *C. magur*, under physiological (fed/fasting), developmental (juvenile/adult), rearing (earthen-pond/FRP tank reared), pathological (*Aeromonas hydrophila* infected and PBS injected control) conditions in 7 different tissues. Results of integrative analysis (n=40) of qRT-PCR data using algorithm-based programme Bestkeeper and Normfinder showed that most stable gene in decreasing order was EF-1α > β-actin > 18S > GAPDH.

Isolation and characterization of *A. hydrophila* from fish

Pathogenicity evaluation of five strains (9C, 10G1, 10C, 7C, 4P) of *A. hydrophila* was evaluated based on serum resistance, swarming activity, swimming assay, biofilm assay, β-haemolysis, starch hydrolysis. Serum resistance of *A. hydrophila* strains in decreasing order was as follow 9C (62.24%), 10G1 (60.31%), 7C (35.04%), 10C (53.8%), 4P (4.47%). Highest swarming activity was observed in 10C strain (400 mm) followed by 10G1 (330) and 9C (250 mm). 9C (80mm) and 7C (80 mm) strain showed highest swarming activity followed by 10G1 (61mm) (Fig. 59). Assessment of biofilm assay in these strain revealed that 9C has lowest biofilm producing capability and 4P with highest biofilm forming capacity. All the isolates were found to be positive for β-haemolysis and starch hydrolysis.

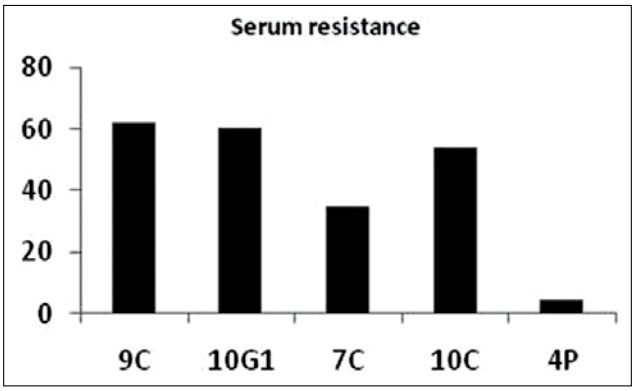


Fig. 59 Demonstration of serum resistance (%) by *C. magur* against different strains of *A. hydrophila*.

Pathogenicity trials of *A. hydrophila* in *C. magur* and determination of LD_{50}

Pathogenicity trial for 5 strains of *A. hydrophila* was done via intraperitoneal injection in 15 numbers of mrigal fish. Results showed that 9C and 10G1 strain are best suitable strain for infection model in *C. magur*

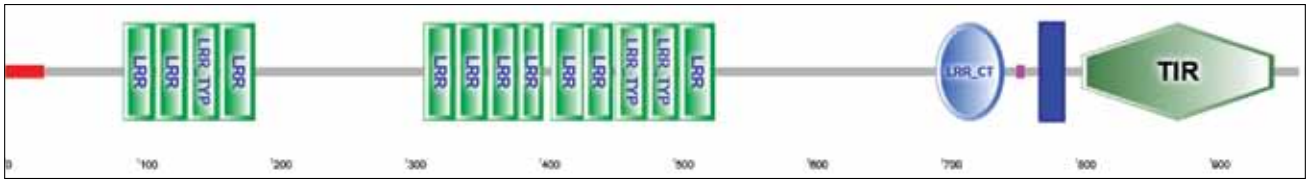


Fig. 58 Domain architecture analysis of TLR22 of *C. magur* using SMART

with calculated LD50 dose of 1× 10^6 CFU/ 100 µL per fish.

Project: Assessment of genetic introgression and variation in hatchery bred Indian major carps

Period: December, 2015 - December, 2020

Personnel: Rupesh Kumar (PI) and Rajeev K. Singh (Supervisor)

Funding Support: UGC-Rajiv Gandhi Fellow

Selection of hatcheries

The hatcheries (Government and private) were selected based on their production level and the seed supply to different parts of the country and those which supply seeds for stocking of the rivers. Samples collected from six different hatcheries of Uttar Pradesh, Madhya Pradesh and West Bengal, were used for truss and molecular analysis.

Shape morphometry and molecular analysis

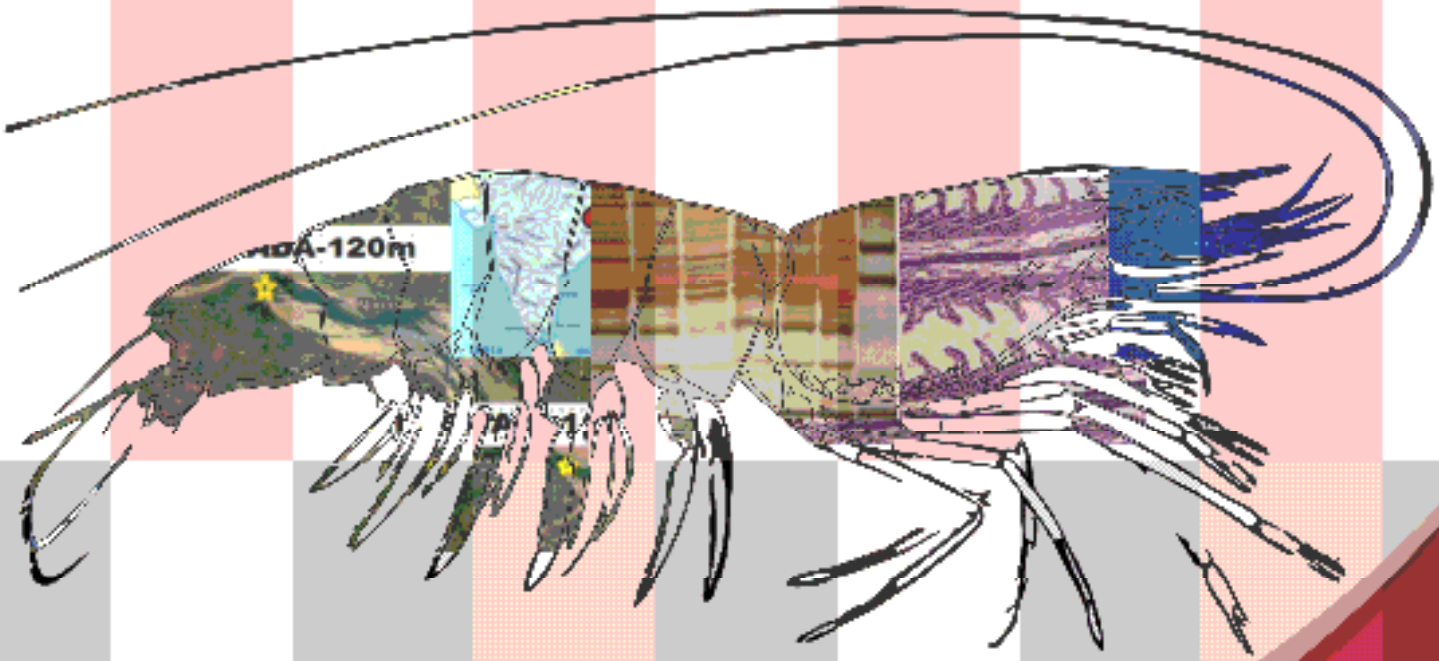
A total of 655 images (*Labeo rohita* 188; *Cirrhinus mrigala* 239 and *Catla catla* 228) were used for truss morphometry at the time of sampling. The landmarks (13) were assigned to individual fish to cover the entire fish in uniform network (Fig. 60). The multivariate analysis is under progress.

Genomic DNA was extracted quantified on agarose gel as well as micro volume spectrophotometer (Denovix). Polymorphic microsatellite loci were optimized for each species and genotyping was done with fluorescently labeled dyes; FAM, HEX and NED (Fig. 2). Upon analysis, the mean number of alleles were calculated in hatcheries and pond it was found to be 7.958 in *L. rohita* and 4.2 in *C. catla* from 4 distant hatcheries of Uttar Pradesh and Madhya Pradesh.

The mean inbreeding coefficient (F_{IS}) was 0.067 for *L. rohita*. F_{IS} in *C. catla* was 0.155, in hatcheries. In *C. mrigala,* a total of 255 individuals are being analysed for 16 polymorphic loci collected from 6 distant hatcheries of Uttar Pradesh, Madhya Pradesh and West Bengal.

Fig. 60 Landmarks on *L. rohita, C. catla* and *C. mrigala* for Truss morphometry

Program 4.3: Genomic resources for important fishes



Fishes as a group exhibit wide diversity and variation at genomic levels. A greater understanding of biological processes and gene functions may not only help in increasing fisheries production but also be useful from conservation perspective. ICAR-NBFGR has been a pioneer in the development of genomic and computational/ bioinformatics resources relevant to Indian fisheries sector. Institute is lead centre in ICAR-Consortium Research Project on Genomics and Agro-biodiversity platforms. The institute is also one of the domain partners in the CABin Scheme of ICAR, implemented through CABin Division of ICAR-IASRI, New Delhi.

We have taken lead in genomics of non-model species. The institute has generated DNA barcodes of over 600 Indian finfish and shellfish species, belonging to marine and freshwater ecosystems. *De novo* genome and transcriptome sequencing of three finfish species, *viz.* Rohu, Magur and Hilsa, and one oomycete fish pathogen has been completed, with genome sequencing of Catla underway. These studies will pave the way for comparative genomics in fishes leading to holistic increase in fish productivity in the country. The knowledge generated in the areas of genomics will be helpful in understanding the mechanisms of fish evolution and pursue innovative approaches and strategies for addressing challenges in aquaculture, disease management, seafood safety, conservation biology etc.

Project: ICAR-CRP Genomics: De-novo genome sequencing of anadromous Indian Shad, *Tenualosa ilisha* (Hamilton 1822)
Period: July, 2015 - March, 2020
Co-ordinator: J. K. Jena
Personnel: Vindhya Mohindra (PI), Rajeev K. Singh, Basdeo Kushwaha and Labrechai M. Chowdhury
Funding Agency: ICAR, New Delhi

1. Identification of genes involved in adaptability to varying salinity to be carried out in Hilsa, *Tenualosa ilisha*, through differential expression

The gill samples of *T. ilisha* from marine, brackish and freshwater environment were analyzed for differential gene expression in different environments. It was found that 807 were up-regulated and 3080 down regulated genes in marine vs freshwater environment and 661 up-regulated genes and 426 down regulated genes in brackish vs freshwater environment.

The GO enrichment analysis revealed that marine vs freshwater, 1829 and 718 genes were up and down regulated, respectively, containing 50 GO terms (Biological Process 44.00 % {22 GO terms}, Cellular Process 28.00 % {14 GO terms}, Molecular Function 28.00 % {14 GO terms}) were specific to osmoregulatory pathway. Analysis of GO term distribution exhibited that signal transduction (GO: 0007165), response to stress (GO: 0006950), cell adhesion (GO: 0007155), ion transport (GO: 0006811) and cellular amino acid metabolic process (GO: 0006520) in BP, extracellular matrix (GO: 0031012), nuclear envelop (GO: 0005635), external encapsulating structure (GO: 0030312), cell envelop (GO: 0030313), periplasmic space (GO: 0042597), and GTPase activity (GO:0003924), GTP binding (GO: 0005525), transcription factor binding (GO: 0008134), ATPase activity (GO: 0016887), ligase activity (GO: 0016874) in MF were most common term in these three GO categories.

The KAAS (KEGG Automatic Annotation Server) deduced functional annotation indicated a total of 1781 (36.03%) gill transcripts. The five main categories included 252 KEGG pathways, in which metabolism retained the maximum number of transcript 786, followed by organismal system (441), environmental information process (294), Cellular processes (124) and genetic information process (84).

While considering only osmoregulatory pathway, KEGG Annotation revealed five main categories, included cellular processes, metabolism, organismal system, brite hierarchy and environmental information processing. In which, sub-category signal transduction contains maximum 135 up regulated and 69 down regulated transcript, followed by endocrine system 91 up regulated and 46 down regulated, cellular community-eukaryotes 41 up regulated and 23 down regulated, energy metabolism 2 up regulated and 60 down regulated, membrane transport 3 up regulated and 57 down regulated, signalling and cellular processes 11 up regulated and 23 down regulated, excretory system 13 up regulated and 7 down regulated and transport & catabolism 12 down regulated transcripts. In endocrine system, the differentially expressed genes belong to specific pathways, such as renin-angiotensin system, ovarian steroidogenesis and Progesterone-mediated oocyte maturation. The results also displayed several signalling pathways to be involved in osmoregulatory activities in hilsa, such as estrogen, glucagon, GnRH, insulin, oxytocin, adipocytokine and thyroid. Other pathways associated with secretory activities were insulin, renin and thyroid.

Project: Network Project on Agricultural Bioinformatics and Computational Biology
Subproject: Construction of physical map of *Clarias magur* genome
Period: May, 2017 – March, 2020
Personnel: Ravindra Kumar (PI), Basdeo Kushwaha, Mahender Singh, Ajey K. Pathak and Murali S.
Funding Support: ICAR - Indian Agricultural Statistics Research Institute, New Delhi

Bacterial artificial chromosomes (BACs) are ideal resource for sheltering long fragments, up to 300 kb size, of genomic DNA. This is important resource useful in various types of genome analyses. The genomic resource of *Clarias magur* has been generated and maintained as library of BAC clones for characterization of the species as well as other genomic analyses. The present study is aimed to generate physical map of *C. magur* genome using BAC library, which will help in generation of anchored well-ordered assembled whole genome sequence of the species.

During the reporting period 2018-19, a total of 907 BAC clones of *C. magur* genome were revived and isolation of BAC insert DNA were accomplished. Further, a total of 1164 forward and reverse end sequences of clones were generated using T7 and pbRP1 primers, respectively.

The BAC end sequences were mapped on scaffolds of *C. magur* genome using BACPipe bioinformatics tool, where 933 end sequences were mapped on the scaffolds of genome, while rest 231 did not map. The genes were mined on those clones as well as scaffolds in which both the forward and the reverse end sequences mapped on the same scaffold. In this way, a total of 769 genes were mapped/ present on 189 BAC clones, while on the other hand, a total of 931 genes were mapped on 281 BAC clones in the new genome assembly of *C. magur*.

The BACs representing higher number of genes, identified after aligning end sequences of clone with scaffolds of draft genome, were undertaken for construction of fluorophore labelled DNA probes used onwards in physical mapping of those genes on the chromosomes of *C. magur* using FISH. A total of over 615 genes were mapped on *C. magur* chromosomes using two fluorophores, *viz.* Fluorescein 12-dUTP (green) and Rhodamine-5-dUTP (red), labelled DNA probes through FISH from 42 BAC clones identified from 12 scaffolds (Fig. 61).

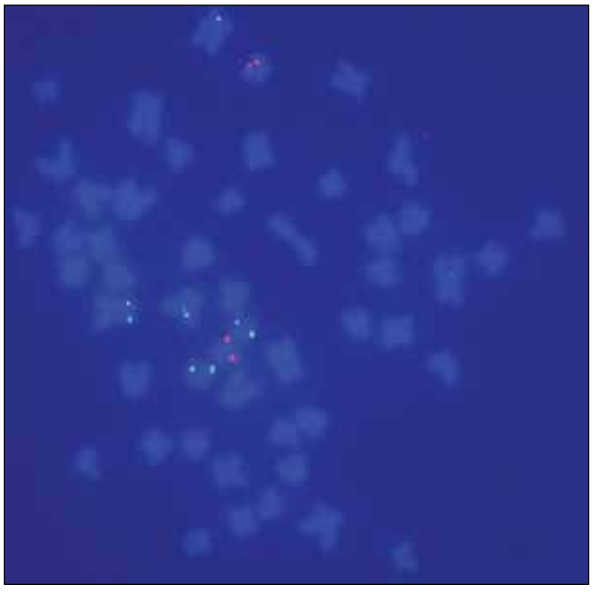


Fig. 61 Image showing localization of 2 clones (*viz.* ICF-001-I02 and ICF-003O9 that are present on Scaffold # 48 and contained 53 genes) and 3 clones (*viz.* ICF-004-M12, ICF-005-M20 and ICF-004-N14 that are present on Scaffold # 80 and contained 50 genes) on 03 (green signals) and 01 pairs (red signals) of *C. magur* chromosomes, respectively, using dual colour FISH.

Four genomic resource databases (*viz.* FishMicrosat, FMiR, FBIS and Fish Karyome) were updated using data available in the public domain. Presently, HRGFish contains 1891 genes of 65 species, FishMicrosat contains 14684 records of 196 species, FMiR contains 2337 records of 2337 species, FBIS contains 35355 records of 1780 species, and Fish Karyome includes 1195 records from 953 species (Fig. 62). FisOmics portal developed under the project at ICAR-NBFGR had 28226 visitors. The hit counts for individual databases were: FBIS-37983, FMiR-23159, FishMicrosat-27526, Fish Karyome-33087 and HRGFish-18867.

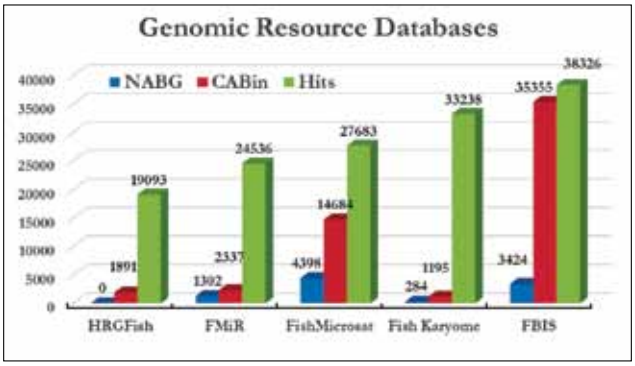


Fig. 62 Image showing genomic resource databases developed in NABG and CABin projects with number of records and hits.

Project: Stress tolerance response in cultivable freshwater fish species
Period: April, 2018 - March, 2019
Personnel: Satish K. Srivastava (PI), Ravindra Kumar and Poonam J. Singh
Funding Support: Institutional, ICAR-NBFGR

Earth's climate has changed several times in the past that were credited to natural causes, but the recent changes mainly associated with global warming, has impacted fishes. Changes in temperature of aquatic environment may have effects on physiology, behaviour, growth, reproductive capacity, mortality and distribution etc. In the project, work was undertaken to estimate the critical limits of abiotic stressors on fishes and also investigate the physiological and behavioural changes such as swimming behaviour in fishes due to high temperature stress.

The specimens of *Clarias magur*, collected from Live Gene Bank of ICAR-NBFGR and local fish market and *Labeo bata, L. calbasu* and *Ompok bimaculatus* were collected from Gomti river and were acclimatized in re-circulatory system at room

temperature. The experiments were conducted separately and control fishes were kept at room temperature while experimental fishes were kept in warm water with daily temperature increase @ 1°C per day till 50% mortality was observed.

The thermal tolerance limits were *O. bimaculatus* (38°C), *C. magur* (37°C), *L. calbasu* (40°C) and *L. bata* (39°C). Thermal tolerance limit of *C. magur* was found to be 37°C which was 1°C below the lethal temperature. The abnormal behavioural response such as abnormal swimming, widening of fins and movement was observed at critical temperature. Physiological parameters, *viz.* blood glucose, cholesterol, serum protein, hemoglobin's, creatin, sodium, potassium, chloride, blood ammonia and nitrous oxide were estimated in control and treated specimens of above species, which were exposed to 0, 15, 30, 45 and 60 days period at sub-lethal temperature. In exposed (*i.e.* 37°C) *C. magur* specimens for 60 days, there was increased levels of serum protein as well as glucose and decreased levels of urea, haemoglobin and cholesterol.

Proteomic profiling of *C. magur* exposed at sub lethal water temperature for 60 days was also done (Fig. 63). The extracted protein samples were analysed for identification of their molecular weight, iso-electric points and LC-MS/MS data. Liquid chromatography was performed for peptide fingerprinting on ACQUITY UPLC BEH C18 column (Waters, UK) (150 mm*2.1 mm*1.7 µm). The raw data acquired from the instrument was processed using PLGS software 3.0.2 within which Data Processing and Database search was performed. Peptide fingerprint data of *C. magur* was blasted and matching data of zebrafish was obtained. Qualitative Differential expression of proteins was carried out based on peptide tolerance of 50 ppm, fragment tolerance of 100 ppm with minimum fragment match of 2 peptides for proteins. Peptides were modified (carbamido methylation and oxidation) and the retrieved proteins were analysed, visualised and interpreted with Reactome peer reviewed pathway database against zebrafish, that showed 1820 proteins under Molecular Function category, 2216 under Cellular Component category, and 2051 proteins under Biological Process category. 25 most relevant pathways sorted by p-values were analysed for control and experimental fishes. Proteomic data shows that out of 25 most relevant peptides at least 12 peptides were commonly expressed in both control and temperature exposed *C. magur* and 13 peptides are expressed different in control and experimental fishes.

In the control samples, 603 identifiers out of 2159 were found, where 957 pathways were hit by at least one of them. In the experimental samples, 556 identifiers out of 1880 were found where 915 pathways were hit by at least one of them.

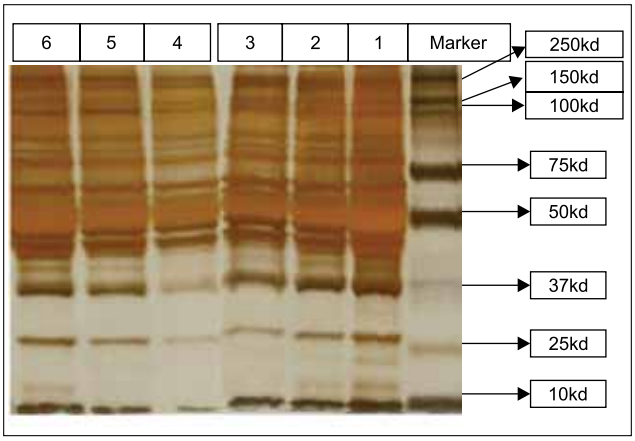


Fig. 63 1D protein profiles of muscle of *C. magur* exposed to 37°C for 60 days

Project: **Understanding genomic mechanisms of thermal tolerance using golden mahseer, *Tor putitora* (Hamilton, 1822) as model.**

Period: **August, 2018 to March, 2020**

Personnel: **Vindhya Mohindra (PI), Trivesh Suresh Mayekar and Labrechai Mog Chowdhury**

Funding Support: **National Initiative on Climate Resilient Agriculture (NICRA), ICAR**

Identification of genetically-regulated adaptation in a species is a precursor to understanding how populations respond to climate induced stressors like temperature. Adaptations to changing climates is a gradual process involving accumulation of beneficial mutations in isolated populations to acquire inheritable variations in genome, adjust physiologically to survive under new sets of climatic conditions and thus these become evolutionary significant units (ESUs). Such ESUs are important for conservation and also useful source of knowledge on genomic variation and also genomic resources for aquaculture use. The isolated *T. putitora* populations found in diverse climate regimes such as high altitude Himalayas and central

plateau are likely to have accumulated genomic variation over millions of years and are valuable genetic resource. Therefore, such species models will provide useful insights into gene functions regulatory mechanisms and factors involved with the thermal tolerance.

Exploration survey and collection of samples of fishes from two divergent habitats

Two exploratory tours was conducted for collection of fish samples of *T. putitora,* one in lower Mahanadi river basin covering two sampling locations (Table 7, Fig. 64 and 65) during September, 2018 and another in Ganga river system covering five sampling locations in October, 2018.

Tissue sample collection

Tissue samples were collected from a total of 14 and 60 fishes from Jharpada and Lankeswari site of Mahanadi river and Uttarkahand from Ganga river system, respectively. Data on length and weight of all the fish samples were recorded during sampling tour. A total number of 24 and 30 individuals collected and verified through COI sequences as *T. putitora*.

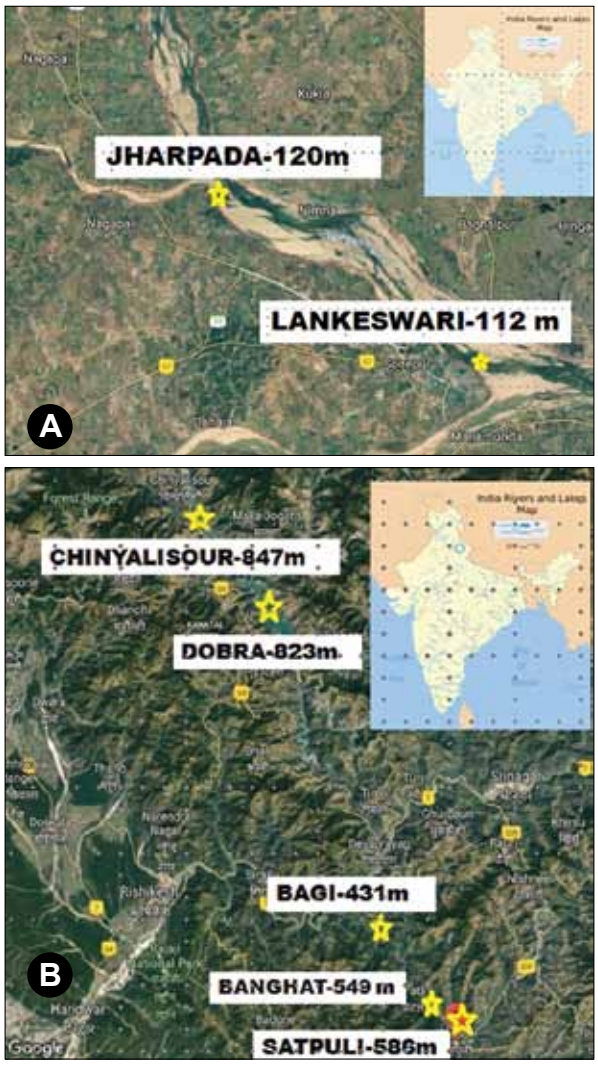


Fig. 64 Map showing Fish sampling locations (A) Jharpada and Lankeswari of Mahanadi river (B) Ganga River System, Chinyalisour, Dobra, Bagi, Banghat and Satpuli.

Fig. 65 Fishing at Jharpada, Mahanadi river system

Table 7. Fish Sampling Locations for *T. putitora*

River System	Tributary/ River	Location	Altitude (m above sea level)	No. of Samples Collected
Ganga River system	Nayar River	Satpuli	586	6
		Banghat	549	5
	Ganga River	Bagi	431	4
	Bhagirathi River	Dobra	823	20
		Chinyali-sour	847	25
Maha-nadi River System	Mahanadi River	Jharpada	120	1
		Lankeswari	112	13
		Total		74

Project: To elucidate the unique biochemical adaptational strategies that allow two air-breathing catfishes (*Clarias batrachus* and *Heteropneustes fossilis*) to survive in ammonia enriched toxic waste

Period: August, 2018 - July, 2021

Personnel: Vindhya Mohindra (PI), Aditya Kumar, Labrechai Mog Chowdhury

Funding Support: NASF - ICAR, New Delhi under consortium mode

The indigenous freshwater catfish (*Clarias magur*) is found in habitat with stagnant water bodies and/ or muddy substratum, where O_2 is limited primarily

because of excessive content of nitrogenous wastes such as ammonia. Further, they occasionally face the problem of higher external ammonia toxicity when they are trapped in puddles of water or while burrowing inside the mud peat during summer. This catfish is known to be tolerant to hazardous levels of ammonia, since no other fishes can tolerate such a high ambient ammonia. Hence, it is important to elucidate the whole set of adaptive genes, factors and regulatory molecules as well as signaling pathways operative in this catfish and their expression patterns .

Collection of experimental animal and treatment with hyperammonia concentration

From *C. magur*, after exposure to 25 mM NH_4Cl and control for a period of 3h, 6h, and 9h, blood ammonia and other physiological parameters were analysed. The accumulation of ammonia in blood plasma showed significantly 3 fold increase at 3h and 6h compared to control. At 9h, ammonia in blood plasma decreased significantly as compared to control. However, blood urea level gradually increased and concentration became maximum at 9h, it was significantly higher than control (Fig. 66). Blood sugar and SGOT values recorded significantly higher at 6h of ammonium chloride treatment. Rest of the other blood and serum parameters did not show any significant difference between ammonium chloride treated group and control.

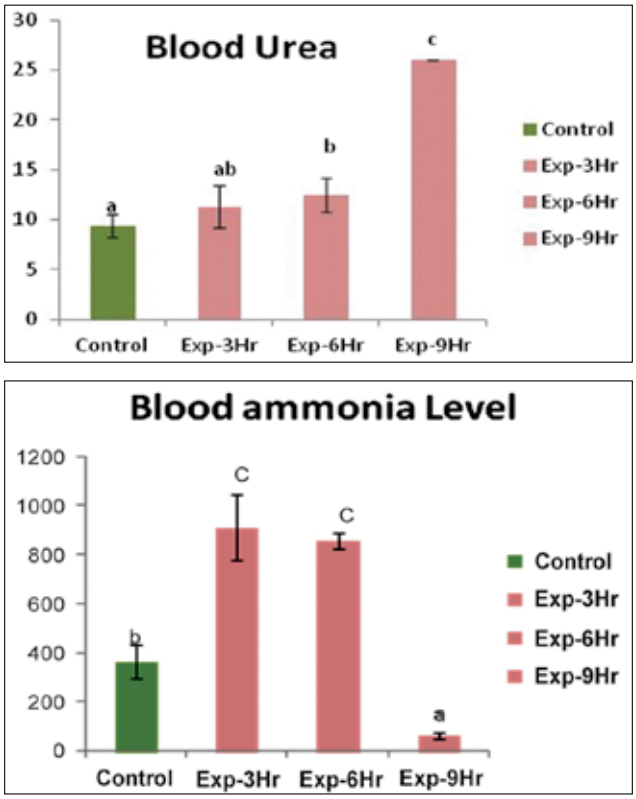
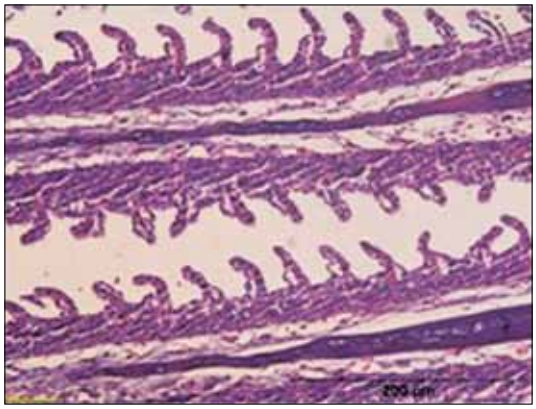


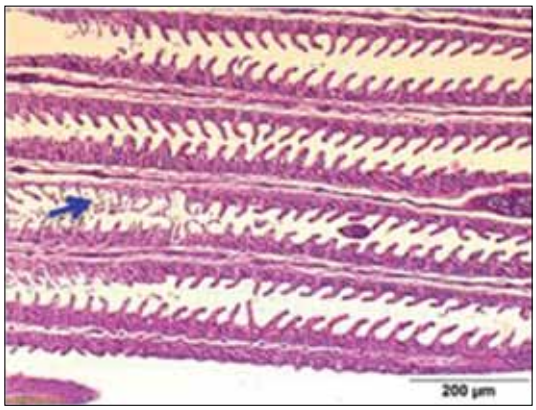
Fig. 66 Level of blood urea and blood ammonia during different time interval of exposure to NH_4Cl

Histological changes in gills of fish exposed to 25 mM NH_4Cl

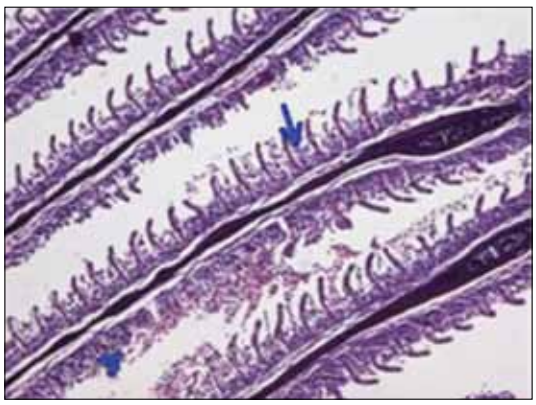
Degeneration of gill lamellae after 3hr of exposure were observed. Chloride cell hyperplasia and degeneration of gill lamellae could be seen after 9hr of exposure (Fig. 67).



Control



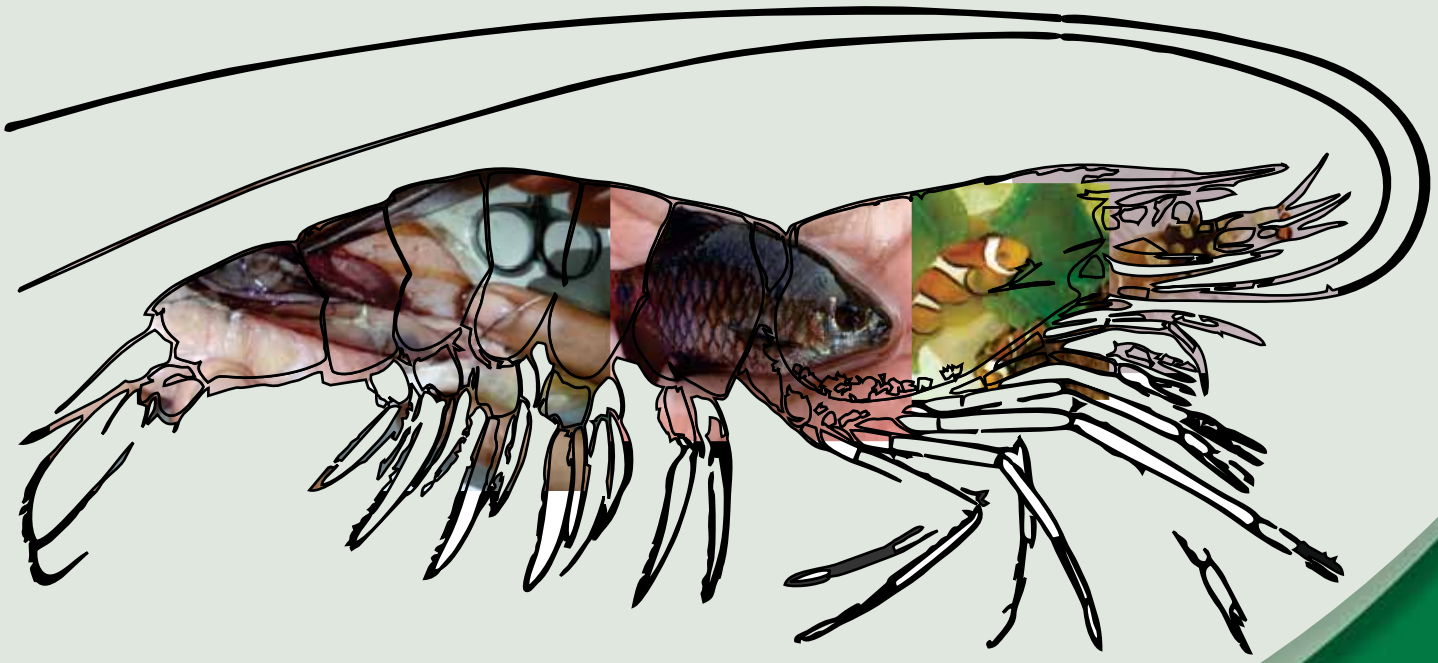
3 hr exposure



9 hr exposure

Fig. 67 Histological appearance of gills after 25 mM Ammonia exposure (a) control (b) degeneration of gill lamellae (arrow) after 3hr exposure to 25 mM ammonia concentration (c) chloride cell hyperplasia (arrow, adaptive process) and degeneration of gill lamellae (arrow head) after 9hr exposure to 25 mM ammonia concentration (H & E staining)

Program 4.4: *Ex situ* and *in situ* conservation



Ex situ and *in situ* conservation is indispensible, being a biodiversity rich country and a signatory to the Convention on Biological Diversity (CBD). In order to conserve biological diversity, for its sustainable use, CBD was enacted giving due emphasis to *Ex situ* and *in situ* conservation which is mentioned under section 9.0 and 8.0 of CBD, respectively. Since, India is a party to CBD, the Biological Diversity Act, 2002 of India was enacted to meet the obligations under CBD. Loss of biodiversity is one of the greatest challenges to be addressed. The aquatic genetic resources are facing serious threats from both natural and anthropogenic stresses and these stresses are depleting our germplasm resources in some of their native distribution range. Hence, conservation of fish genetic resources of agrobiodiversity importance is a vital aspect for sustainable utilization of these resources. ICAR-NBFGR has been constantly working in this area of research, since its beginning. The major activities of the institute have been development of species–specific sperm cryopreservation protocol for finfish species, tissue banking, cell lines, DNA Bank and captive breeding of some prioritized fish species (i.e., commercial or conservation importance). Recently, the institute has also established germplasm resource centre for marine ornamental, invertebrates and fish. Initiatives for using stem cells as conservation tools, brought success in capacity building by providing promising results as it is capable of storing diploid germplasm in contrast to the haploid storage through sperm. In order to alleviate the sperm related problems in the coming days, the institute has taken a major initiative of setting up cryobank of Indian major carps. However, stem cells are more encouraging for long-term conservation of germplasm.

Project:	**National Repository of Fish Cell Lines in NBFGR (Phase II) and Access Centre in C. Abdul Hakeem College and research on application of cell lines in virology, toxicology and gene expression studies**
Period:	**May, 2017 - May, 2020**
Personnel:	**Basdeo Kushwaha (PI), Ravindra Kumar, Murali S. and Akhilesh Kumar Mishra**
Funding Support:	**Department of Biotechnology, Government of India.**

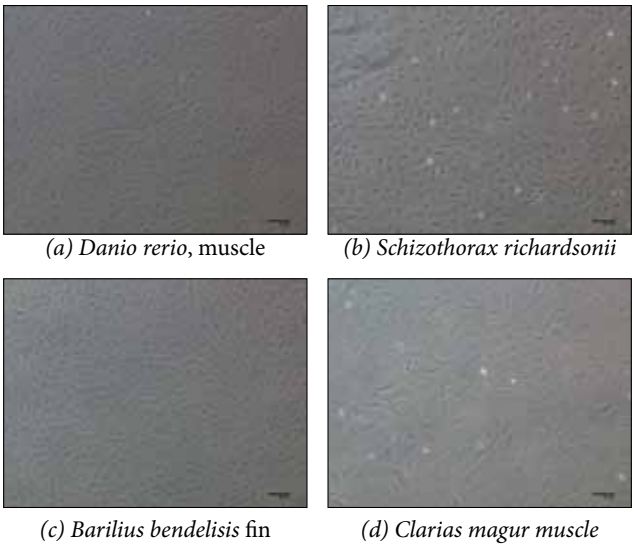
National Repository of Fish Cell Line (NRFC) was established with the objectives to receive, authenticate, characterize, maintain and distribute fish cell lines on request for R&D works. Recognizing the importance of fish cell lines, the Department of Biotechnology, Government of India, supported the above project to facilitate research and development in fish cell culture studies.

During the reporting period 2018-19, four new fish cell lines developed from different tissues, namely, PHF (*Pangasiodon hypothalamus,* fin), CMP (*Cirrhinus mrigala,* peritoneal), ClDu (*Clarias dussumieri,* caudal fin) and FtGf (*Carassius auratus,* caudal fin) were received from different labs of ICAR-NBFGR for preservation and further maintenance. After receipt, these cell lines were again characterized using COI and also tested for mycoplasma contamination, and then included in the NRFC with accession numbers. Presently, 59 fish cell lines are being maintained in the repository. Routine cell line maintenance activities, like revival and cryopreservation, were carried out for 19 fish cell lines. The cells were cryopreserved in 1.8 ml cryo-vials in LN_2 using Leibovitz 15 (L-15) medium supplemented with 10% Fetal Bovine Serum (FBS) and addition of 10% dimethyl sulphoxide (DMSO) as cryo-protectant.

Attempts were also made to develop new fish cell lines of different fish species. Four fish cell lines using various tissues, *viz.,* ZFM (*Danio rerio*, muscle), SRE (*Schizothorax richardsonii*, eye), BBF (*Barilius bendelisis*, fin) and CMT (*Clarias magur*, testis) were developed. All the four cell lines were characterised using COI sequences and also found negative for mycoplasma. Immuno-phenotyping was performed for these cell lines (Fig. 68).

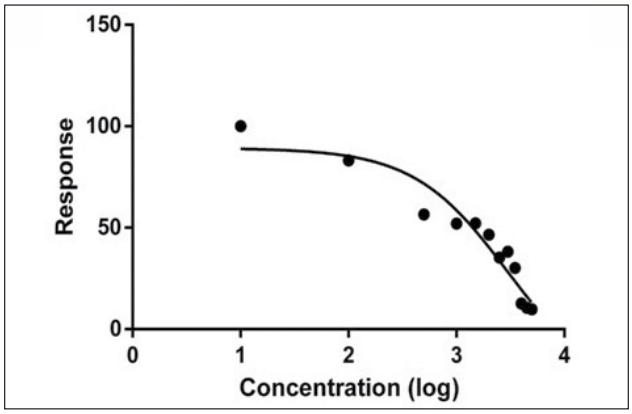
Chromosome preparation was carried out for 6 fish cell lines. Mycoplasma testing based on PCR method was carried out for 20 cell lines and found to be negative. Cytotoxicity testing of tembotrione pesticide was carried out using alamarBlue assay in ZFM cell line. Minimum 50,000 cells were seeded per well in triplicates in 96 well plates along with a control. Eleven pesticide concentrations, *viz*., 5000 uM, 4500 uM, 4000 uM, 3500 uM, 3000 uM, 2500 uM, 2000 uM, 1500 uM, 1000 uM, 500 uM and 100 uM were tested. The inhibition constant (IC50) value for the pesticide was found to be 2984 µM. Cytotoxicity testing of 3 heavy metals, *viz*. mercury chloride, sodium hydrogen arsenate heptahydrate and potassium dichromate was carried out using alamarBlue assay in CMT primary cell culture. Minimum 50,000 cells were seeded per well in triplicates in 96 well plates along with a control. The toxicity was estimated in the order of chromium>mercury>arsenic with IC50 values of 47.03, 203.7 and 298.1 µM, respectively (Fig. 69).

Supply of cell lines to researchers for R&D purposes is one of the important activities of the repository. In this regard, 13 fish cell lines were distributed to various researchers, including institutions, like ICAR-CIFE, Mumbai; Delhi University; Maharaja Sayajirao University, Vadodara; College of Fisheries, Mangalore; and CUSAT, Kochi; across the country on demand, for R&D purposes. A Short term hands-on training course on "Cell Line: Development, Maintenance and Applications" covering various aspects of cell culture techniques, like cell line development, characterization, cryopreservation, maintenance, virus isolation, cytotoxicity testing etc., was conducted during 24 September to 01 October, 2019, at ICAR-NBFGR.

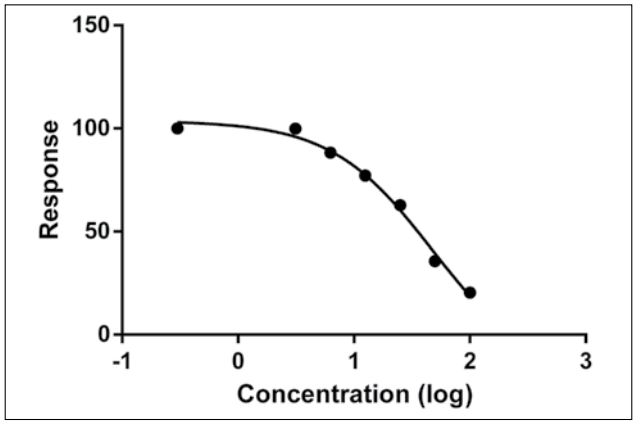


(a) Danio rerio, muscle *(b) Schizothorax richardsonii* *(c) Barilius bendelisis* fin *(d) Clarias magur muscle*

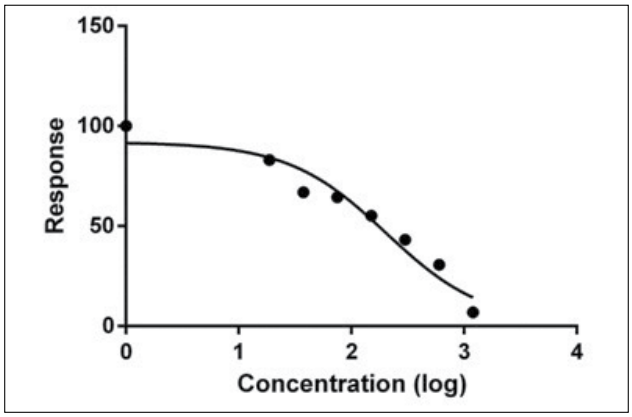
Fig. 68 New fish cell lines developed at ICAR-NBFGR, Lucknow



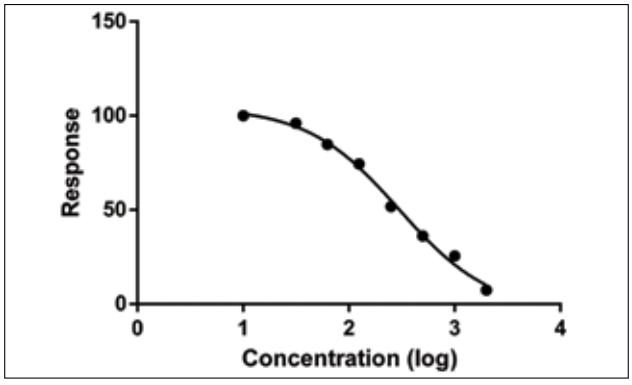
(a) Tembotrione in ZFM



(b) Chromium in CMT



(c) Mercury chloride in CMT



(d) Arsenic in CMT

Fig. 69 Dose response curve of pollutants in fish cell lines

Project: Assessment of biological response of *Tor putitora* (golden mahseer) to hydropower infrastructure and operation in Alaknanda and Bhagirathi river basins

Period: June, 2017 - May, 2019

Personnel: Saurabh Dewan (PI) and Vindhya Mohindra (Supervisor)

Funding Support: Science and Engineering Research Board (SERB)

Hydropower infrastructure transforms the local aquatic environment via alteration in flow, barriers, sedimentation and changes in nutrient adversely affecting downstream fishes. *Tor putitora* (Golden mahseer) a 'flagship' species is an endangered freshwater fish, inhabiting Himalayan Rivers. In recent years, conservationists have expressed concern over its declining populations due to indiscriminate fishing besides severe adverse effects of dams. Most studies hitherto, have evaluated changes in community structure or population which have long response time extending beyond the monitoring periods required by regulatory agencies. Current proposal, aims to assess efficacy of methods like biometry, physiological activities, quantification of biomolecules which have been rarely applied to hydropower settings. As majority of critical riverine habitats of mahseer have been subjected to or are under the process of regulation for hydropower generation, it is important to make serious efforts for conservation of this remarkable species. To assess the impacts of hydropower infrastructure and operations, tools that measure suborganismal responses should be developed and validated as it can provide information on time scales consistent with most monitoring programs. However, none of the studies in these basins have included such markers or linked individual condition with behaviour and fate in a hydropower context. The purpose here is to gain insight into the basic biological responses, employing a suite of physiological and molecular tools in order to properly manage endangered mahseer populations in hydropower-impacted river system.

Water and Habitat quality assessment

The current proposal is being executed at four hydroelectric project sites: Srinagar and Birahi Ganga (in Alaknanda basin), Tehri-I and Maneri Bhali-II (in Bhagirathi basin). Field assessment was done to assess the area under influence at each project via

site surveys as well as by consulting project officials and previous EIA reports. Accordingly, twelve sampling points were identified, *i.e.*, one upstream and downstream at each of the four hydroelectric project sites and four unobstructed flow sites in order to gather information on water quality and habitat alteration due to hydropower operations and infrastructure developments. Monthly data was collected and significant variations in habitat quality and water chemistry were observed between upstream reservoirs and downstream river stretches (Fig. 70). Water temperature of the reservoir showed typically rapid warming-up (up to 25°C) between December to March owing to the low flow rate as the power plants were storing rather than generating electricity. Similarly, high pH (up to 8.5) was recorded in reservoirs during Feb-March which might be due to increased photosynthetic activity and decomposition of allochthonous matter with rise in temperature.

The dissolved oxygen concentration reduced (up to 5.1 mg/l) in the reservoirs in comparison to downstream stretches (8.1 mg/l) as a result of suspended materials brought into the reservoirs by rain increasing oxygen demand while oxygen production by photosynthesis is reduced by turbidity. Total alkalinity in downstream unobstructed flow showed wide range of fluctuations (40-105 mg/l) which is due to varied location, bottom deposits and season, while less variability was observed upstream (65-90 mg/l). Higher level of nitrates and phosphates in reservoirs was observed in post-monsoon months (0.086 and 0.091 mg/l, respectively). This could be attributed to runoff after rainfall from nearby farmlands containing fertilizers and herbicides leading to increased concentration in reservoirs.

Significant variation in the conductivity in upstream values was observed (59-240 µS/cm), which may due to dilution by influx of rain water and later reduction in water level in the reservoirs due to evaporation with the start of dry season. A large accumulation of total solids in the reservoirs (125-342 mg/l) than unregulated river stretches (97-155 mg/l) was recorded, which may reduce light penetration and suppress photosynthetic activity leading to decrease in productivity of aquatic ecosystem.

Stock assessment and physiological study

The current stock aggregation and length weight pattern at all sites was assessed. 69 samples were collected at AHPC Srinagar site, 38 samples from Birahi HEP, 75 samples from THDC Tehri site. No samples have been found, till now, around Maneri Bhali-II hydroproject at Uttarkashi. 26 samples were recorded at control sites (unobstructed Nayar stream at Devprayag and at Satpuli). The b value was calculated to assess whether the samples of *T. putitora* obtained were growing allometrically or isometrically. For all the samples clubbed together, the b value was

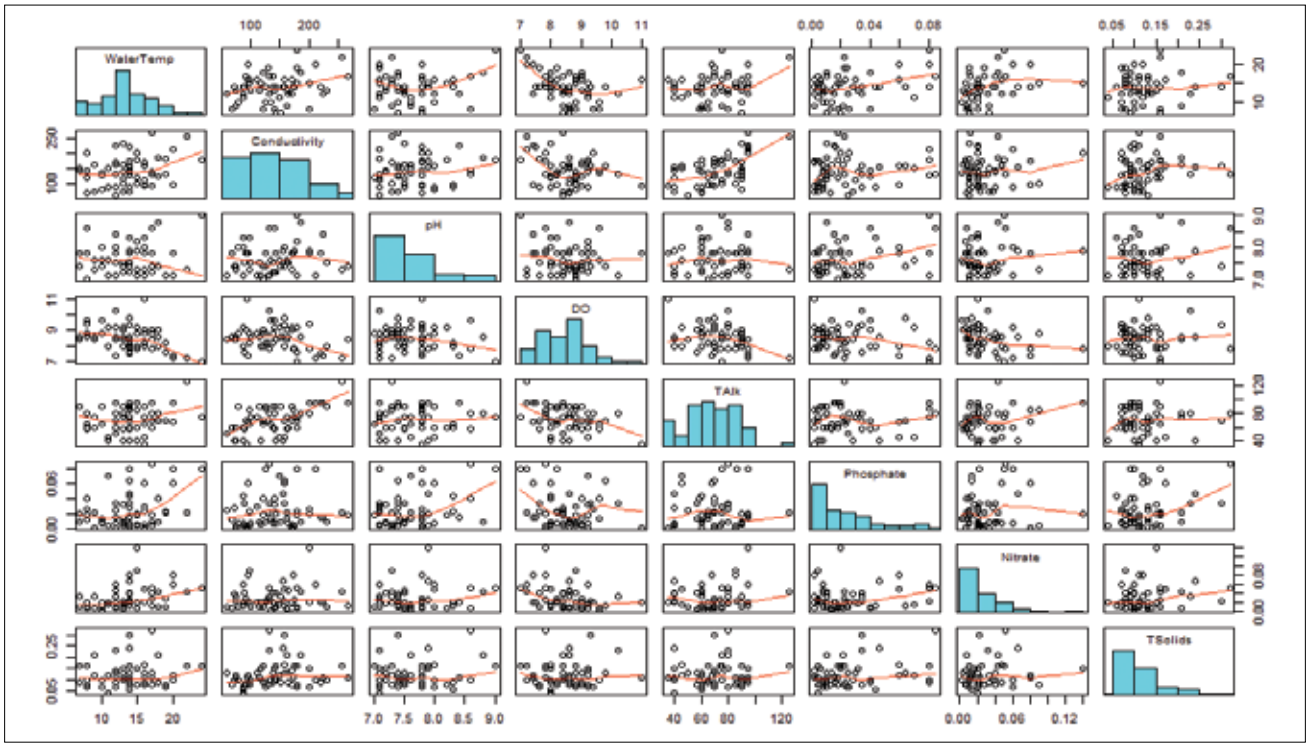


Fig. 70 Eighteen month trend for variation in water quality between upstream and downstream stretches

2.9 depicting that the growth is almost isometric, the value less than 3 may be due to small sample size or due to the fact that fish in these stretches are growing with a slower weight increase relative to the length.

The serum glucose and lactate levels and serum lipid profile is currently being assessed using commercially available diagnostic kits while the glycogen levels in liver and muscle are being measured by Anthrone method. The variations in physiological parameters are being observed between upstream reservoirs, downstream river stretch and control sites, however, rigorous data analysis is currently underway.

Gonadal study and other indices

For condition factor, highest (1.79-1.91) and lowest range (0.79-0.96), were observed in control sites (unobstructed), however, in reservoirs 0.81-1.31 values were recorded even in peak breeding season. The value of k, indicates peak activity of gonads in control sites (as per seasons) but is significantly influenced in reservoirs even in peak seasons. Higher GSI (2.89) was observed in July, August (coinciding the breeding months) in control sites. However, the higher value (2.11) was also observed post-winter (Jan, Feb) in Tehri reservoir, hinting some shift due to prevalent habitat conditions (Fig. 71).

Fig. 71 Gonad maturation recorded round the year for *T. putitora*

Feeding biology

The relative length of gut (RLG) value (feeding) were 2.27 upstream, while 1.46 in downstream areas. Higher RLG indicates herbi/ herbiomnivorous while lower RLG indicates omni/ carniomnivorous nature.

Conclusion

Monthly data collected depicts significant variation in habitat quality and water chemistry between upstream reservoirs and downstream river stretch at all four hydroelectric project sites. Significant variations were also observed in pre and post-monsoon months, hinting that these may be interfering breeding behaviour of *T. putitora* in reservoirs. For more than 200 fish samples procured from four project sites and four unobstructed flow sites, till date, and the current stock aggregation, length weight pattern, GSI and condition factor with further collected data is being analysed. These biological indices may have significant importance in studying the growth, gonadal development and general well-being of fish population with respect to hydropower operations.

Project: Livelihood improvement through integrated fish farming model using indigenous resource
Period: April, 2017- March, 2020
Personnel: Sharad K. Singh (PI), Lalit K. Tyagi, Akhilesh K. Yadav and Sanjay Kr. Singh
Funding Support: Institutional, ICAR - NBFGR

Survey of a new site for the project was undertaken due to switch over of previous year surveyed farmer to the other agency. New site in the district of Lucknow was surveyed for the selection of farmer (Shri Jeetendra Pratap Singh S/o Shri Rampal Verma, Lalaikheda, Mazara, Sameshi village, Mohanlalganj, Lucknow

(Fig. 72-75). Soil sampling and analysis of the area was done. The surface soil parameters are depicted in Table 8. They are as pH (8.00-9.46), EC (0.2-0.5 dS/m), organic carbon (0.003-0.005%), respectively. Water retention of the surface soil was within the range of 17.5-28.2%. Available nitrogen was within the range of 1.25-1.7 kg/ha. Available phosphorus was within the range of 0.28-0.31 kg/ha. The water quality from nearest sources was normal for aquaculture led activities. MoU has been signed between farmer and institute for under taking project activities in the area of 0.4 ha.

Table 8. Surface soil parameter of selected plot

Soil Parameter	Sampling Site				
	1	2	3	4	5
Soil pH	8.0	8.4	8.6	9.46	8.8
Soil EC (dS/m)	0.2	0.4	0.3	0.35	0.5
Organic Carbon (%)	0.003	0.004	0.004	0.003	0.005
Nitrogen (kg/ha)	1.5	1.4	1.6	1.7	1.3
Phosphorus (kg/ha)	0.28	0.31	0.28	0.32	0.30
Water Retention Capacity of Soil (%)	28.2	20.3	20.4	17.5	19.5

Fig. 72

Fig. 73

Fig. 74

Fig. 75

Fig. 1-4 Project Site/Study Area: Lalaikheda, Mazara, Sameshi village, Mohanlalganj, Lucknow; NL- 26°36'45" & EL-81°06'56"

Project: Establishing National Germplasm Repository and Museum at NBFGR as an Integrated Resource for AqGR research and societal Awareness

Component I: Structure, Mechanisms and Resources Integration

Period: April 1, 2018 - March 31, 2021

Personnel : Kuldeep Kumar Lal (PI), Ravindra Kumar, Vindhya Mohindra, Gaurav Rathore, Ajith Kumar, Sullip Kumar Majhi, Ajey Kumar Pathak and Rajesh Dayal

Funding Support: For specific tasks NFDB, DBT

Design of the interpretation centre at the repository was finalized after holding various meetings with the farms. The cell line repository, microbial repository, sperm cell and DNA repository were constructed. Equipments, such as, Cryo-vessel (1000L capacity, 2 numbers) (Fig. 76), LN_2 vapour storage system and dry shippers were procured to meet the needs of various repositories. Fish and shellfish specimens from

different water bodies of India (marine, freshwater and brackish water) were procured, preserved and are on display at the repository for societal awareness. The online database (Beta Ver.) on the fish fauna of India was launched.

Fig. 76 2000 L capacity cryo-vessel for supply of liquid nitrogen to various repositories.

Component-II: **Diploid Germplasm Cryobanking for *Ex-situ* Conservation and Multiplication of Aquatic Resources.**
Period: **April, 2018 - March, 2021**
Personnel: **Sullip Kumar Majhi, Aditya Kumar and Labrechai Mog Chaudhury**
Funding Support: **Institutional, ICAR-NBFGR**

Under this project *Catla catla, Labeo rohita*, *Cirrhinus mrigala*, *Cyprinus carpio* and *Carassius auratus* caudal fin explains culture were carried out (Fig. 77). The cell growth and radiation started from 4th day and formed complete monolayer after day 15 of the culture. After 2 passages, the somatic cells were cryopreserved using DMSO based cryoprotectants. The project envisages preserving the somatic cells of valuable fish germplasm of India for posterity use, specifically for conservation.

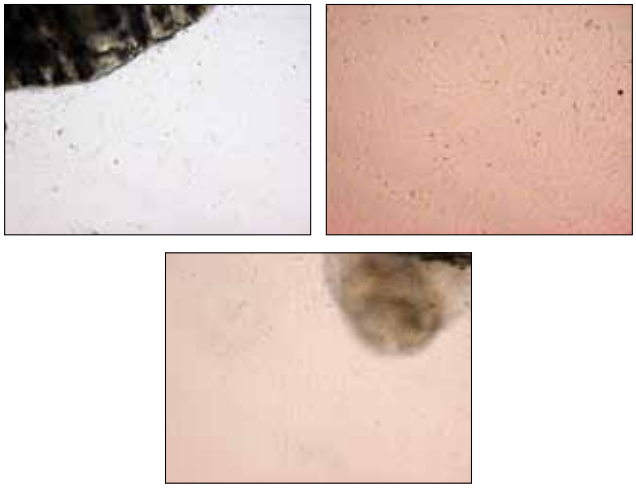


Fig. 77 Explant of (a) *C. catla* caudal fin (b) *L. rohita* fin (c) *C. mrigala* caudal fin

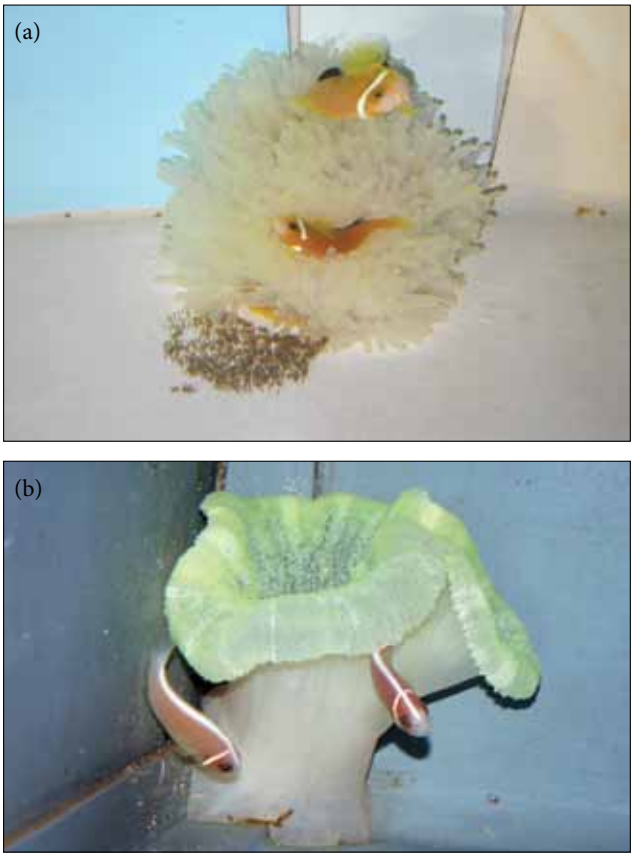
Project: **Setting up of Marine Ornamental Fish Village at Maharashtra: Way Forward to Promote Livelihood to Mangrove Dwellers and Biodiversity Conservation**
Period: **July, 2018 - June, 2021**
Coordinator: **Kuldeep K Lal**
Personnel: **T. T. Ajith Kumar (PI), L. K. Tyagi and Charan Ravi**
Funding Support: **UNDP - Mangrove Foundation and Mangrove cell, Department of Forest, Govt. of Maharashtra**

Marine ornamental fish hatchery facility was established at the premises of the Coastal and Marine Biodiversity Centre of Mangrove Foundation at Airoli with all required infrastructure (Fig. 78 a & b). Sub-adults of 10 different species of clown fishes and 2 species of sea anemones were collected/ procured from Andaman & Nicobar, Gulf of Mannar and Lakshadweep Island regions and stocked in the hatchery for broodstock development. Water quality parameters were standardized for raising broodstock in captivity, besides a low cost biological filtration unit was developed for re-circulation. Among the fishes stocked, 57 pairs were successfully raised for five species of clown fish and the sub-adults of other five species are under broodstock development. Spawning achieved for three species and larval rearing is in progress for *Amphiprion sebae*, *A. ocellaris* and *A. percula* (Fig. 79 a, b and c). Stock culture facility for livefeed was also established in the premises of the hatchery and three species of algae and two species of rotifers are being maintained. Visits have been made at different coastal villages of Thane, Palghar, Raigad

(a)

(b)

Fig. 78 ICAR-NBFGR Marine ornamental fish hatchery at Airoli, Mumbai (a) Outer-view (b) Inner-view



(a)

(b)

(c)

Fig. 79 Breeding pairs with *S. haddoni* in the NBFGR hatchery at Airoli (a) *A. sebae* (b) *A. akallopisos* (c) *A. percula*

and Ratnagiri districts of Maharashtra and suitable sites were identified for establishing beneficiaries of clownfish rearing units.

Project: Evolutional significance of hypothalamus - pituitary-gonadal axis in fishes, with special reference to Indian species
Period: September, 2016 - October, 2018
Personnel: A.K. Pandey
Funding Support: Institutional, ICAR-NBFGR

To have a database on hypothalamus-pituitary-gonad (HPG) axis, 568 references including Indian fishes were collected and documented. Gonadotropin releasing hormone (GnRH) appeared first in cnidarians (coelenterates). It is also recorded from molluscs, echinoderms and protochordates. With evolution of HPG axis, GnRH plays pivotal role in neuroendocrine regulation of reproduction in chordates. This neuro-peptide has also been reported from non-hypothalamus tissues where it performs autocrine/paracrine functions.

Project: Indian Major Carp Milt Cryobank for Improving Genetic Exchange Between Farms and Commercial Level Quality Seed Production.
Period: December, 2018 - November, 2020
Personnel: Sullip Kumar Majhi, Santosh Kumar, Aditya Kumar, Ajay Kumar Singh and Rama Shankar Sah
Funding Support: National Fisheries Development Board (NFDB)

Basic facility for cryo-storage of carp milt on large scale has been established. This includes Liquid nitrogen vapour phase storage system, Cold handling cabinet, Programmable freezer, Dry shippers, 1000 L Liquid Nitrogen Storage Tank (Fig. 80). The potential brooders of Indian major carps were segregated, PIT tagged and reared separately. These brooders will be used for collection of milt, those will be cryopreserved and supplied to selected hatchery operators for quality seed production. Under this project, two training programs on fish milt cryopreservation for genetic up-gradation of broodstock, with a target of 20 in each batch, for hatchery operators from Uttar Pradesh,

Madhya Pradesh and West Bengal was completed. A total of 42 hatchery operators participated in the training program.

Fig. 80 Large scale storage of Indian major carp milt in Liquid nitrogen vapour phase storage system.

Project: Development of Biotechnological Approach for Production of *Clarias magur* (Hamilton, 1822) Spermatozoa for Aquaculture.
Period: January, 2018 - December, 2020
Personnel: Sullip Kumar Majhi and Santosh Kumar
Funding Support: Department of Biotechnology (DBT)

Application of assisted reproductive biotechnology appears to be a promising approach for the generation of valuable genetic materials from the fish species those have difficulty in releasing them smoothly in captivity. This project, during year 1, examined the suitability of treatment with Busulfan, a cytotoxic agent, and warm water that is known to cause germ cell degeneration, for depletion of endogenous germ cells in *Pangasianodon hypophthalmus* intended to be used as surrogate father for *Clarias magur*. Busulfan (40 mg/kg) was intraperitoneally injected into the animals at 2-week intervals (6 doses in total), and they were maintained in water at 38°C between 0 and 12 weeks. The effectiveness of the treatments was assessed using gonadal index and histology. At the end of 12 week, very severe gonadal degeneration was observed in fish treated with the heat-chemical combination and all the sampled fish were found to be devoid of endogenous germ cells (Fig. 81 a & b). Further, condition was standardized for surgery of *C. magur* for partial harvest of spermatozoa, without sacrificing the males. Our investigation so far suggests such harvested spermatozoa can be immediately used for fertilization of *C. magur* eggs and produce viable seed for aquaculture. At the same time, these cells could be successfully stored at ultra low temperature for posterity. The data obtained so far also revealed that, the fertilization and hatching percentage of eggs fertilized with partially harvested *C. magur* spermatozoa was very much similar to that of results obtained from usual sacrificing method.

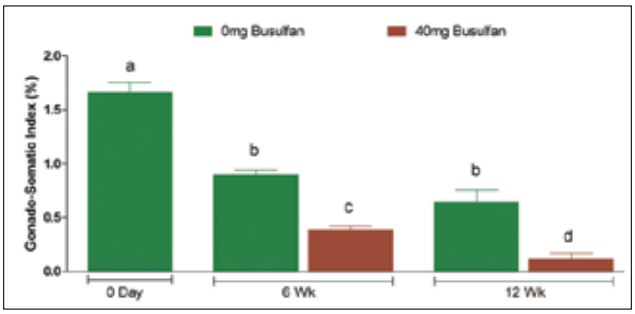


Fig. 81a Changes in the gonado-somatic index of *P. hypophthalmus* subjected to heat (38°C) and Busulfan treatments (40 mg/kg) between 0 and 12 weeks.

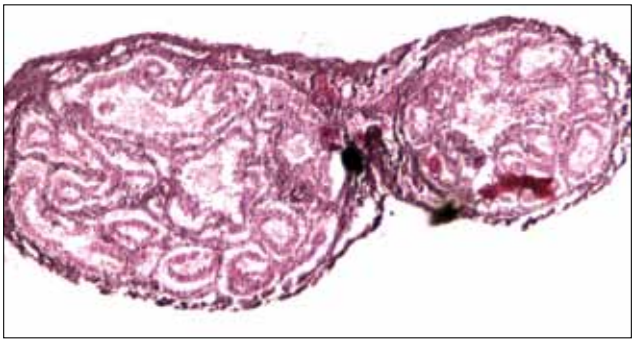


Fig. 81b Histological section of *P. hypophthalmus* recovered after 12 weeks treatment period showing absence of spermatogonia and all other stages of spermatogenesis.

Project: Network project on Ornamental fish breeding and culture
Period: November, 2018 to March, 2019
Personnel: V. S. Basheer and A. Kathirvelpandian
Funding Support: ICAR

Three prioritised fishes were collected from the wild, transported to lab and kept in the FRP tanks. Breeding of one species, *Dawkinsia rubrotinctus* initiated this year.

D. rubrotinctus (Jerdon, 1849) is beautiful fish and can be distinguished by its unique colour pattern consisting of three well-defined black blotches on the body, two scales high and three scales wide. It is available in Cauvery and its tributaries across the states of Karnataka, Kerala and Tamil Nadu in India.

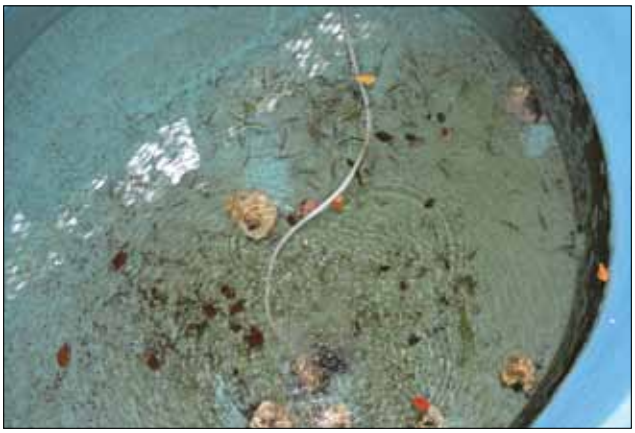
Collection of fishes

Natual habitat of *P. nigripinnis*

D. rubrotinctus

Young ones of *D. rubrotinctus* (3 month old)

Spawning trap, Set up for breeding



Rearing tank

H. fasciata

P. nigripinnis

Fig. 82 Collection and breeding strategy

Specimens were collected from Srirangapatnam and Sivanasamudra in Karnataka (Fig. 82). Fishes were brought to the lab and maintained in 500 l FRP tanks. Fishes were fed on commercial carp feed (Growell 2 mm pellets) supplemented with live mosquito larvae and earthworms.

Four pair of breeders were taken for breeding. Spawning traps consisting of 45 cm dia x 30 cm depth plastic tubs filled partly with gravel and topped with nylon spawning media were introduced into the rearing tubs. Spawning started after two days of introduction, the traps were removed two days after spawning. The eggs were reared in a separate tank. 15-20 eggs were collected daily. The water temperature was in the range of 22-25 °C and pH was 6.5-7.2. The process continued for a month. A total of 450 eggs were collected and from that 300 hatchlings obtained. The hatchlings were fed with green water for 48 hours and then, newly hatched artemia nauplii. Fry were fed with e-larval feed after three weeks and then crushed pellets (Growell). A total of 100 young ones were obtained after 2 months of rearing.

Specimens of *Haludaria fasciata* (Jerdon, 1849) and *Pethia nigripinnis* (Knight, Rema Devi, Indra & Arunachalam, 2012) were collected from tributaries of Kabani river, Wayanad, transported to lab and kept in the FRP tanks. These fish will be taken up for breeding in next breeding season. Biology of the species taken up for breeding will also be studied.

Project: Establishing Germplasm Resource Center for Marine Ornamental Invertebrates: Harmonizing Biodiversity Conservation and Promoting Livelihood to the Islanders of Lakshadweep
Period: August, 2018 - July, 2021
Coordinator: Kuldeep K. Lal
Personnel: T. T. Ajith Kumar (PI), Charan Ravi and T. Jaffer Hisham
Funding Support: Department of Biotechnology (DBT)

Exploration has been conducted in Agatti, Kalpitti, Bangaram, Thinnakara, Parali I and Parali II islands of Lakshadweep for animal collection. Suitable sites have been identified for the same and collections of target organisms are being progressed. Besides, renovated/ created the NBFGR & DBT hatchery facility in the premises of the Centre for Marine Living Resources and Ecology (CMLRE) field station at Agatti, Lakshadweep (Fig. 83). The ornamental shrimps and sea anemones collected from different islands were stocked in the hatchery facility for broodstock development. 350 individuals of shrimps, which belongs 7 families, 8 genera and 12 species and 60 individuals of Sea anemone, *Heteractis magnifica* has been collected and stocked in the hatchery.

Broodstocks of five species of shrimps (*Lysmata amboinensis, Gnathophyllum americanum, Stenopus hispidus, Saron marmoratus* and *Periclimenes brevicarpalis*) were successfully raised under captive conditions and spawning was achieved for three shrimp species and larval rearing is in progress for *L. amboinensis, G. americanum* and *S. hispidus* (Fig. 84). Among the wild collected shrimps, parasitic infestation (Boyprid parasite, *Argeiopsis inhacae* Kensley) in *S. hispidus* was noticed from Agatti island, which is the first report in Indian waters. *Thor hainanensis,* an ornamental shrimp collected from Agatti island is the first report from Indian waters, besides, *T. amboinensis, Alpheus lottini* and *L. amboinensis* were reported for the first time in Lakshadweep waters.

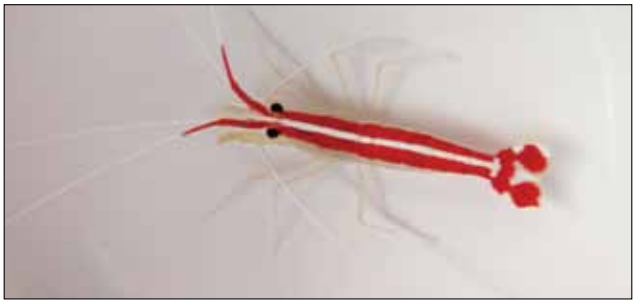
(a)

(b)

Fig. 83 ICAR-NBFGR Germplasm resource centre for marine ornamental invertebrates at Agatti, Lakshadweep (a) Inner-view (b) Outer-view.

(a)

(b)



(c)

Fig. 84 Ornamental shrimps in NBFGR hatchery at Agatti island, Lakshadweep (a) *S. marmoratus* (b) *P. brevicarpalis* (c) *L. amboinensis*

Program 4.5: Documentation of fish genetic resources of India

Documentation is essential for efficient conservation, management and utilization of genetic resources. It is important to gather background knowledge and information about genetic resources in the country, in order to facilitate resource management for sustainable utilization of the potential resources. Thus, country can claim its sovereign stake on its biological wealth. Such knowledge is also vital for fulfilling country's obligations towards international requirements such as Aichi's Biodiversity Targets under Convention on Biological Diversity (CBD) and State of World Aquatic Genetic Resources of CGRFA under FAO. Keeping in view the importance of the subject, ICAR-NBFGR has been continuously working towards cataloguing and documentation of fish genetic resources, since its inception. The generated database has become more important for strategic planning and decision making for management of Fish Genetic Resources (FGR). The institute has developed document FGR database on web interactive format, with added information on genetics, genomics and diseases etc., for its wider use. This is a part of initiative to provide a single window framework for existing information. ICAR-NBFGR is also a nodal centre for National Fish Museum and Repository, recognised by National Biodiversity Authority under section 39 of Biological Diversity Act, 2002 of India. In this direction, efforts are being made to develop infrastructure facilities as well as acquiring the required materials for taxonomic reference, integrated fish germplasm repository housing research accessions and IPR protection.

Project:	Intellectual Property Management and transfer/ Commercialization of Agricultural Technology scheme (Up-scaling existing components i.e. Intellectual Property Right)
Period:	April, 2017 - March, 2020
Personnel:	Poonam J. Singh (PI and Nodal Officer)
Funding Support:	National Agriculture Innovation Fund (NAIF), ICAR

Entrepreneurship and Creativity

For encouraging entrepreneurship and creativity among rural women, an outreach workshop "Women Empowerment through Innovation and Creativity" was organized through National Agriculture Innovation Fund (NAIF) of ICAR to celebrate World IP Day on April 26, 2018 at Pradhan Mantri Kaushal Vikas Kendra, Kalli Paschim, Lucknow (Fig. 85). The workshop was celebrated in line with the theme of the World IP Day 2018 "Powering change: Women in Innovation and Creativity." Thirty women belonging to 2 Self Help Groups participated in the discussion programme and discussed about their problems in their entrepreneurial journey. They spoke about working space, price and market constraints. The need for systemic design intervention was explained to create opportunities such as using clay. The women have made clay creations and used them for decorations for Terrariums.

IP Awareness & Creativity inculcation

For IP Awareness & Creativity inculcation among kids, an endeavour was initiated to ignite young minds with ideas for creative learning, by trying, failing fast and redoing things and experimenting as different scenarios will emerge for utilising creativity for a solution. For raising IP awareness among school kids, a creativity exercise based on different IPRs was organized at Bal Vidya Mandir Senior Secondary School near Charbagh, Lucknow on November 2, 2018 as mentor of change supported by Atal Innovation Centre of Niti Ayog to understand how to create articles from simple things and protect with IPR. Four ITMU meetings were conducted in 2018. The objective of the programme was to raise awareness among kids to come up with a lot of different ideas with a fun learning journey to allow the minds of kids to open up to unseen possibilities for thinking differently in daily works.

Rural Village Level Women lead Incubator for co-creating sustainable design solutions

Four Women Self Help Groups namely Radhey SHG, Shakti SHG, Saraswati SHG and Sai SHG participated in an interaction session on "Co-creating Community Empowerment through design-based intervention for Women Empowerment" with an exhibition of handicrafted products prepared by women of Self Help Groups using natural fibre jute, that is ecofriendly, biodegradable and chikan embedded products with an objective to create new livelihood opportunities through enhancing sustainable productivity and fulfilling One District-One Product concept. The exhibition was inaugurated by the Director, ICAR-NBFGR, Dr. Kuldeep K. Lal, who admired the efforts of women of the Self Help Groups and stressed the need to strengthen them economically by buying their products. The jute bags, boarding pass bag, file covers, files, and samosa bags were exhibited. The program was attended by ex-Block Pramukh Mrs. Kiran Yadav who has initiated Kalyani Womens Rural Village Level Incubator (KWIC) to promote Self Help Groups from marginal urban communities for co-creating reusable and sustainable products and bridging urban demand with rural created products. The Incubator, first of its kind was mentored by ICAR-NBFGR through systemic design intervention with inclusive environment for ideation and rapid prototyping. This model can pave way to enhance livelihood options and curb the menance of plastic by using natural fibre as a sustainable and biodegradable option. Capacity was built by handholding, mentoring and by institutional support for women Self Help Groups through entrepreneurship and sustainable livelihood incubation through systemic design approach by exploring possibilities for co-creating workable ideas through systemic design approach for rural empowerment and women entrepreneurship.

An interaction activity was organized at Kalyani Womens Rural Village Level Incubator (KWIC) with SHGs during International Womens Day on March 8, 2019 for thinking equal, balancing for better, building smart solutions and innovating for change (Fig. 86).

Fig. 85 Rural women of SHGs participating the programme "Women Empowerment Through Innovation and Creativity" on World Intellectual Property Day, 2018 at Kalli Paschim, Lucknow; 2) Interactive session on "Co-creating Community Empowerment through design-based intervention for Women Empowerment"; 3) Group photograph of SHG women co-creating products; 4) Director, ICAR-NBFGR inaugurating the exhibition of products by SHGs under the theme Co-creating Community Empowerment through design-based intervention for Women Empowerment.

Fig. 86 Rural women of SHGs celebrating Womens Day at Village Incubation Centre, at Kalli Paschim, Lucknow on the theme of thinking equal, innovating for change and balancing for bettter. 2.1 and 2.2) Mr. Yerripilli Nukaraju, a traditional fisherman displaying alternate use of fishing net as a household cooling filter; 2.3) Self-made safety gear for fishing at sea; 2.4) Tool made for location marking of fishing net spread at sea.

Scouting for Grassroots Innovations

Scouting and documentation was done for grassroot innovations related to the surviving gear, self-developed by traditional fishermen in fishing village of Vodarevu, Prakasam district, Andhra Pradesh. During the tour, fishermen disclosed the information that swim bladder of fishes were used as isinglass by pharmaceutical companies fetch a very high price. A traditional fishing festival locally called as "Revu Pandaga" is celebrated every year usually in June/July, just after the fishing ban period of three months from April-June. The fishermen also expressed concern about plastic pollution.

Project:	**Establishing National Germplasm Repository and Museum at NBFGR as an Integrated Resource for AqGR research and societal Awareness**
Component-III:	**Information on Aquatic Genetic Resource Information System of India**
Period:	**April, 2018 - March, 2021**
Personnel:	**Ajey Kumar Pathak, T.T. Ajithkumar, Mahender Singh, Poonam J. Singh, Rejani Chandran, Rajesh Dayal, Reeta Chaturvedi and Ravi Kumar**
Funding Support:	**Institutional, ICAR-NBFGR**

Aquatic Genetic Resource Information System of India known as AqGRISI is a web based e-product developed from the project entitled "Information-base on Fish Genetic Resources of India". This e-product on the World Wide Web hosted at the institute web server is an information system that provides the ability for user to browse and view the information on different aspects of fish genetic resources native to

Indian waters. This resource provides link to the other worldwide available databases like FishBase, NCBI, WORMS, Google Patents, Natural History Museums etc. and other databases developed by FAO, IUCN, CMFRI and CIFRI. It is a unique platform included with data and user management capabilities, which can be accessed at URL: http://mail.nbfgr.res.in/agrisi. The system presents vivid and diverse information about the native finfish and shellfish genetic resources reported from the Indian waters. Worldwide, hardly there will be any country-specific database providing such diverse information on fish genetic resources. Presently, the system covers 3138 native finfish species belonging to 10212 genus, 247 families and 47 orders and provides information on systematics, biology, length-weight, type specimen, disease, habitat, distribution in India and outside, patent and fish nutrition. Additionally, it provides information about accessions from different repositories of ICAR-NBFGR like Live germplasm, Tissue, Cell lines and Museum. The system also includes a beautiful photo gallery of fish pictures and the GIS-based interactive point map to know about the occurrence information on the Indian fish specimens recorded in the Global Biodiversity Information Facility as well as documented in the worldwide different museums or repositories. To provide the molecular information about the fish covered in AqGRISI, the existing molecular resources of this institute available already in the public domain like HRGFish (A database of hypoxia responsive genes in fishes), FBIS (Fish Barcode Information System), FishKaryome (A Chromosome Database of Fishes and other Aquatic Organisms), FishMicrosat (Fish and Shell fish Microsatellite Database) and FMiR (Fish Mitogenome Resources) have been integrated as well with AqGRISI. During the development phase of this system, all the necessary care were taken to suitably digitize the data and display the quality information collected from worldwide published secondary resources and further linking the system to the relevant sources for cross validation of data.

To access AqGRISI, open any Internet browser and type URL: http://mail.nbfgr.res.in/agrisi in the address search bar and click on 'GO' or press "Enter" key on your keyboard that presents a home page of AqGRISI (Fig. 87). This can also be accessed by clicking on the icon included in the header section of the website of ICAR-NBFGR. This page provides the ability for the user to work interactively with different menu items, search options, options of menu and links. The Home page has menu items 'Home', User guide', 'Shellfish', 'Fish photo gallery' 'Add new species, 'GIS occurrence map' and 'Fish Nutritional Profile' that includes sub items 'Proximity composition', 'Amino Acids', Fatty acids', 'Minerals, 'Vitamins' and information for nutritionists, dieticians and physicians into its pull-down menu. A click on 'Home' displays the Home page of AqGRISI. 'User guide' contains documents related to the guidelines for data entry and guidelines of working with AqGRISI in PDF format and a click on this link facilitates to view these documents. 'Fish Photo Gallery' provides the ability for the user to view pictures of different fish species. 'Add new species' provides the ability for the user to entry data on various parameters of the fish genetic resources by log in into the system. 'GIS occurrence map' provides the ability to view the occurrence point map of the specimens reported from the worldwide museums and repositories. The 'Fish Nutritional profile' provides the ability to the user to view information on different nutritional aspects of the fish species. The 'Shellfish' provides the information on molluscan species of India.

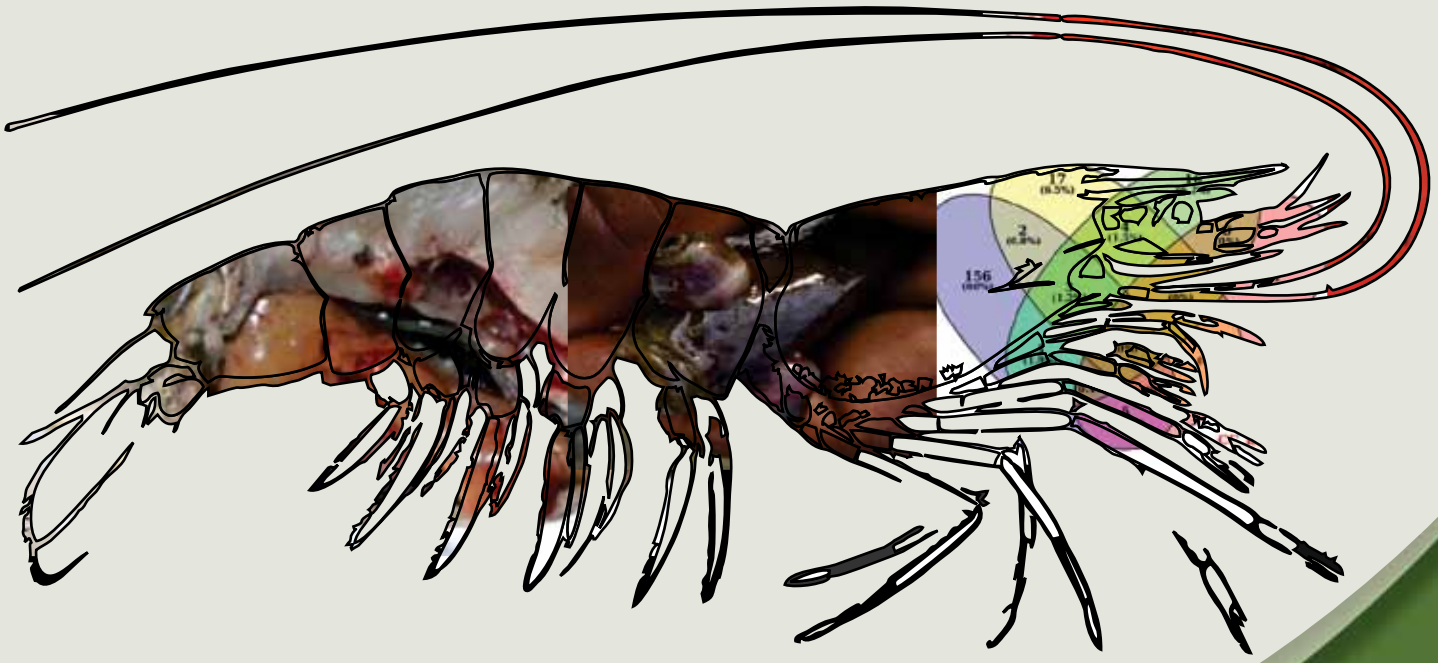
Fig. 87 Homepage of AqGRISI.

Inauguration of AqGRISI

To promote the utility and services of AqGRISI, it was inaugurated by the Deputy Director General, Fishery Science and Animal Science on February 27, 2019 in the presence of Director, ICAR-NBFGR, Lucknow, Director General, NACA, Thailand, Senior Aquaculture Officer, FAO and Mentor, NACA, Thailand. Director, ICAR-NBFGR, Lucknow briefed about AqGRISI to the dignitaries and participants (Fig. 88).

Fig. 88 Inauguration of AqGRISI.

Program 4.6: Evaluation of fish genetic resources; exotics and health management



Fish genetic resources of the country need to be evaluated for health risks for their sustainable utilization. Transboundary and emerging aquatic animal diseases are one of the major concern in aquaculture causing economic losses to the farmers. ICAR-NBFGR has been instrumental in the implementation of National Surveillance Programme on Aquatic Animal Diseases in 20 states of the country. The institute has been carrying out several research programmes on development of rapid diagnostic tools, therapeutic and prophylactic measures against major aquatic animal diseases. Antimicrobial resistance (AMR) is an emerging health concern globally; and a National program on AMR is being coordinated by the institute to assess its status in the fisheries sector. Introduction of exotic fish species is resorted for several purposes, particularly for species diversification to enhance the production. However, these introductions are associated with ecological and disease risks for indigenous fish species. Hence risk assessment of exotics before introduction is one of the key area of research. In addition, impact assessment of already introduced exotic species in open waters is also being carried out by the institute.

Project: Poverty alleviation through prevention and future control of the two major socioeconomically important diseases in Asian aquaculture

Period: May, 2016 –November, 2019

Personnel: Neeraj Sood (PI), Pravata K. Pradhan and Vindhya Mohindra

Funding Support: Department of Biotechnology - Biotechnology and Biological Sciences Research Council - Department for International Development (DBT-BBSRC-DFID)

Under the DBT-BBSRC funded project, for socio-economic analysis, the work focussed on carp farming areas in Maharajganj district of Uttar Pradesh on poor farmers engaged in aquaculture as well as poor people who did not have a farm but had an experience of poverty. A total of 150 farmers from 17 villages of 5 different blocks were involved in the study. Analysis of the data revealed that 44.3% of the farmers considered their personal health to be the most serious risk affecting their livelihood whereas, threat to their fish farms from diseases and poisoning was perceived to be the second most significant risk. It was found that 40% of fish farmers are illiterate and about 33% had only primary education. Further, more than 80% of the farmers did not have formal training on fish farming. Most of the farmers (91%) had encountered disease(s) in their farm over the last five years. Importantly, 48% of the farmers incurred a loss during last year (2016-17) and none of the farmers were able to save anything from their income from fish farming. Therefore, none of the fish farmers wanted their children to venture into fish farming.

The results of the epidemiological survey carried out in fish farms in Maharajganj district of Uttar Pradesh revealed that mortalities were observed in one out of every three farms (38%). Maximum mortalities in fish were recorded during the months of November to January and importantly, two out of three (66%) of the causes of death listed were related to water quality. Fish farmers having knowledge about major water quality parameters, namely temperature, dissolved oxygen, ammonia and pH was found to be 64.1, 20.5, 11.5 and 10.9%, respectively. Knowledge about dissolved oxygen and observing its effect by simply watching fish behaviour was found to reduce the risk of fish death. Further, farmers who report seeing algal bloom have a two-fold risk of mortality i.e. relative risk (RR) 1.9, whereas, adding products to the water which aim to improve fish health had no effect on fish deaths. In adition, higher stocking density was found to be associated with mortality in fish farms.

Based upon the results of epidemiological study, a Fish Farmers Interaction Meeting with involvement of 135 fish farmers was organised at Maharajganj district of Uttar Pradesh, India on December 17, 2018. The farmers were made aware about the risk factors associated with fish mortality. Thereafter, a presentation on Better Management Practices in carp culture was made, with emphasis on minimizing the risk factors.

For understanding host-pathogen interaction in dynamic disease situation, RNA sequencing data was generated from muscle and kidney tissues of susceptible rohu and resistant common carp experimentally infected with *Aphanomyces invadans* zoospores. To identify differentially expressed genes in response to infection with *A. invadans* in common carp, *de novo* transcriptome assembly of kidney and muscle tissue samples was performed separately using necklace v 1.0 software. The assembly of kidney and muscle tissue comprised of 47,231 and 41,651 unigenes with the BUSCO completeness of >90% and >96%, respectively. Following normalization, the clustering of unigenes sharing similar expression patterns revealed that a total of 344 and 2552 unigenes were differentially expressed significantly (FDR<0.05; R-squared >0.7) in common carp kidney and muscle tissue, respectively (Fig. 89a). Significant changes in expression pattern in both the tissues were observed at 6 and 12 days post-infection (DPI). All the DEGs were classified into 9 clusters according to their expression patterns. GO functional analysis revealed that genes of profile 7, 8 and profile 1, 7, 9 were significantly enriched for various biological processes in the kidney and muscle, respectively.

In *Labeo rohita*, *de novo* transcriptome assembly of kidney and muscle tissue samples was performed separately. The assembly of kidney and muscle tissue were performed with Trinity v 2.8.4. Each assembly was comprised of 20,86,568 and 1,75,438 unigenes with the BUSCO completeness of >98% and >94%, respectively. A total of 603 and 11083 unigenes were differentially expressed significantly (FDR<0.05; R-squared >0.7) in rohu kidney and muscle tissues, respectively (Fig.

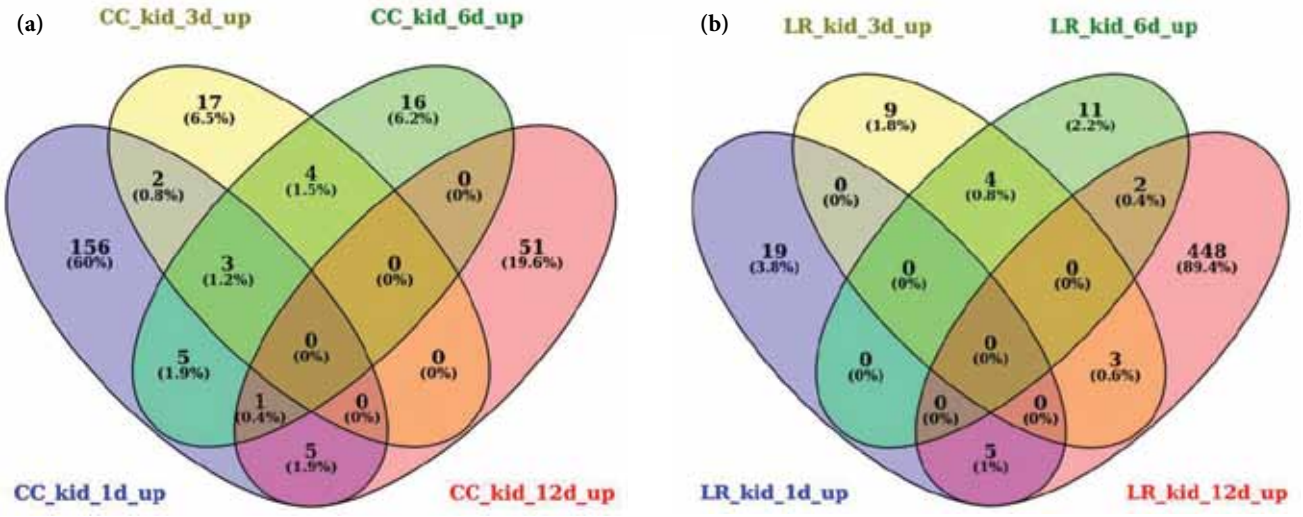


Fig. 89 Venn diagram showing up-regulated genes in kidney tissue following experimental infection with *A. invadans* (a) common carp (b) rohu.

89b). All the DEGs were classified into 9 clusters according to their expression patterns. The result of GO functional analysis revealed that genes of profile 1, 6, 8 were significantly enriched in both the tissues and involved in various biological processes.

Experimental infection of rohu fingerlings with *A. invadans* zoospores was carried out under controlled temperature (18 and 25°C) and pH (6.5 and 8.5). The tissue samples, namely muscle and kidney have been collected at different time intervals for quantifying changes in transcription of key genes.

Project: National Surveillance Programme for Aquatic Animal Diseases (NSPAAD)
Period: February, 2013 - September, 2019
Coordinator: J. K. Jena, Deputy Director General (Fisheries Science)
Co-coordinator: Kuldeep K. Lal, Director, ICAR-NBFGR, Lucknow
Funding Support: National Fisheries Development Board, Hyderabad
Sub-Project I: Nodal Centre for National Surveillance Programme for Aquatic Animal Diseases
Personnel: Neeraj Sood (PI), Pravata K. Pradhan, T. Raja Swaminathan and Gaurav Rathore

NSPAAD is being implemented in 20 states through the involvement of 29 collaborating institutes and is being coordinated by ICAR-NBFGR. During this period, four new centres, namely College of Fisheries, Ludhiana; College of Fisheries, Kwardha; Fish Farmer Training Centre, Department of Fisheries, Ranchi and Fisheries Research Station, P.V.N.R. Telangana Veterinary University have been included for undertaking surveillance in Punjab, Chhattisgarh, Jharkhand and Telangana under NSPAAD.

Red sea bream iridovirus (RSIV) disease, an OIE-listed disease, was reported in sea bass by College of Fisheries, Mangalore from Karnataka. Since, this is the first report of the disease from the country, the collaborating centre was asked to send the samples to ICAR-CIBA and ICAR-NBFGR for cross-validation. The samples have been found to be positive for red seabream iridovirus at ICAR-NBFGR in PCR and by sequencing of PCR products.

Quarterly Aquatic Animal Disease Reports for the quarters January-March 2018, April-June 2018, July to September 2018 and October-December 2018 were compiled on the basis of reports received from NSPAAD collaborating Centres and submitted to Department of Animal Husbandry, Dairying and Fisheries. The positive controls for OIE/NACA-listed and emerging pathogens were sent to ICAR-CIFT, ICAR-CMFRI, ICAR-CIFA, College of Fisheries, GADVASU and NITTE University.

Technical backstopping was provided to Department of Animal Husbandry, Dairying and Fisheries on different issues including declaration of disease free zones, status of amphibian disease *Batrachochytrium dendrobatidis*, queries regarding Infectious myonecrosis from Thailand and to MPEDA regarding Organisational structure and responsibilities of the Competent Authority for disease surveillance.

Sub-Project II: **Surveillance of freshwater fish and shelfish diseases in Uttar Pradesh and Haryana**

Personnel: **Pravata K. Pradhan (PI), Neeraj Sood, Chandra Bhushan Kumar and Gaurav Rathore**

Under NSPAAD-NBFGR component, inland shrimp farms in Haryana were surveyed to know the prevalence of shrimp diseases (Fig. 90). From the available list of shrimp farms of the state, a total of 45 farms were sampled randomly in different districts of Haryana and shrimp samples were screened for the presence of *Enterocytozoon hepatopenaei* (EHP), White spot syndrome virus, Hepatopancreatic Parvovirus, Infectious Hypodermal and Haematopoietic Necrosis Virus and Monodon Baculovirus (Fig. 91). Out of the 45 farms sampled, 35 farms were found to be positive for EHP infection and all the 45 farms were found negative for rest of the pathogens.

In Uttar Pradesh, one hundred forty five Pangas farms were surveyed and their baseline information was collected. In addition, mortalities in rohu, *Labeo rohita* from fish farm near Lucknow were diagnosed to be caused by concurrent infection with dactylogyrids, trichodinids, myxosporeans and epitheliocystis

Fig. 90 Sampling in Inland Shrimp farms of Haryana.

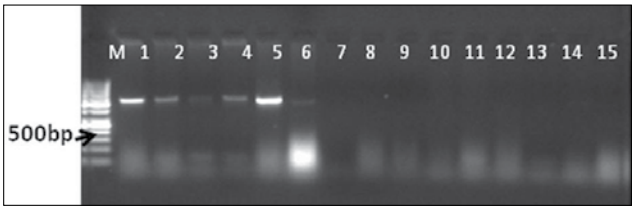


Fig. 91 Detection of *Enterocytozoon hepatopenaei* from shrimp samples collected from inland saline farms in Haryana.

(Fig. 92). The causative agent of epitheliocystis was found to belong to the family *Candidatus* Parilichlamydiaceae and were found to be novel. This is the first report of epitheliocystis from any of the Indian major carps, and adds to the growing host range of this disease.

A training programme on "Fish Health Management" was organized for the State Fisheries Officers of Haryana during October 8 to 12, 2018, in which 11 officers participated. The officers were provided hands-on training on analysis of water quality; level I diagnosis and were given an overview of level II and III diagnosis. In addition, they were made aware about management practices including biosecurty measures and treatment.

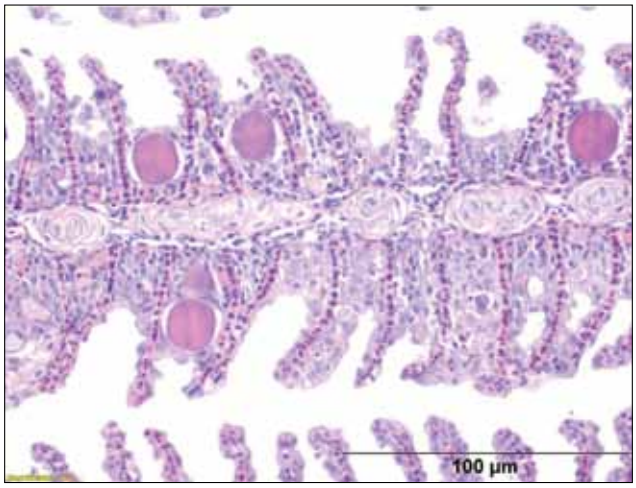


Fig. 92 Section of rohu gills showing intracytoplasmic inclusions typical of epitheliocystis.

Project:	**National Surveillance Programme for Aquatic Animal Diseases**
Sub-Project III:	**NSPAAD Sub Project No - 09 Surveillance of ornamental fish diseases**
Project Duration:	**April, 2013 – March, 2019**
Project Personnel:	**T. Raja Swaminathan**
Funding Agency:	**NFDB, Hyderabad**

Diseases are playing major setback for sustainability of the ornamental fish industry, which is a multimillion dollar industry all over the world. The loss due to diseases are increasing day by day due to spread of aquatic pathogens within and outside the country. All effective disease control measures need sound information on the distribution and nature of significant diseases. Further, India being a signatory of WTO, to substantiate the claim of freedom from diseases to protect the domestic aquaculture industry as well as to facilitate safe exports, we should be able to demonstrate that adequate system of active surveillance is in place to detect, diagnose and control aquatic animal diseases.

To carry out targeted active surveillance of Spring viraemia of carp and Koi herpes virus in ornamental fish, a total of 275 ornamental fish samples were collected from 5 districts of Kerala *viz.,* Ernakulam, Thrissur, Allapuzha, Kottayam, and Kollam and 2 districts in Tamil Nadu *viz.*, Chennai and Madurai and all samples found negative. A total of 152 goldfish samples were also tested for Cyprinid Herpesvirus-2 (CyHV-2) and 45 samples found positive for CyHV-2 and 123 koi carp samples were found positive for Carp edmea virus (CEV). Ornamental fish disease management consultation was given to 12 ornamental fish farmers and 8 antibiotic sensitivity tests were carried out to found the correct antibacterial agent to treat the diseased fish.

Aeromonas veronii caused bilateral exophthalmia and mass mortality in cultured Nile tilapia, *Oreochromis niloticus* (L.)

Aeromonas spp. cause significant mortality and high economic losses in Nile tilapia, *O. niloticus* culture worldwide. Four bacteria had been isolated from diseased Nile tilapia showing signs of bilateral exophthalmia, loss of scale, haemorraghes on the body (Fig. 93) in Tamil Nadu, India. All the four isolates failed to produce positive CAMP reaction on 5% sheep blood agar (Fig. 94). The bacterial isolates were identified as *Citrobacter freundii, Pseudomonas aeruginosa*, *Acinetobacter juvenii* and *A. veronii* based on biochemical and 16S rRNA gene sequence analysis. Phylogenetic analyses based on the 16S rRNA gene of other reported *A. veronii* and with other species of same *Aeromonas* from GenBank were conducted with MEGA6.0, using the neighbour-joining method with the Kimura 2-parameter model. Percentage bootstrap values (1000 replicates) are shown at each branch point. The scale bar represents 0.01-nucleotide change per nucleotide position. *Proteus hauseri* was selected as an out-group. (Fig. 95). No cytopathic effect was observed in *OnlL* cell line after inoculating filtrate of the tissue homogenates prepared from the affected Nile tilapia. A histological investigation was carried out on tissues of fish infected with *A. veronii*. Sections of the eye showed detachment of sensory retina from retinal pigment epithelium, the liver showed severe fatty changes with hepatocyte necrosis along with sinusoidal congestion, mild degenerative changes along with loss of nuclei and pyknosis were observed in the kidney and inflammatory exudates were observed between the secondary lamellae of the gills (Fig. 96). Experimental challenge infection assays revealed that out of the four, *A. veronii isolate* alone killed 100% of experimental fish within 120 h and the bacteria could be subsequently re-isolated from the dead fish (Fig. 97). It was proved that *A. veronii* isolated from Nile tilapia was the etiological agent for the bilateral exophthalmia and eye lesions in Nile tilapia. *A. veronii* isolates were also found sensitive to cefixime, ciprofloxacin, chloramphenicol, kanamycin, cifixime/clavulanic acid, suggesting the possible application of these antibiotics in aquaculture.

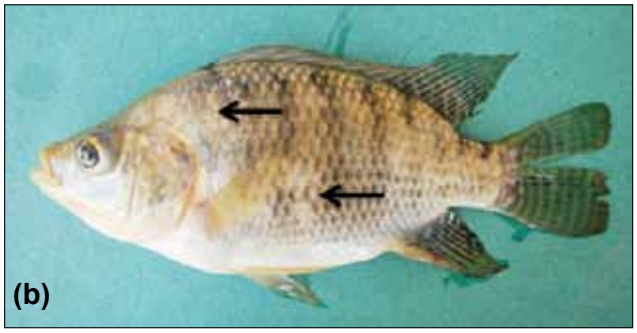


Fig. 93 Pathological features of diseased Nile tilapia showing (a) bilateral exophthalmia; (b) loss of scales (black arrow); (c) gross pathology lesions of enlarged liver and gall bladder and haemorrhages on liver.

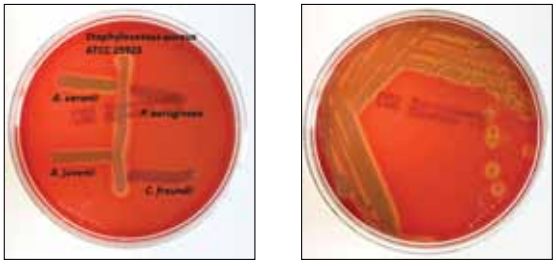


Fig. 2a Fig. 2b

Fig. 94 Characteristics of bacteria isolated from diseased Nile tilapia on 5 % Sheep blood agar (a) Four bacterial isolates *A. veronii, P. aeruginosa, C. freundii* and *A. juvenii* colonies showed CAMP test negative; (b) beta hemolytic colonies of *A. veronii.*

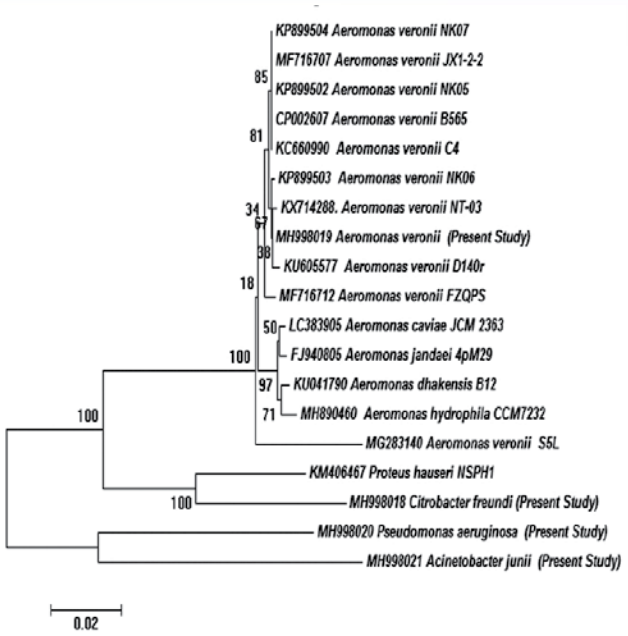


Fig. 95 Phylogenetic tree based on 16S rDNA of *A. veronii, P. aeruginosa, C. freundii* and *A. juvenii.*

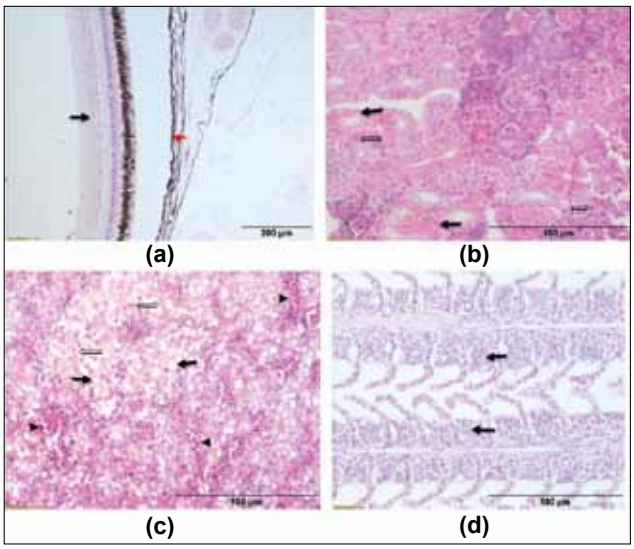


Fig. 96 Histological changes of the fish infected with *A. veronii.* (a) Section of eye showing detachment of sensory retina (black arrow) from retinal pigment epithelium (red arrow) d; (b) section of kidney showing mild degenerative changes along with loss of nuclei (black arrows) and pyknosis (line arrows); (c) Section of liver showing severe fatty changes (black arrows) with hepatocyte necrosis (line arrow) along with sinusoidal congestion (arrowheads); (d) Section of gill showing inflammatory exudate between secondary lamellae (arrows).

Fig. 97 Experimental challenge studies of Nile tilapia with *A. veronii* (a) experimentally challenged Nile tilapia with *A. veronii* showing exophthalmia and opacity in eye; (b) haemorrhages and congestion and enlargement of liver and gall bladder.

Project: Network Programme on Antimicrobial resistance in fisheries and aquaculture
Period: October, 2016 - March, 2020
Personnel: Gaurav Rathore (PI), Chandra Bhushan Kumar, Anutosh Paria, Chinmayee Muduli, Satyendra Mohan Srivastava and Vikash Sahu
Funding Support: Institutional, ICAR-NBFGR

Preparation of SOPs and developing operational framework

Standard operating procedures for isolation, identification and antibiotic sensitivity testing of microorganisms for fisheries sector has been developed. This includes a field-based questionnaire for survey of farms to help in establishing link between AMR data and actual use of antibiotic in culture practices. This network programme is part of Indian Network for Fishery and Animal Antimicrobial Resistance (INFAAR). A high-level advisory body comprising of DDG (AS), DDG (Fy. Sc.) and other senior scientists and external experts has been established by ICAR to guide all aspects of network, review the data generated and have an oversight on its operations. ICAR-NBFGR has been identified as Nodal centre for Fisheries component. Currently, the program is operational in 12 states and involves all eight ICAR fisheries institutes. The focus of the Network programme is to identify the AMR in aquatic animal pathogens and microorganisms, including human pathogens, present on food derived from aquatic animals. The priority microorganisms identified by the group are *Escherichia coli, Staphylococcus* spp. and *Aeromonas* spp. in freshwater aquaculture and *E. coli, Staphylococcus* spp. and *Vibrio parahemolyticus* in brackishwater and marine aquaculture. AMR testing was done by disc diffusion method following CLSI guidelines and data was analysed by WHONET software.

Sample Information for AMR Analysis during Oct-March, 2019

Fish samples were collected from 4 districts of Uttar Pradesh. A total of 60 farms were sampled and 60 fish samples were analysed during the reporting period for isolation of *E. coli*, *Aeromonas* spp., and *Staphylococcus* spp. During the course of study, a total of 167 bacterial isolates were analysed comprising of 50 isolates of *E. coli*, 60 isolates of *Staphylococcus* spp., and 57 isolates of *Aeromonas* spp (Table 9, 10).

Table 9. Details of samples collected

Total districts covered	Total farms sampled	Total samples analyzed	*E. coli*	*Staphylococcus* spp.	*Aeromonas* spp.	Total isolates analysed
4	60	60	50	60	57	167

Table 10. Fish Species-wise details

Species	Fish code	No.
Cyprinus carpio	(ccr)	6
Catla catla	(cca)	6
Cirrhinus mrigala	(cmr)	11
Hypophthalmicthys molitrix	(hmo)	8
Labeo rohita	(lro)	16
Ctenopharyngodon idella	(cid)	9
Pangasianodon hypophthalmus	(phy)	4
Total		60

District-wise isolate details

- Number of isolates-167 (2018-124 no.; up-to March 2019-43 no.)
- Barabanki-41/167 (25%)

- Bareilly-43/167 (26%)
- Maharajganj-43/167 (26%)
- Varanasi-40/167 (24%)

Analysis of AMR in *E. coli* isolated from freshwater fish of Uttar Pradesh

A total of 50 isolates of *E. coli* were tested for AMR during Oct-March, 2019 using 16 antibiotics. High resistance was observed against penicillins and cephalosporins. Low antibiotic resistance was seen against colistin and chloramphenicol, whereas 40% of isolates were resistant to imipenem (Table 11).

Analysis of AMR in *Staphylococcus* spp. isolated from freshwater fish of UP

A total of 60 isolates of *Staphylococcus* spp. were for AMR during Oct-March, 2019 using 10 antibiotics. Highest resistance was observed against penicillin (43.3%), followed by co-trimoxazole (20%) and ciprofloxacin (18.3%). Resistance to chloramphenicol was seen in 6.7% of isolates, whereas none of the isolates were resistant to linezolid (Table 12).

Analysis of AMR in *Aeromonas* spp. isolated from freshwater fish of UP

A total of 57 isolates of *Aeromonas* spp. were tested for AMR during Oct-March, 2019 using 14 antibiotics. Highest resistance was observed against ampicillin/sulbactam (75.5%), followed by cephalothin (43.9%). Low antibiotic resistance was seen against tetracycline (1.8%). No resistance to chloramphenicol was seen, whereas 17.5% of isolates were resistant to imipenem (Table 13).

Table 11. Antibiotic resistance in *E. coli* isolated from freshwater of Uttar Pradesh during Oct-March, 2019

Antibiotic name	Breakpoints	Number	% R	% S	%R 95% C.I.
Ampicillin	14 - 16	50	44	56	21.6-48.9
Amox-Clav	14 - 17	24	33.3	66.7	13.5-51.3
Ceftazidime	18 - 20	48	31.2	68.8	15.8-42.1
Ceftriaxone	20 - 22	50	30	70	18.3-44.8
Cefotaxime	23 - 25	50	42	58	18.3-44.8
Cefoxitin	15 - 17	49	14.3	85.7	3.8-23.0
Cefpodoxime	18 - 20	24	25	75	7.9-42.7
Aztreonam	18 - 20	50	30	70	16.7-42.7
Imipenem	20 - 22	50	40	60	19.9-46.8
Amikacin	15 - 16	50	64	36	13.5-38.5
Nalidixic acid	14 - 18	50	32	68	12.0-36.3
Enrofloxacin	17 - 22	24	41.7	58.3	7.9-42.7
Co-trimoxazole	11 - 15	48	20.8	79.2	8.0-30.8
Colistin	S >= 11	24	4.2	95.8	0.2-23.2
Chloramphenicol	13 - 17	48	6.2	93.8	0.7-15.5
Tetracycline	12 - 14	50	28	72	12.0-36.3

Table 12. Antibiotic resistance in *Staphylococcus* spp. isolated from freshwater of Uttar Pradesh during Oct-March, 2019

Antibiotic name	Breakpoints	Number	% R	% S	%R 95% C.I.
Penicillin G	S >= 29	60	43.3	56.7	30.8-56.7
Oxacillin	11 - 12	37	8.1	91.9	2.1-23.0
Cefoxitin	S >= 25	60	10	90	4.1-21.2
Gentamicin	13 - 14	60	6.7	93.3	2.2-17.0
Ciprofloxacin	16 - 20	60	18.3	81.7	7.5-27.1
Co-trimoxazole	11 - 15	60	20	80	9.9-30.8
Erythromycin	14 - 22	60	18.3	81.7	4.1-21.2

Antibiotic name	Breakpoints	Number	% R	% S	%R 95% C.I.
Linezolid	S >= 21	30	0	100	0.0-14.1
Chloramphenicol	13 - 17	60	6.7	93.3	2.2-17.0
Tetracycline	15 - 18	60	13.3	86.7	4.1-21.2

Table 13. Antibiotic resistance in *Aeromonas* spp. isolated from freshwater of Uttar Pradesh during Oct-March, 2019

Antibiotic name	Breakpoints	No.	% R	% S	%R 95% C.I.
Amoxicillin/Clavulanic acid	14 - 17	41	9.8	90.2	0.0-10.7
Ampicillin/Sulbactam	12 - 14	53	75.5	24.5	47.9-74.9
Cephalothin	15 - 16	57	43.9	56.1	27.9-54.2
Ceftazidime	18 - 20	57	3.5	96.5	0.1-10.7
Ceftriaxone	20 - 22	57	5.3	94.7	0.6-13.2
Cefotaxime	23 - 25	57	14	86	6.7-26.3
Cefepime	19 - 24	57	17.5	82.5	0.1-10.7
Cefoxitin	15 - 17	57	17.5	82.5	6.7-26.3
Imipenem	20 - 22	57	17.5	82.5	1.4-15.6
Amikacin	15 - 16	57	31.6	68.4	4.3-22.2
Ciprofloxacin	16 - 20	57	10.5	89.5	1.4-15.6
Co-trimoxazole	11 - 15	56	10.7	89.3	4.4-22.5
Chloramphenicol	13 - 17	57	0	100	0.0-7.9
Tetracycline	12 - 14	57	1.8	98.2	0.0-7.9

Project: Risk and benefit assessment modeling for exotic species

Period: April, 2017 - March, 2020

Personnel: Kripal Datt Joshi (PI), V.S. Basheer, Aditya Kumar, Satyendra M. Srivastava and Vikash Sahu

Funding Support: Institutional, ICAR-NBFGR

Risk and benefit assessment modelling for exotic species

Prepared a base paper entitled 'An Overview of Alien Fish Species in India and Risk Assessment Options" for introducing the issue to the stakeholders and experts and subsequent discussions in the Consultation on 'Invasive Alien Fish Species: Need for a Risk-Benefit Assessment and Management Framework for Healthy Freshwater Ecosystems', held at WWF-India, Lodi Road, New Delhi on December 19, 2018 (Fig. 98). All relevant information on history, introduction, expansion, impacts, governmental framework and globally available models were explained in the document.

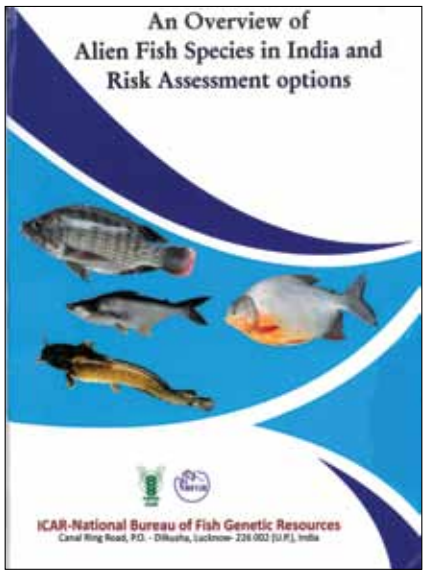


Fig. 98 An Overview of Alien Fish Species in India and Risk Assessment Options - Base paper developed for consultation.

ICAR-National Bureau of Fish Genetic Resources (NBFGR), Lucknow and World Wide Fund for Nature-India (WWF-India) organised a Consultation on Invasive Alien Fish Species: Need for a Risk-Benefit Assessment and Management Framework for Healthy Freshwater Ecosystems at WWF-India, Lodi Road, New Delhi on December 19, 2018. The program was aimed to develop a risk benefit analysis framework, which can be used for assessing the new

proposed introductions, or perspective introductions in the country as well as to discuss the mitigation strategies for eradicating invasive species established in natural waters. Besides experts from International organizations like NACA & SAARC, the program was attended by a galaxy of very senior experts of fishery sector and representatives from Wild Life Institute, Dehradun; National Biodiversity Authority, Chennai; Marine Products Export Council, Kochi; Department of Animal Husbandry, Dairy & Fisheries (DAHD&F), New Delhi, Zoological Survey of India, Chief Conservator of Forest, Chandigarh; Universities and ICAR institutes.

The consultation was attended by Dr. M.V. Gupta, World Food Prize Laureate as the chief guest. The other guests of the honour and distinguished experts present on the occassion were Dr. J.K. Jena, Deputy Director General (Fishery Science), Dr. Dilip Kumar, Dr. George John, Dr. A.G. Ponniah, Dr. Brij Gopal, Dr. Biju Kumar, Dr. Prakash Nautial, Dr. Eduardo Leono (NACA, Bangkok), Dr. S.S. Giri, (SAARC, Dhaka) and Dr. Kenton Morgan (U.K.).

Status of alien species in India and certain South-East countries was explained and discussed during the Consultation. Further, globally available Risk-benefit assessment models were also discussed and a draft workable model suitable for Indian context was prepared and discussed with the stakeholders.

Surveys of Aliens in different open water systems

Conducted exploratory surveys and samplings on the rivers Ganga, Yamuna and Tons around Allahabad to assess status of alien fish species in the riverine catches before monsoon flooding condition. The rivers Ganga and Yamuna were observed under massive invasion of common carp (*Cyprinus carpio*) and Nile tilapia (*Oreochromis niloticus*) (Fig. 99). Availability of all life forms in the catches evidence established populations of both the species. The size range of common carp from catches of river Yamuna comprised 150 to 900 mm with corresponding weight of 46.0 to 13062.0 g, respectively and tilapia from 190 to 310 mm with corresponding weight of 136.0 to 630.0 g, respectively. Likewise, the size range of common carp from catches of river Ganga comprised 156 to 346 mm with corresponding weight of 58.0 to 738.0 g, respectively and tilapia from 145 to 292 mm with corresponding weight of 54.0 to 544.0 g, respectively. Estimated composition of alien fishes was 30-35 % in the river Ganga and 40-45% in the river Yamuna at Allahabad. Availability of stray samples of common carp and tilapia was reported from the river Tons at Chakghat, Allahabad.

Fig. 99 Large common carp and tilapia samples observed from the river Yamuna at Allahabad.

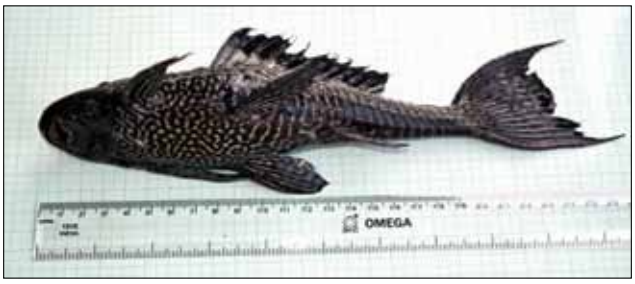


Fig. 100 Sucker-mouth catfish caught from Govardhan stream, Mathura.

The stretch of the river Yamuna between Mathura and Agra was explored for alien fishes and the ambient water quality. Occurrence of aliens, *O. niloticus, C. carpio,* and *Clarias gariepinus* was observed from the river stretch. All sized samples of *O. niloticus* were observed from the stretch and the body length and weight of the largest fish sample recorded as 422 mm & 1422 g, respectively. Among the aliens, tilapia form dominant population, the rest of the species were collected as stray samples.

The vital water quality parameters of the river Yamuna at Mathura-Agra sites were recorded during October 2018. The water temperature varied between 25.8 to 27.99 °C. The water was alkaline in nature

(pH 8-8.8) with moderately high dissolved oxygen content (7.0- 8.29 mgl^{-1}). Values of total dissolved solids (TDS) were between 524.0 to 537.0 mgl^{-1}.

The water of Govardhan stream draining into the river Yamuna near Mathura is highly polluted as the parameters indicated high pH (10.9), low dissolved oxygen (3.6 mg^{-l}) and high TDS (1744.0 mg^{-l}). Still the water was observed congenial for aliens like *O. niloticus, C. gariepinus* and *Pterygoplichthys pardalis* (Fig. 100).

Preliminary data on fort moat (trench) of Lohagarh fort, Bharatpur, Rajasthan was collected. The moat encircling the fort was about 3 km in length and 3-10 m in depth (width 15-50 m) is fully dominated (70%) by tilapia. The moat water was highly alkaline in nature (pH 9.5) with moderately low dissolved oxygen content (2.5 mgl^{-1}). Values of total dissolved solids (TDS) were extremely high (2994.0 mgl^{-1}), due to incoming effluents load from the city.

The status of aliens in Sur Sarovar Bird Sanctuary (Keetham jheel) in Mathura, Uttar Pradesh and Keoladeo Bird Sanctuary, Bharatpur, Rajasthan were also preliminarily assessed. Sur Sarovar Bird Sanctuary is spread over 7.97 km^2 area and Keoladeo Bird Sanctuary in 29 km^2 geographical area includes the water spread area. The wetland in the sanctuary area reportedly comprises 50 fish species. On preliminary observation (eye estimation), the Sur Sarovar was fully infested with alien fish *O. niloticus*. The authorities of the Keoladoo Sanctuary, Bharatpur, Rajasthan informed about mass scale successful removal of highly infested African magur, *C. gariepinus* from the wetland.

Explored selected open water resources of peninsular region to assess occurrence of alien fishes, especially African magur, *C. gariepinus* and sucker mouth catfish, *Pterygoplichthys* spp. The water bodies covered under the study were Periyar lake in Thekkady, Kumaly, Killi River in Trivandrum, Pampa and Manimala rivers in Thiruvalla, Kabani river in Wayanad and reservoirs in Idukki district. Heavy infestation of sucker-mouth catfish was observed from Killi river, Amayizhnchan thodu and Vellayani Lake in Trivandrum (Fig. 101). The size range of sucker-mouth catfish from catches of Trivandrum district comprised 220 to 540 mm with corresponding weight of 99.0 to 1510 g, respectively.

Observed considerable infestation of African magur, *C. gariepinus* (Fig. 102) in Periyar lake as evidenced by fish catch data. Average weight of the fish ranged from 550 and 3000 g caught during the period from November 27, 2018 to February 05, 2019. A meeting with the lake authorities and stake holders was convened for removal of *C. gariepinus* from the lake. Study on food matter ingested by the fish comprised of detritus (47.7 %), plant matter (37.2 %) and the rest by fish, molluscs and benthic fauna. Sexual maturity observed after 2 years of life span and above 2.0 kg body weight (Fig. 103).

Fig. 101 Sucker-mouth catfish catch from Killi river, Trivandrum.

African catfish population was also observed from Mananthawady river, a tributary of Kabani river, at Mananthawady, Wayand. The size and weight of the fishes caught comprised of 240 to 600 mm with corresponding weight of 117.5 to 1446.0 g, respectively. Stray samples of African magur and sucker-mouth catfish were observed from Pampa and Manimala rivers. Sizeable infestation of sucker-mouth catfish was noticed in highly polluted streams traversing

Fig. 102 African magur caught from Periyar lake.

Fig. 103 Mature African magur caught from Manimala river.

through Trivandrum. Established population of sucker-mouth catfish was also reported from Vellayani lake, Trivandrum. Fully mature fish samples were collected from the lake. The size range of sucker-mouth catfish from catches of Trivandrum district comprised 220 to 540 mm with corresponding weight of 99.0 to 1510 g, respectively. Presence of African magur was also reported from water bodies of Idukki district and tributaries of Kabani rivers.

Project: ICAR-Consortia Research Platform on Vaccines & Diagnostics

Sub-project: ICAR-NBFGR Component: Evaluating the effect of immunization on protection against infection with *Aphanomyces invadans*

Period: October, 2017- March, 2020

Personnel: Pravata K. Pradhan (PI), Neeraj Sood and Chandra Bhushan Kumar

Funding agency: ICAR, New Delhi

Immunization can be one of the strategies to reduce disease-related losses due to infection with *Aphanomyces invadans*. As to date, there is no effective treatment for control of infection with *A. invadans*. In an earlier study, use of inactivated germinated zoospores of *A. invadans* as antigen in conjunction with adjuvant Montanide™ ISA 763 A VG, showed promising result with 66.6% relative percent survival (RPS) against *A. invadans* infection in *Labeo rohita* after 7 days of booster immunization. In the present study, we evaluated same formulation for assessing their efficacy for long-term protection against *A. invadans* infection during May-July, 2018. For the experiment, rohu *L. rohita*, (n=120, 70 ± 1.2 g) were divided into 2 groups (control and immunized) with 60 fish in both the groups. The fish in control group were injected intraperitoneally with PBS, whereas immunized group was injected with inactivated germinated zoospores emulsified with adjuvant. After 28 days of immunization, the fish were given a booster dose as above. After 14 and 28th days of the booster dose, the 20 fish from both groups were challenged with zoospores of *A. invadans* to determine the relative percent survival (RPS). The results revealed that all the fish in control group succumbed to infection (0% RPS) in both the challenged studies. The fish in the immunized group showed significantly higher ($p < 0.05$) protection (90% RPS and 85% RPS at 14 and 24 days challenge, respectively). In addition, at 14 and 28 days following booster immunization, the antibody level in the immunized group was significantly higher ($p < 0.05$) than the control group.

Further, histopathological examination of the muscle tissue revealed that, in fish of immunized

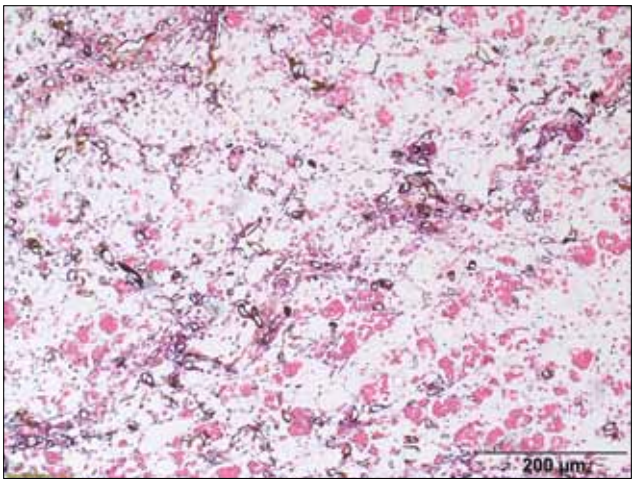


Fig. 104 Severe necrosis of muscle fibres in control rohu following infection with *A. invadans*.

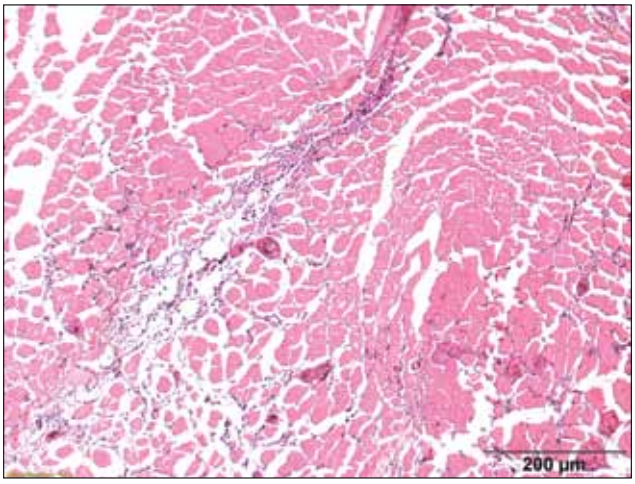


Fig. 105 Mild inflammatory reaction in immunized rohu following infection with *A. invadans*.

group without any gross lesions, there was infiltration of mononuclear cell restricted to the site of injection, whereas, in the control group, there was extensive myonecrosis with proliferating hyphae (Fig. 104 & 105). The results reinforce the potential of germinated zoospores as immunizing antigen for vaccination against *A. invadans*.

Project: All India Network project on Fish Health
Period: July, 2017 - March, 2020
Personnel: Pravata K. Pradhan (PI), Gaurav Rathore, Neeraj Sood and Anutosh Paria
Funding Support: ICAR, New Delhi

The efficacy of commonly used chemicals and antifungal drugs against different stages (zoospores, germination of zoospores and growth of hyphae) of *Aphanomyces invadans* was studied *in vitro*. In the present reporting period, 9 more common antifungal drug/disinfectant were evaluated which includes terbinafine hydrochloride, amphotericin B, fluconazole, ketoconazole, trans-ferulic acid, potassium permanganate, hydrogen peroxide, benzalkonium chloride (BKC) and formalin. Effect of different doses of the above mentioned products on different life stages of *A. invadans* was evaluated (Fig. 106 & 107).

Terbinafine was used at three different doses. At 10 ppm, there was complete inhibition of zoospore production, germination and hyphal growth. In the case of amphotericin, there was complete inhibition of zoospore production, germination and hyphal growth at a concentration of 100 ppm. With fluconazole there was complete inhibition of zoospore production, germination of zoospores and hyphal growth at a concentration of 100 ppm.

With potassium permanganate, at a concentration of 100 ppm, there was complete inhibition of zoospore production and germination of zoospores. However, hydrogen peroxide had no significant effect on sporulation, germination and growth of hyphae even at 100 ppm. With benzalkonium chloride, there was complete inhibition of zoospore production germination and hyphal growth at 100 ppm. In the case of formalin, there was complete inhibition of zoospore production and germination of spores and the hyphal growth at a conc of 50 ppm.

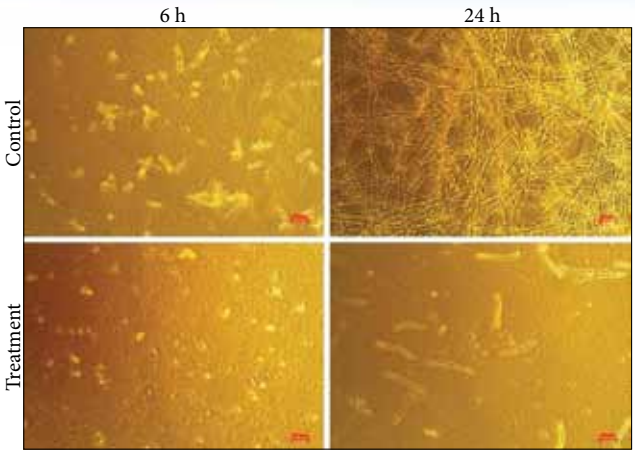


Fig. 106 Estimation of germination percentage of *A. invadans* zoospores following treatment with specific dose of antifungal drug/disinfectant.

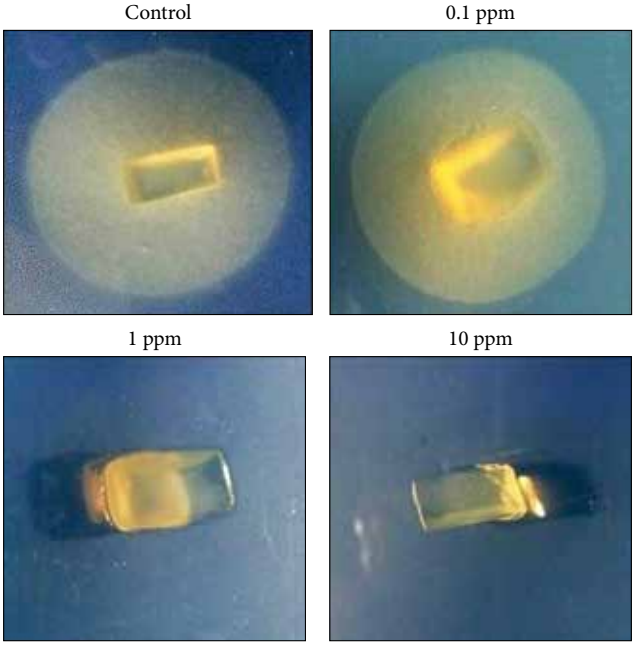


Fig. 107 Fungiostatic effect of antifungal drug/disinfectant on growth of *A. invadans* hyphae after 3 days.

Project: Development of vaccines and diagnostic kit for the disease management of Goldfish Herpesviral Hematopoietic Necrosis Disease in India
Period: April, 2017 - March, 2022
Personnel: T. Raja Swaminathan (PI)
Funding Support: External (ICAR Education Division)

The cyprinid herpesvirus 2 (CyHV-2) is one of the most infectious viral pathogens of goldfish and causes herpesviral haematopoietic necrosis (HVHN) disease that is characterized by skin haemorrhaging, bleeding and pale gills, enlarged spleen and kidney, and internal organ haemorrhaging and mortality can

reach 90-100%. Disease outbreaks caused by CyHV-2 infection has been observed in farmed goldfish in India that appears to be spreading. An effective prevention and treatment program for HVHN disease and as well rapid field level detection/diagnosis are desperately needed. Established cell lines are vital tools for virus isolation, identification, propagation and characterization. There is a need for highly permissive cell line for the efficient propagation of CyHV-2 to high concentrations for development of vaccine and diagnostic kits for the virus and the characterization of its pathogenesis in fish.

Development and characterisation of highly permissible cell line

Herpesviral haematopoietic necrosis disease, caused by cyprinid herpesvirus-2 (CyHV-2), is responsible for massive mortalities in goldfish. We have developed 4 cell lines, namely, FtGF (Fantail Goldfish Fin) from caudal fin, FtGG (Fantail Goldfish Gill), FtGL (Fantail Goldfish Liver), FtGB (Fantail Goldfish brain) of goldfish, *Carassius auratus*. The cell lines have been passaged up to 55, 24, 20 and 18 times respectively, in L-15 with 10% FBS (Fig. 108). Karyotyping of FtGF cells at different passage indicated that modal chromosome number was 2n = 104. Species authentication of all the cell lines was performed by sequencing of the fragment of 16S rRNA and COI genes. The immunophenotyping assay revealed that the four cells were of epithelial origin. The FtGF cell line was used for continuous propagation of CyHV-2 over 20 passages with high viral titer of $10^{7.8\pm0.26}$ $TCID_{50}$ ml^{-1}. Following inoculation of positive for CyHV-2 tissue homogenate, FtGF cells showed cytopathic effect by 2 day post-inoculation (dpi) and complete destruction of cells was observed by 10 dpi. An experimental infection of naïve goldfish using supernatant from infected FtGF cells caused 100% mortality and CyHV-2 infection in the challenged fish was confirmed by the amplification of DNA polymerase gene, histopathology and transmission electron microscopy. These findings provide confirmation that the FtGF cell line is highly permissive to the propagation of CyHV-2.

Amplification of capsid gene from nodavirus

The gene coding for CyHV2 major capsid protein (CyHV2-ORF92) were amplified by PCR with gene specific primer designed for eukaryotic expression vector (pTARGET™ Mammalian Expression Vector) from genomic DNA of Indian isolates and a band corresponding to 3.789 Kb were observed in agarose gel. The PCR product were purified from agarose gels using a commercially available DNA purification kit (Bangalore Genei, India). The concentration of purified PCR product were measured by using Nanodrop (Thermo Scientific, USA). The resultant PCR product were stored at -20°C until further use. The amplified full length of major capsid protein gene of CyHV2 has been sequenced (AgriGenome Labs Pvt Ltd, Kerala, India) and submitted to NCBI (MH512899.1).

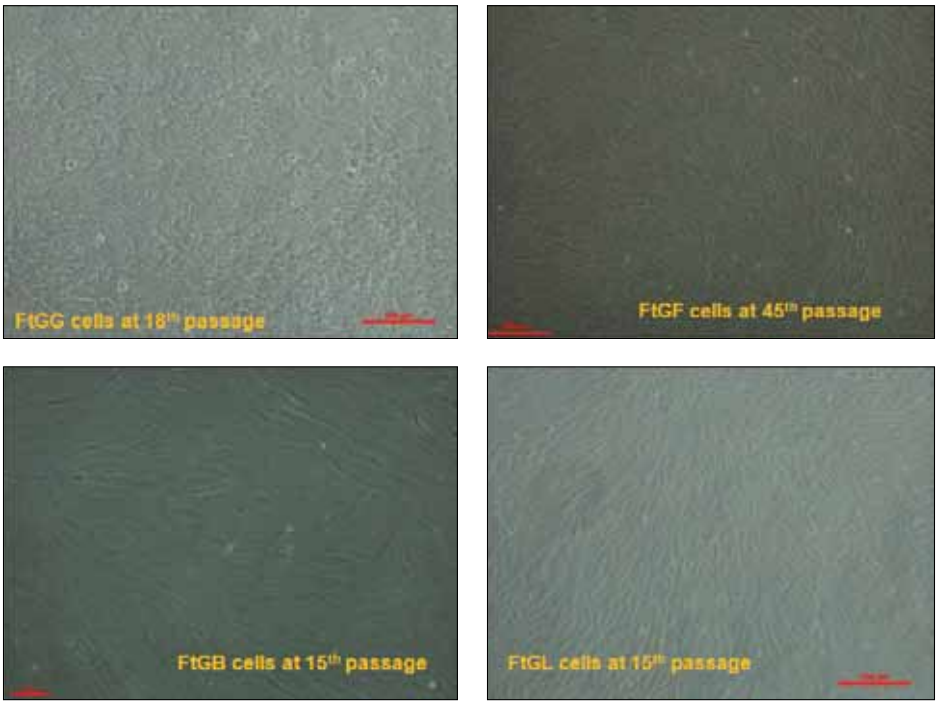
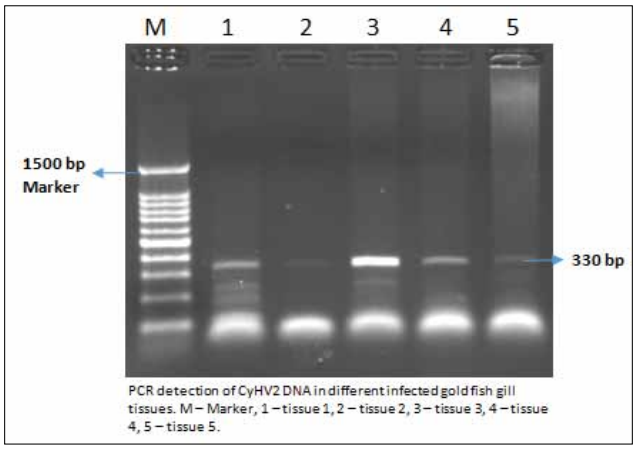


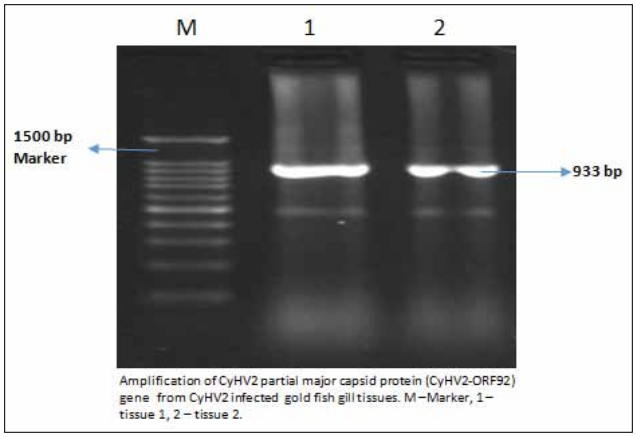
Fig. 108 Development of cell lines from goldfish.

Cloning and sequencing of viral capsid gene of CyHV2

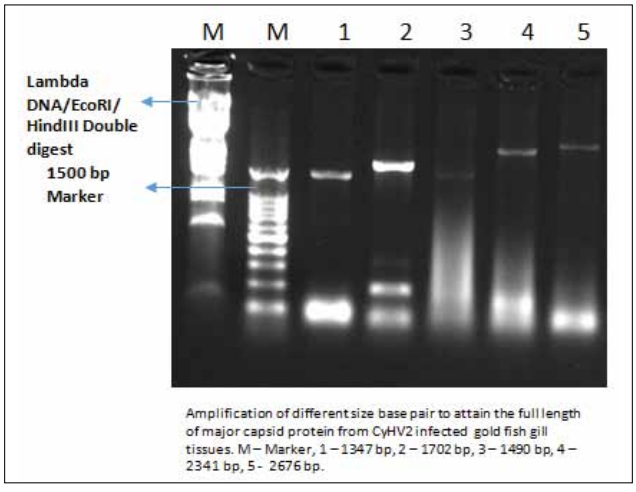
The plasmid vector pTARGET™ were extracted from the bacterial host (DH5α). Restriction enzyme digestions were performed using double digestion of EcoRI enzymes with the buffers recommended by the manufacturer (New England Biolabs, MA, USA). Simultaneously, the PCR products were also subjected to restriction by double digestion of EcoRI enzyme and the restricted product were observed in agarose gel. The purified restricted product were ligated into pTARGET™ vector (Fig. 109).



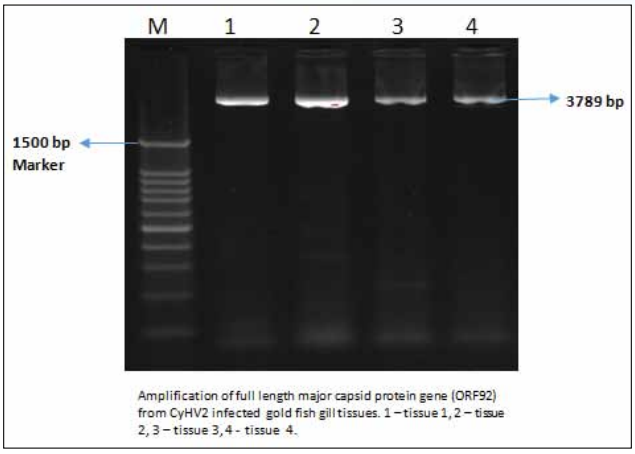
PCR detection of CyHV2 DNA in different infected gold fish gill tissues. M – Marker, 1 – tissue 1, 2 – tissue 2, 3 – tissue 3, 4 – tissue 4, 5 – tissue 5.



Amplification of CyHV2 partial major capsid protein (CyHV2-ORF92) gene from CyHV2 infected gold fish gill tissues. M – Marker, 1 – tissue 1, 2 – tissue 2.



Amplification of different size base pair to attain the full length of major capsid protein from CyHV2 infected gold fish gill tissues. M – Marker, 1 – 1347 bp, 2 – 1702 bp, 3 – 1490 bp, 4 – 2341 bp, 5 - 2676 bp.



Amplification of full length major capsid protein gene (ORF92) from CyHV2 infected gold fish gill tissues. 1 – tissue 1, 2 – tissue 2, 3 – tissue 3, 4 - tissue 4.

Fig. 109 Cloning of CyHV2 fragment in pTARGET™ vector.

Transformation and screening for the recombinants

The recombinant plasmids were transformed into DH5α strains of *E. coli* according to the method of Hanahan (1983) using CaCl2 for the preparation of competent cells. The bacterial suspension were plated onto the Luria Bertani (LB) agar containing ampicillin and X-gal. The plates were then incubated at 37 °C for 14 h. Positive clones, identified by blue/white screening were then checked by PCR.

Sequence analysis using the bioinformatic tools

The clones that contained plasmid with appropriate inserts have to be checked for frame shift. The clones were sent to a Biotech company for sequencing.

Project: Identification and characterization of novel viral etiology from undiagnosed disease outbreaks of fishes using meta-genomic and metatranscriptomic approaches

Period: June, 2017 - June, 2019

Personnel: Gaurava K. Rai (PI) and Gaurav Rathore (Supervisor)

Funding Support: Science and Engineering Research Board (SERB)

Screening of Megalocytivirus in ornamental fishes

A total of 26 samples of black molly fish and 4 samples of angelfishes were procured from different aquarium shops at Lucknow and tested for the presence of Megalocytivirus. Megalocytivirus specific primers; C1105 & C1106 were used for PCR based detection and specific fragment of 431bp size were observed. All samples were found negative for presence of Megalocytivirus. Hence, screened ornamental fish samples were not processed further for viral metagenomics (Table 14).

Screening of Cyprinid Herpesvirus 2 (CyHV-2) in goldfishes

For the screening of CyHV-2 virus in goldfishes; 31 samples of goldfish, 2 samples of lichi goldfish, 2 samples of red-cap goldfish and 2 samples of bubble-eye goldfish were purchased from aquarium shops at different locations in Lucknow. Samples were PCR tested with CyHV-2 specific CyHV2PolF and CyHV2PolR primers and amplification of 362bp fragments were analysed on agarose gel. Out of tested samples, 6 samples of goldfish, 2 samples of bubble-eye goldfish, 2 samples of lichi goldfish and 1 sample of red-cap goldfish were detected positive for CyHV-2 virus (Table 14).

CyHV-2 positive samples were processed for virion enrichment that comprises of tissue homogenization, centrifugation, 0.45µ filtration and digestion of non-viral nucleic acids using nucleases. Total viral nucleic acids were extracted from enriched virion samples and again tested for CyHV-2 by PCR. None of the samples were detected positive for CyHV-2 in enriched virions. This could be due to low CyHV-2 virion titre in enriched samples or due to integration of CyHV-2 genome in host genome.

CyHV-2 infection in CCFK cell lines and gold fish fin primary cell lines

CyHV-2 infection in *Cyprinus carpio* koi fin cell lines (CCFK) was attempted, but no CPE was observed. Goldfish fin primary cell cultures were also developed to achieve successful CyHV-2 infection but CPE was not observed in primary cultures. This may be due to integration of CyHV-2 genome in the host genome.

Screening of viruses in water bodies for viral metagenomics

For the screening of viruses in water, 7 pond water samples were collected from NBFGR ponds (pond no. 2, 7, 13 and 22) and processed for virus enrichment comprising filtration, virus precipitation and nuclease digestion of non-viral nucleic acids. Out of 7 pond water samples, viral nucleic acids were obtained in 2 samples (Fig. 110, Table 14). Pond water samples positive for viral nucleic acids are being processed for metagenomic sequencing.

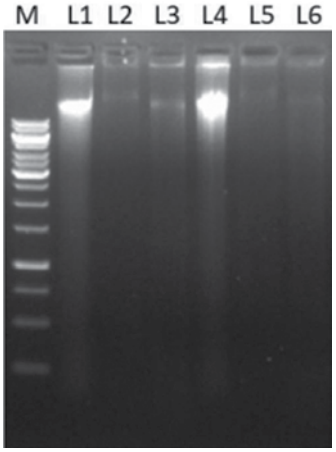


Fig. 110 Isolation of viral nucleic acids in pond water samples. Lane M -1kb molecular marker, L1 & L4- viral nucleic acid extracted from nuclease digested sample, L2 & L5- nuclease digested sample (sample directly loaded into wells without DNA extraction), L3 & L6-virus precipitated samples without nuclease digestion (sample directly loaded into wells without DNA extraction).

Screening of viruses in fish intestine for viral metagenomics

Intestine from 2 samples of Pangasius fish were collected and processed for virion enrichment and viral nucleic acid extraction but viral nucleic acid could not be detected.

Table 14. Screening of viruses for viral metagenomics

Name of Fish/Pond	Samples collected	Name of virus for screening	PCR test	Virion enrichment test
Screening of viruses in ornamental fishes for viral metagenomics				
Black molly	26	Megalocytivirus	Negative	N/a
Angelfishes	4	Megalocytivirus	Negative	N/a
Gold fish	31	CyHV-2 virus	6 Positive	Negative
Lichi goldfish	2	CyHV-2 virus	2 Positive	Negative
Red-cap goldfish	2	CyHV-2 virus	1 Positive	Negative
Bubble-eye goldfish	2	CyHV-2 virus	2 Positive	Negative
Screening of viruses in water bodies for viral metagenomics				

Name of Fish/Pond	Samples collected	Name of virus for screening	PCR test	Virion enrichment test
Pond no. 7	2	Metagenomic viruses	N/a	Negative, No viral nucleic acid obtained
Pond no. 2	1	Metagenomic viruses	N/a	Positive but contains non-viral nucleic acids
Pond no. 13	2	Metagenomic viruses	N/a	Positive, viral nucleic acid obtained
Pond no. 22	2	Metagenomic viruses	N/a	Positive, but contains non-viral nucleic acids
Screening of viruses in fish intestine for viral metagenomics				
Pangasius	2	Metagenomic viruses	N/a	Negative

Project: **Biocontrol of *Aeromonas hydrophila* and *Flavobacterium columnare* infection in *Labeo rohita* through phage therapy and para-probiotics**

Period: May 2018 - May 2021

Personnel: Gaurav Rathore and Anutosh Paria

Funding Support: DBT-Twinning

Collection of water, sediments and fish samples

A total of 7 water samples (two sewage water & 5 pond water) and four fish samples (gills and intestine) were collected and processed for isolation of bacteriophages specific to *A. hydrophila*. Five strains of *A. hydrophila* (9C, 10G1, 10C, 7C, 4P1) were selected as hosts for bacteriophage isolation.

Enrichment of collected sample and isolation of bacteriophages specific to *A. hydrophila*

Collected water samples were enriched in presence of specific bacterial host in nutrient broth for 24 hours. After enrichment, the samples were centrifuged and filtered to remove bacteria and spotted on bacterial lawn to obtain clearing zone or plaques (spotting method) (Fig. 111).

Out of the seven water samples processed, only one pond water sample yielded plaques against three strains of *A. hydrophila* (10G1, 7C, 4P1).

Similarly, fish samples were enriched in presence of specific bacterial host in nutrient broth for 24 hours. After enrichment, the samples were centrifuged and filtered to remove bacteria and spotted on bacterial lawn to obtain clearing zone or plaques (spotting method). Out of the four samples processed, only two fish sample yielded plaques against two strains of *A. hydrophila* (10G1, 4P1). The spots were picked, enriched further and stored for estimation of virus titres.

Estimation of bacteriophage titers by soft agar overlay technique

A. hydrophila broth culture and dilutions of bacteriophage filtrate were mixed with molten soft agarose and poured over TSA plates. The plates were incubated for 16-18 hr and observed for formation of plaques. Plaques were counted in different dilutions to estimate the virus count as plaque forming unit (pfu/ml). All the isolated bacteriophages had titres > 10^9pfu/ml (Fig. 112).

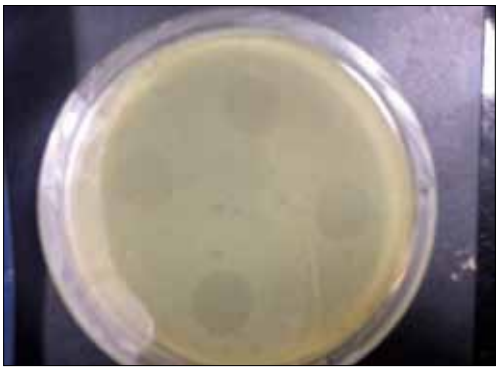


Fig. 111 Enrichment of water samples and plaque assay (spotting method) for isolation of bacteriophages.

Fig. 112 Representation of estimation of phage titre by soft agar overlay technique.

Determination of host range of isolated phage against various strains of bacteria

The isolated phages were tested on lawns of five different strains of *A. hydrophila* by spotting method. However, no plaques were obtained on any other strain of target bacteria indicating strain specific host range of isolated phages.

Project: **Establishment of spermatogonial stem cell line (SSC) from *Sahyadria denisonii***
Period: **August, 2018 to March, 2020**
Personnel: **T. Raja Swaminathan, Charan Ravi and P. R. Divya**
Funding Support: **ICAR Extra Mural**

Spermatogonial stem cells (SSCs) have the potential to self renew and at the same time generate the cascade of differentiating germ cells that will eventually lead to the formation of sperm throughout the life of the organism. There is a very little information about spermatogonial self-renewal and differentiation in fish testis. A major problem associated with *in-vitro* propagation has been the lack of sufficient knowledge regarding their candidate phenotypic and genotypic features. Unlike other animals, evidence regarding a well defined culture system for highly purified SSCs is not available for any fish species. The enrichment of SSCs from total testicular cells by magnetic-activated cell sorting (MACS) using Gfr-1 antibody has been demonstrated in mammalian species. We have previously devised a modified two-step protocol (Ficoll gradient centrifugation followed by Thy1 antibody-labelled MACS sorting) for enriching SSCs of a commercially important red-line torpedo barb, *Sahyadria denisonii*. *In-vitro* production of sperm from the cultured spermatogonial cells under culture condition could be an alternative strategy for producing male gametes to be used in breeding programmes and conservation. Here we attempt in the derivation of a normal spermatogonial cell line from the adult testis of *S. denisonii* and in the recapitulation of spermatogenesis from this line to produce motile sperm *in vitro*.

Three different size *S. denisonii* (BW 9 g, 12 g and 18 g) were collected from wild and acclimatized in the laboratory condition for the preparation of testis explant preparation. Testis were collected from ten different sized *S. denisonii* (bw - 10-15 gm; bl - 7-10 cm) to carry out histopathology of testis to find out the correct stage of the testis to harvest more SSC. Primary culture was initiated from testis tissues and cells were cultured at 28°C in L-15 medium (pH 7.0), supplemented with 20 % fetal bovine serum, basic fibroblast growth factor, penicillin and streptomycin. A total number of ten trails of testis tissues explants of *S. denisonii* was carried out and radiation of cell reported from the explants, but monolayer could not be obtained (Fig. 113). Specialized Media was formulated for the successful culture of SSC cells *in vitro*.

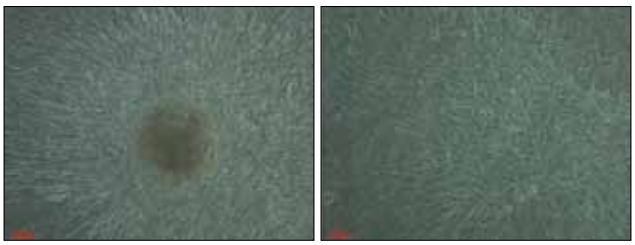


Fig. 113 Establishment of primary cell culture from the testis of *S. denisonii* by explant method.

Project: **Molecular characterization of antimicrobial resistant bacteria from ornamental fish**
Period: **April, 2018 - April, 2020**
Personnel: **Preena P.G. (PI) and T. Raja Swaminathan (Supervisor)**
Funding Support: **Science and Engineering Research Board (SERB)**

Antimicrobial resistance is one of the major threats faced in aquaculture systems. Diseased freshwater ornamental guppy fishes, gold fishes and koi carps were collected from different fish farms for testing their antimicrobial susceptibility. Around fifteen isolates were resolved from five guppy fishes, and the isolates were subjected to phenotypic and genotypic characterization. Dendrogram generated 5 clusters using NTsys software based on the biochemical tests and the 16SrRNA gene sequences of representative isolates were sequenced and identified as *Aeromonas hydrophila*, *A. sobria*, *Pseudomonas putida*,

Acinetobacter soli and *Kurthia gibsonii.* The Shannon wiener diversity index of the resolved isolates was found to be 1.395 as determined by Primer-E software. Disc-diffusion method was adopted for checking the antibiotic susceptibility using 17 antibiotic discs belonging to different classes. Among the isolates, the majority of them was found to be *P. putida* and exhibited higher antibiotic resistance towards antibiotics of 10 classes including third generation Cephalosporin and others showed the same against antibiotics of at least 5 classes tested. All of the recovered isolates possessed the MAR index of greater than 0.5, indicating the heavier dose of antibiotics in the farm. The detection of plasmid-mediated class I integron in *A. hydrophila*, *A. sobria* and *A. soli* indicated the possibility of heavier dissemination of antimicrobial resistant genes among the ornamental fishes. Gentamycin and Ciprofloxacin were significantly effective against all the isolates and can be successfully applied in aquaculture.

Altogether seventeen isolates were segregated from 10 gold fishes and their phenotypic and genotypic tests were performed. Dendrogram created 7 clusters on the basis of biochemical tests and on sequencing, the isolates were identified as *K. gibsonii, Edwardsiella tarda, Comamonas testosteroni, Citrobacter freundii, Klebsiella aerogenes, A. nosocomialis* and *Enterobacter cancerogenus.* Primer-E software detected their diversity index as 1.864. Fourty seven antibiotics including third and fourth generation antibiotics were selected for checking their antimicrobial susceptibility using disc diffusion method. Out of the isolates, *A. nosocomialis* and *E. cancerogenus* were found to be the most resistant groups. They were resistant against thirty seven and thirty six antibiotic classes respectively. Their MAR index was found to be > 0.35 and indicated the severe exposure of antibiotics in the fish farm. *C. testosteroni* and *E. tarda* were found to be the sensitive groups, showing resistance against only eleven and eight antibiotics respectively. Minimum inhibitory concentration (MIC) was calculated for all the isolates using MIC strips (Himedia) and found to be very high with > 256mcg. Molecular characterization of antimicrobial resistance genes were determined using the PCR targeting forty resistance genes such as class I and class II integrons, gene cassettes, tetracycline resistance, erythromycin resistance, beta lactam resistance, vancomycin resistance, aminoglycoside resistance genes etc. Meanwhile the presence of AMR genes was not confirmed and the standardization is going on.

Twenty isolates were isolated from 10 ornamental koi carps and their biochemical tests were carried out. Based on their phenotypic chararacterization, NTSYS software generated the dendrogram of 11 clusters. *A. hydrophila*, *A. popoffi, A. junii, A. caviae, Bacillus drentensis K. gibsonii, Lactococcus lactis, C. aquatica, C. testosteroni, E. cloacae* and *E. tarda* were identified on sequencing the representative isolates. Shannon wiener diversity index was calculated as 2.359 using Primer-E software. Out of the 47 antibiotics tested using disc diffusion, each isolate exhibited different pattern of antibiotic resistance on Muller Hinton agar. *A. caviae* and *E. cloacae* possessed higher antibiotic resistance towards 32 and 33 antibiotics respectively. Higher MAR index of > 0.4 was observed for the resistant isolates. While *B. drentensis* and *C. aquatica* showed resistance against only a maximum of 4 and 8 antibiotics respectively. Minimum inhibitory concentration of all resistant isolates determined using MIC strips (Himedia) were found to be greater than 256mcg and the rest of the work is under progress. Standardization of PCR detection of different antimicrobial resistance genes such as tetracycline, beta lactam, vancomycin, aminoglycoside and macrolide resistance genes and class I & II integrons and gene cassettes are undergoing.

A total of 23 16SrRNA gene sequences of all the studied isolates were submitted in GenBank and the accession numbers are as follows; MK272938, MK272939, MK272940, MK272941, MK272942, MK426815, MK426816, MK426817, MK426818, MK426819, MK426820, MK426821, MK426822, MK426823, MK426824, MK426825, MK4268126, MK426827, MK426828, MK426829, MK426830, MK426831, MK426832.

WORKSHOPS/ SYMPOSIA/ TRAININGS/ MEETINGS ORGANIZED

Workshop and Symposia

Fisheries Entrepreneurship Seminar-2018

Fisheries Entrepreneurship Seminar-2018 was organized by ICAR-NBFGR and Centre for Agriculture and Rural Development (CARD), New Delhi on April 11, 2018 at ICAR-NBFGR, Lucknow. More than 300 aquaculturist and officials including scientists participated in the seminar. Dr. Anees Ansari, Chairman, Centre for Agriculture and Rural Development inaugurated the seminar. Dr. Dilip Kumar, Ex-Director, ICAR-CIFE, Mumbai, Dr. K.K. Lal, Director, ICAR-NBFGR, Shri S.K. Singh, Joint Director (Fy.), Uttar Pradesh, Shri Rajender Prasad Singh, DGM, Fish Development Corporation, Shri P.K. Chaube, Dayal Group, Shri Ravi Chhapa, UNIBET were also present in the inaugural session. Dr. Ansari stressed on doubling of fish farmer income in the state of Uttar Pradesh and also suggested that this type of seminar may be organized at district level in years to come. Different interactive sessions were organized among industry representative, fish farmer/ entrepreneurs and scientists. Different media houses covered the proceedings of the seminar. The speakers highlighted that the possibility of extensive and intensive aquaculture development is vast in the state. Aquaculture in the state is operational in undrainable multi-purpose ponds. Enhancement of entrepreneurship in fish culture required in the area of modern aquaculture and fish feed production and marketing.

Experts delivering lecture in the seminar

Outreach workshop on "Women Empowerment through Innovation and Creativity"

An outreach workshop "Women Empowerment through Innovation and Creativity" for encouraging entrepreneurship and creativity among rural women was organized through National Agriculture Innovation Fund (NAIF) of ICAR to celebrate World IP Day on April 26, 2018 at Pradhan Mantri Kaushal Vikas Kendra, Kalli Paschim, Lucknow. The workshop was celebrated in line with the theme of the World IP Day 2018, "Powering change: Women in Innovation and Creativity." 30 women belonging to 2 Self Help Groups participated in the discussion programme and spoke about their entrepreneurial journey. They spoke about working space, price and market constraints. The need for systemic design intervention was explained to create opportunities such as, using clay. The women have made clay creations and used them for decorations for terrariums.

Outreach programme on IPR for kids

For raising IP awareness among school kids, a creativity exercise based on different IPRs was organized at Bal Vidya Mandir Senior Secondary School near Charbagh, Lucknow on November 2, 2018 as mentor of change supported by Atal Innovation Centre of Niti Ayog to understand how to create from simple things and protect with IPR.

Training Programmes for Capacity Development

A customized training on "Use of PCR in shrimp disease diagnosis" was organized during July 30 to August 3, 2018, for Mr. Ajay Chahal, Post graduate student, Chaudhary Devi Lal University, Sirsa-125055, India.

FAO - ICAR training on WHONET software for data Management of Antimicrobial Resistance (AMR)

A two day "FAO - ICAR training on WHONET software for data Management of Antimicrobial Resistance (AMR)" was organized at ICAR-NBFGR, Lucknow on August 17-18, 2018. The inauguration of the training programme was presided by Dr. Kuldeep K. Lal, Director, ICAR-NBFGR. Dr. Rajesh Bhatia, Regional Technical Advisor on AMR, FAO, New Delhi was the Chief guest and key resource person of the training. Dr. Jyoti Misri, Principal Scientist, Animal Science Division, ICAR, New Delhi attended the training programme as representative of INFAAR (Indian Network of Fishery and Animals Antimicrobial resistance). A total of 15 participants from 7 ICAR-Fisheries Institutes attended the training programme. Dr. Rajesh Bhatia delivered an introductory talk on Antimicrobial Resistance: Global and regional perspectives and GLASS, which was followed by presentation on Methods of Antimicrobial susceptibility (AST) by Dr. Gaurav Rathore. Subsequently, Dr. Rajesh Bhatia briefed the participants on "WHONET: AMR data management". Technical session was followed by hands-on training sessions on WHONET software in the computer laboratory of ICAR-NBFGR. During this session, demonstration on installation of software, data entry and data analysis was carried out by Dr. Bhatia. The participants practised on-spot exercises and simulations on AMR data entry and analysis.

Group photo on the occasion of launch of the training programme

Training Programmes on Clownfish Aquaculture

The ICAR-NBFGR recently initiated a program with an objective of "Establishment of marine ornamental fish village at the coastal Maharashtra" with the financial support of Mangrove Cell and Mangrove Foundation, Government of Maharashtra, first of its approach in the country. In this context, a master facility on marine ornamental fish breeding was established by the ICAR-NBFGR on the premises of the Coastal and Marine Biodiversity Centre, Mangrove Foundation Govt. of Maharashtra, Airoli, Thane and Mumbai.

As a part of the programme, 500 beneficiaries from different villages/ districts along the Maharashtra coast were identified by the mangrove foundation. The ICAR-NBFGR imparted training on Clownfish aquaculture for the first batch of beneficiaries (50 members) at the Faculty of Marine Sciences, Annamalai University during August 29 to September 01, 2018. During Inauguration, Prof. M. Srinivasan, Director and Dean Faculty of Marine Sciences, Annamalai University welcomed the gathering and briefed about the activities of their centre and the University. The Presidential address was delivered by Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, who emphasised about the institute and the need for participatory approach in conservation of fish genetic resources and livelihood development of coastal communities. The inaugural address was given by Shri E. Rajendran, I.F.S, District Forest Officer, Cuddalore, Govt. of Tamil Nadu, who addressed about the importance of conserving biodiversity and the need for enhancing income of fish farmers. Prof. L. Kannan, Former Vice Chancellor, Thiruvalluvar University, Tamil Nadu, Dr. G. Gopakumar, former Head, Mariculture division of ICAR-CMFRI and Prof. R.M. Kathiresan, Director, Centre for Research and Development Annamalai University also graced the occasion. During the programme, a training manual on Clownfish Aquaculture was released, which covers fish culture, feeding, water quality, disease diagnosis and management, packaging and transportation and socio-economic studies. Hands-on training about clownfish rearing, setting up of filtration units and handling of water analysis kits were also explained. On

September 1, 2018 the beneficiaries visited Kolathur, Chennai ornamental fish market and interacted with the traders. The programme concluded with a Valedictory function, which was chaired by Prof. M. Srinivasn, Director and Dean of Faculty of Marine Sciences, Annamali University. Dr. Charan Ravi, Scientist, ICAR-NBFGR welcomed the gathering. Mr. S. Ramalaingam, Executive Officer of local Panchayat offered Valedictory address and Mrs. Teena Jayakumar T.K., Scientist, ICAR-NBFGR extended vote of thanks and distributed certificates to the participants.

In continuation, a second training programme was conducted for 30 beneficiaries of Thane district at the Coastal and Marine Biodiversity Centre, Mangrove foundation Govt. of Maharashtra, Airoli, Thane during March 5-7, 2019. The training was inaugurated by Mr. Mayur S. Bothe, Range Forest Officer, Government of Maharashtra, Thane and facilitated by Dr. G. Gopakumar, former HoD, Mariculture Division, ICAR-CMFRI. Mrs. Teena Jayakumar, Scientist, ICAR-NBFGR briefed about the activities of NBFGR and need of the training. During this occasion, a training manual on Clownfish Aquaculture in Marathi was released. The Valedictory session was chaired by Mr. Prakash R. Chaudhary, Range Forest Officer, Govt. of Maharashtra. Dr. A. Kathirvelpandian, Dr. Charan Ravi and Mrs. Teena Jayakumar T.K. Scientists; ICAR-NBFGR distributed certificates to the participants.

During both the trainings, the beneficiaries were trained about identification of different species of clownfish, hatchery propagation and rearing, feeding strategies, disease diagnosis and treatment methods, setting up of filtration units, water quality management, hatchery equipments and marketing strategies. Both the programmes were funded by the Mangrove Foundation, Govt. of Maharashtra.

Release of training manual by the dignitaries at Annamalai University

Demonstration to the trainees about *Artemia* culture and setting of biological filtration unit

Release of training manual

Training Course on 'Cell Line: Development, Maintenance and Applications'

A Short-term Hands-on training course on "Cell Line: Development, Maintenance and Applications" was conducted at ICAR-NBFGR, Lucknow, during September 24 to October 01, 2018. The aim of the training was to develop trained manpower in the area of cell culture, particularly development of

cell line and its maintenance and applications. The training course comprised of class room discussion and hands-on practices covering various aspects of cell culture techniques like cell line development, characterization, cryopreservation, maintenance, virus isolation, cytotoxicity testing etc.

The training was inaugurated by Prof. Rakesh Kapoor, Director, SGPGIMS, Lucknow. In his address, he emphasised upon hands-on practices rather than lectures. A total of 11 trainees from various parts of the country, such as ICAR-CIRB, Hissar; CUSAT, Kochi; College of Fisheries, Mangalore; BBAU, Lucknow; Bharathiar University, Coimbatore, etc. participated in the training program.

Prof. Rakesh Kapoor, Director, SGPGIMS, Lucknow addressing participants and staff members of ICAR-NBFGR.

Hands-on Training Programme on 'Fish Health Management'

A Hands-on Training Programme on 'Fish Health Management' was organised at ICAR-NBFGR, Lucknow for State Fisheries Officers of Haryana during October 8-12, 2018 under National Surveillance Programme on Aquatic Animal Diseases (NSPAAD) funded by National Fisheries Development Board, Department of Animal Husbandry Dairying and Fisheries, Ministry of Agriculture and Farmers Welfare, Government of India. A total of 11 fisheries officers from Haryana participated in the training programme. During the training programme, the participants were familiarised with level I diagnostics i.e. clinical signs of important diseases of freshwater fishes. Analysis of water quality parameters using kit and titration methods was also demonstrated. The participants were apprised of level II diagnostic techniques, *viz.,* bacteriology, mycology, parasitology and histopathology. They were also introduced to level III diagnostic techniques including virology, DNA and antibody based diagnostics. The officers were made aware about the surveillance programme, particularly about the information that needs to be collected and reported, so that the passive surveillance system is strengthened and each disease outbreak is reported and investigated.

Glimpses of the training programme

Training programme on Opportunities for tribal farmers in fisheries based enterprise

The Institute in joint collaboration with the Department of Zoology, Gauhati University, Guwahati, organised a training programme on 'Opportunities for tribal farmers in fisheries based enterprise' at the Aquaculture and Biodiversity Centre, Department of Zoology, Gauhati University, Guwahati during October 11-13, 2018. A total of 34 tribal men and women farmers of district Baksha, Assam attended the training programme which was organised under the TSP scheme. The training included lectures and demonstrations on various aspects of integrated fish farming and ornamental fish rearing.

Training programme for M.F.Sc students

One month attachment training program in FHME division was organized during November 12, 2018 to December 12, 2018 at ICAR-NBFGR for three M.F.Sc students of ICAR-CIFE. The participating

students were - Ms. Dawa Droma, Mr. Kuntal Krishna Bera and Mr. David Waikhom.

Orientation training on Establishing Germplasm Resource Center for marine ornamental invertebrates at the Lakshadweep

The ICAR-NBFGR initiated a DBT funded programme with the objective of "Establishing Germplasm Resource Center for marine ornamental invertebrates: Harmonizing biodiversity conservation and promoting livelihood to the islanders of the Lakshadweep". As an initiation of the project, orientation training was conducted at the Central Marine Living Resources and Ecology (CMLRE), Kochi during November 22-24, 2018. The DBT project personnel along with the students from CMLRE attended the training. During the opening session, Dr. V.S. Basheer, Principal Scientist and Scientist-in-charge of the NBFGR Kochi Centre gave his remarks. Dr. Charan Ravi, Scientist and Co-Principal Investigator of the DBT Project, briefed about the programme. Inaugural address was delivered by Dr. M. Sudhakar, Director, CMLRE, Kochi. This was followed by a lecture of Prof. K.V. Jayachandran, Director of Research (Retd.), Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi on the overview and taxonomy of marine ornamental shrimps. Dr. S. Prakash, Scientist, Sathyabhama University, Chennai and Dr. P. Santhanam of Bharathidasan University, Tamil Nadu and Mrs. Teena Jayakumar served as Resource Persons. The programme ended with the closing remarks of Mr. N. Saravanane, Scientist E, CMLRE.

Lightning the lamp during Inauguration by Dr. M. Sudhakar, Director, CMLRE

Prof. K.V. Jayachandran conducting practical session

Training on HRD for Agricultural Research

A three-days training on "Human Resource Development for Agricultural Research" was organized during December 04-06, 2018 by ICAR-National Bureau of Fish Genetics Resources, Lucknow. The training was conducted under Annual Training Programme (ATP) by HRD unit of ICAR-NBFGR, Lucknow. The programme was inaugurated by Shri V.K. Thakur, Former IFS as Chief Guest and Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, Lucknow. A training manual as a ready reference for the participants was also released during inaugural session. Apart from staff members of NBFGR headquarter, staff from PMFGR Centre, Kochi participated through skype, staff from ARTU Chinhat and 5 Staff from ICAR-Central Institute of Subtropical Horticulture, Lucknow also attended the program.

Release of the training manual

Lecture in the training session

During the programme, lectures were delivered by external and internal resource persons on various fields such as, climate smart agriculture and conservation of natural resources, personality types and communication, waste utilization, empathy in improving organizational behavior, plagiarism in research, GFR Rules and regulation, vigilance and its awareness, gender issues in agriculture and ICAR-ERP system.

ICAR-NACA School on "Aquatic Animal Epidemiology and Disease Surveillance"

ICAR, New Delhi in collaboration with Network of Aquaculture Centres of Asia-Pacific (NACA), Bangkok organised a School on "Aquatic Animal Epidemiology and Disease Surveillance" at ICAR-NBFGR, Lucknow during March 1-6, 2019 under National Surveillance Programme for Aquatic Animal Diseases. Prof. Kenton L. Morgan, Ex-Chair of Epidemiology, University of Liverpool, United Kingdom was the Convener of the School. A total of 12 researchers from 7 institutes participated in the School. The major topics covered during the School included concept and principles

Glimpses of the School

of epidemiology, use of epidemiological principles in design and implementation of surveillance, sampling considerations for surveillance, population survey, estimation of sensitivity and specificity of diagnostic test and questionnaire design etc. In addition, Dr. Eduardo Leano, Coordinator, Aquatic Animal Health Programme, NACA made a presentation on 'Transboundary Aquatic Animal Diseases (History and Impacts in Asian Aquaculture)', whereas Prof. Iddya Karunasagar delivered a lecture on 'Emerging Disease Risks in Global Aquaculture'.

Training program on "Fish Milt Cryopreservation for Genetic Up-gradation of Broodstock"

Two training programs on fish milt cryopreservation for genetic up-gradation of broodstock were organized between March 8-11 and 13-16, 2019. Series of lectures and practical demonstration were arranged during the programme. Total 42 hatchery operators from West Bengal, Uttar Pradesh and Madhya Pradesh participated in the program.

Inauguration of training

Demonstration on milt collection

Demonstration on cryopreservation

Group photograph

Important Days and Celebrations

World Intellectual Property Day

ICAR-NBFGR celebrated World IP Day through creativity of women Self Help Group (SHG) members of Kalli Paschim, Lucknow on April 26, 2018. On the occasion, an outreach activity was organised through National Agriculture Innovation Fund (NAIF) of ICAR to understand the problems faced by women in their entrepreneurial journey starting at SHG, a micro level. Though handholding, training and Mentorship was provided, basic problems do exist as opined by the women who are striving hard to bring about a positive change in their lives through creativity and innovation. An endeavour was started with Ms. Kiran Yadav, Ex Block Pramukh, Dr. Aruna Parashar and Dr. Poonam Jayant Singh to create creative opportunities where systemic design intervention could be used to create articles like Terrariums, made up of local material like clay.

Members of Self Help Group on IP Day celebration

Agriculture Education Day

ICAR-NBFGR celebrated 'Agriculture Education Day' on December 3, 2018 to rejoice the birth anniversary of Bharat Ratna Dr. Rajendra Prasad, first Indian Union Agriculture Minister and first President of Independent India. The aim of the programme was to develop interest among the students in agriculture and allied sciences and to choose 'agriculture' as their professional and research career or engage themselves in farming as agri-entrepreneurs.

Activities during the 'Agriculture Education Day' celebration

The institute invited students of different schools of Lucknow to participate in the Painting and Drawing (Theme: Jai Jawan Jai Kisan Jai Vigyan for Students upto 6th standard and Swachh Nadiyan Saksham Bharat for students of 7th to 12th standard) and Essay Writing (Theme: Global warming and Aquatic life for students of 8th to 12th standard) competitions. The programme was attended by 55 students who were accompanied by 10 teachers from 9 schools of the city. Event participation certificates were given to all the students. Competition winners were awarded prize during the ICAR-NBFGR Foundation Day celebration on December 12, 2018.

Foundation Day of ICAR- NBFGR and Farm Innovation Day

ICAR-NBFGR celebrated its '35th Foundation Day' and 'Farm Innovation Day' on December 12, 2018. Prof. U.S. Gautam, Vice Chancellor, Banda University of Agriculture and Technology (BUAT), Banda was the Chief Guest of the function. On this occasion, Annual Institute Awards for the year 2017-18 were presented to the staff of ICAR-NBFGR for their performance in various categories. Selected fish farmers were also awarded for their contribution and achievements in the field of fish farming. The student winners from different schools, who participated in drawing/painting and essay writing competitions during 'Agriculture Education Day' on December 03, 2018 at the institute, were also awarded with prize and certificate during the program.

Foundation Day Celebration

Presentation of Annual Institute and Farmer Awards

Aqua-Poultry Dairy Expo-2018

ICAR-NBFGR, Lucknow in collaboration with Centre for Agriculture and Rural Development (CARD), Govt. of Uttar Pradesh, Department of Fisheries, Animal Husbandry hosted Aqua-Poultry Dairy Expo-2018 on December 11, 2018 at its campus. The program was inaugurated by Hon'ble Minister of Animal Husbandry, Minor Irrigation and Fisheries, Prof. S.P. Singh Baghel in the presence of Dr. Sudhir M. Bobde, Principal Secretary, Fisheries, Dr. Kuldeep Kumar Lal, Director, ICAR-NBFGR and Dr. S.K. Srivastava, Director, Animal Husbandry, Dr. Anis Ansari, Chairman, CARD. Aquaculture, Poultry and Dairy farmers across the country participated in the program and interacted with experts during seminar and exhibitions. The combined exhibition of these commodities also attracted the attention of farmers to integrated farming systems.

National Productivity Week on the Theme: Circular Economy for Productivity and Sustainability

ICAR-NBFGR, Lucknow observed National Productivity Day on February 12, 2019 and Productivity Week from February 12-18, 2019 with great enthusiasm. The celebration started with inaugural session organised at the institute on February 12, 2019. Dr. A.K. Sharma, Principal Scientist (Agri. Economics), ICAR-IISR, Lucknow delivered the guest lecture on "Circular economy in Indian Context, Role, Relevance and Need of Time". Dr. Poonam J. Singh, Scientist, ICAR-NBFGR explained about the product designed by the Self Help Group of rural women's through use of waste material and displayed the product made from clay, corn and scales of fishes. Dr. K.D. Joshi, Pricipal Scientist, ICAR-NBFGR highlighted the sustainable use of water resources, fishery based eco-tourism, sport fishery and fish watching to harness optimum returns from specific water bodies. Dr. Kuldeep K. Lal, Director ICAR-NBFGR explained about various measures undertaken by the institute in waste management at the farm and laboratories. He also explained about various other measures that would be taken by the institute in this direction to minimise solid and bio-waste. The daily activities organized during the week were covered by 10 local newspapers.

Launch of Productivity Day and National Producitvity Week Celebration

Remarks of the Director on Celebration of Productive Day and National productivity Week

Address of Dr. Vindhya Mohindra, HoD, Fish Conservation Division

School students with Director, Dr. Kuldeep K. Lal & Chief Guest of the occassion.

International Women's Day celebrated at ICAR-NBFGR, Lucknow

ICAR-NBFGR, Lucknow celebrated International Women's Day 2019 on March 8, 2019. Dr. Vindhya Mohindra, Chairperson Women's Cell, spoke on the necessity and importance of Women's day celebrations. A debate competition on the topic "Equal Rights to all, Equal opportunities to all" was organised on the occasion, which received great support from the staff, where 10 participants placed forth their views on gender equality and its significance in empowering women. Dr. Sangeeta Srivastava, and Dr. Diksha Joshi from ICAR-Indian Institute of Sugarcane Research, Lucknow also participated in the event. A Rangoli Competition on the topic "Women and Fisheries" was also organised on March 7, 2019 in which 4 teams participated. Dr. Rejani Chandran, Member Secretary, NBFGR Women's Cell delivered the Vote of Thanks.

Women of ICAR-NBFGR recjoicing on the occasion of International Women's Day

Important Meetings

Meetings of Department of Biotechnology at ICAR-NBFGR

- Department of Biotechnology organized a Selection Committee Meeting on Biotechnology Social Development Awards-2017 at ICAR-NBFGR, Lucknow on April 16, 2018. The meeting was chaired by Dr. V.P. Kamboj, Former Director, CSIR-CDRI, Lucknow.
- Department of Biotechnology organized a Task Force Committee Meeting on "Aquaculture & Marine Biotechnology" at ICAR-NBFGR, Lucknow on June 12-13, 2018. The meeting was chaired by Dr. S. Ayyappan, Former Secretary DARE and Director General ICAR.

Distinguished partcipants in the DBT meeting

Consultation on Risk-Benefit Assessment for Alien fishes by ICAR-NBFGR & WWF-India

ICAR-NBFGR, Lucknow and World Wide Fund for Nature-India (WWF-India) organised a Joint Consultation on Invasive Alien Fish Species: Need for a Risk-Benefit Assessment and Management Framework for Healthy Freshwater Ecosystems at WWF-India, Lodhi Road, New Delhi on December 19, 2018. The program was aimed to develop a risk benefit analysis framework, which can be used for assessing the new proposed introductions, or retrospective introductions in the country as well as to discuss the mitigation strategies for eradicating invasive species established in natural waters. Besides experts from International organizations like NACA and SAARC, the program was attended by a galaxy of very senior experts of fishery sector and representatives from

Glimpses of Consulative Program on Risk-Benefit Assessment for Alien fishes

Wild Life Institute, Dehradun; National Biodiversity Authority, Chennai; Marine Products Export Council, Kochi; Department of Animal Husbandry, Dairy & Fisheries (DAHD&F), New Delhi; Zoological Survey of India; Chief Conservator of Forest, Chandigarh; Universities and ICAR institutes.

ICAR-NACA Regional Expert Consultation Meet on "Genetically Responsible Aquaculture: Sustainability of Genetically Fit Broodstock and Seed of Certified Origin in Asian Aquaculture"

ICAR, New Delhi and Network of Aquaculture Centres in Asia-Pacific (NACA), Bangkok, Thailand jointly organized an International two-day Regional Expert Consultation Meet on "Genetically Responsible Aquaculture: Sustainability of Genetically Fit Broodstock and Seed of Certified Origin in Asian Aquaculture" from February 26-27, 2019. The programme was conducted with an aim of identifying the several missing components in the current aquaculture production economy of Asia and global South region. Approximately 90% of the global aquaculture production is the product of sustainable intensification of aquaculture in the region.

Dr. J.K. Jena, DDG (Fisheries & Animal Science), ICAR, New Delhi presided over the session on February 26, 2019. Dr. Cherdsak Virapat, Director General, NACA marked his presence as the Chief Guest of the programme along with Dr. Roger W. Doyle, Fish Geneticist from Canada as the Guest of Honour. Earlier, Dr. Kuldeep K. Lal, Director, ICAR-NBFGR welcomed the delegates. He presented the context of consultation. The consultation was aimed for addressing the quality of seed that is the most critical input in aquaculture. The programme registered a total participation by 40 delegates from 13 countries including international organizations, namely NACA and FAO.

Launch activities of the Regional Expert Consultation

Interactive session with the experts

Valedictory Program

Research Advisory Committee Meeting

The 23rd meeting of the Research Advisory Committee (RAC) of ICAR-NBFGR was held on March 18-19, 2019 at the headquarters. The meeting was chaired by Dr. George John, former Sr. Adviser, Department of Biotechnology, Government of India and Former Vice Chancellor, Birsa Agricultural University. Dr. P. Pravin, ADG (Marine Fisheries), Dr. A. K. Sahu, Former Principal Scientist, ICAR-CIFA, Bhubaneswar and Dr. Deepti D. Deobagkar, Professor and Director, Bioinformatics Centre, Pune University participated in the meeting as expert members of the RAC. Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, Lucknow apprised the RAC about the Institute's achievements in research, extension, capacity development and infrastructure development during last one year. Dr. Lal informed the RAC that the main focus of research has been on harmonizing genetic resources utilization with conservation. The Member Secretary, RAC, Dr. G. Rathore, Principal Scientist and Head, Fish Health Management and Exotics Division, ICAR-NBFGR, Lucknow presented the action taken report on the recommendations of RAC held during 2018. The Heads of the Divisions/In-charges of units also gave presentations on significant achievements under different projects of the respective divisions/ units. The RAC reviewed progress of all the ongoing research programmes of the Institute and suggested to further strengthen capacity on bioinformatics, molecular modeling and computational biology. The Chairman emphasised the importance of initiating a program on documentation of genetic erosion in fish farm stocks. Expert members gave valuable suggestions to improve upon the research programmes of the Institute. In his concluding remarks, Dr. Kuldeep K. Lal, Director thanked the RAC for its positive attitude, valuable recommendations and guidance to research programs of ICAR-NBFGR.

Institute RAC meeting in progress

Annual Institute Research Committee (IRC) meeting

The 32nd Institute Research Committee (IRC) meeting for the year 2018-19 was held ICAR-NBFGR during April 29-May 3, 2019 under the Chairmanship

of Dr. Kuldeep K. Lal, Director, NBFGR. Dr. Rajeev K. Singh, Member Secretary, IRC, welcomed the chairman and members of IRC. The concerned officials from administration and finance were also invited to the meeting. In his introductory remarks, the Chairman, IRC recalled the research activities of the last year and mentioned that the year was eventful and vibrant. Several new programs got initiated, while external funding support was received for several projects. He underlined that the ICAR-NACA consultation meet was a successful and futuristic endeavour. It has not only extended the footprints of the Bureau but also provided greater visibility at the national and international front. He stressed on explicit research strategies and planning so as to give a boost to publications. After the remarks from Chairman, HoDs and SICs, progress reports of different projects were presented by the respective Principal Investigators. Following the presentation of ongoing/completed projects, the new concept proposal was presented, discussed and approved with suggested modifications.

Annual IRC meeting in progress

Institute Management Committee Meeting

The 33rd annual meeting of Institute Management Committee (IMC) was organised on February 18, 2019.

Annual Institute Management Committee Meeting

Independence Day Celebrations

The Institute celebrated Independence Day on August 15, 2018 with full enthusiasm. Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, Lucknow hoisted the National flag in the presence of staff members of the Bureau. Director appreciated the efforts made by the Bureau in the past and highlighted future plans in his address. On this occasion, a cultural programme was organised in which large number of the staff and children of the ICAR-NBFGR family participated.

Independence Day Celebrations

Republic Day Celebrations

Dr. Kuldeep K. Lal, Director hoisted the National Flag on January 26, 2019 in the presence of staff members of the Bureau to mark the Republic Day. In his address, he highlighted the achievements of ICAR-NBFGR during the year 2018. He emphasized upon the need to keep updated with recent developments in the fisheries sciences and society as a whole and adapt research programmes in accordance with the emerging needs of the society. Dr. Lal also informed the staff that the Institute has undertaken several initiatives, to comply with the recent efforts of the Govt. of India towards digitization. The programme was followed with a cultural programme in which large number of children and staff of the ICAR-NBFGR family participated.

Republic Day Celebrations

EXTENSION ACTIVITIES

NFDB sponsored Training of Trainers Programme for State Officials

Three residential training programmes of 5 days duration under NFDB sponsorship for all India state officials, entrepreneurs and progressive fish farmers were conducted on ToT for Recirculatory Aquaculture System (RAS). A total of 60 participants attended the training as detailed below:

S. No	Area of training	Duration of training	No. of Trainees
1	ToT on Recirculatory Aquaculture System (RAS)	August 6-10, 2018	22
2	ToT on Recirculatory Aquaculture System (RAS)	November 26-30, 2018	13
3	ToT on Recirculatory Aquaculture System (RAS)	January 21-25, 2019	25

ToT activities at ARTU, Chinhat, Lucknow

NFDB sponsored Skill Development Programme for Farmers

Four residential training programme of 3 days duration for all India fish farmers under NFDB sponsorship were conducted on Skill Development Programme (SDP) on Recirculatory Aquaculture System (RAS) for 187 participants with following details:

S. No	Skill area of training	Duration of training	No. of Trainees
1	SDP on Recirculatory Aquaculture System (RAS)	August 28-30, 2018	46
2	SDP on Recirculatory Aquaculture System (RAS)	September 25-27., 2018	50
3	SDP on Recirculatory Aquaculture System (RAS)	December 20-22, 2018	43
4	SDP on Recirculatory Aquaculture System (RAS)	January 15-17, 2019	48




SDP Training activities at ARTU, Chinhat, Lucknow

Special Training Programme for skill development of the U.P. state level beneficiaries

One special training programme was conducted on, "Importance of Feed in Aquaculture Production System and their Availability in Market" from September 11-15, 2018 for the U.P. state beneficiaries of SAME (ATMA) Rehmankheda, Lucknow. A total of 35 beneficiaries attended the training program.


Activities under SAME (ATMA) Training at ARTU, Chinhat, Lucknow

Training Programme for Youth under Skill Development

Two residential training programmes of 25 days duration for the youth under Agricultural Skill Council of India, New Delhi/ATARI, Kanpur were conducted by ICAR-NBFGR at ARTU, Chinhat, Lucknow on Freshwater Aquaculture for 40 farmers of Uttar Pradesh.

Training on Freshwater Aquaculture

Mera Gaon Mera Gaurav Programme

A number of activities were conducted in Bahuta village of Barabanki District, U. P. under the Govt. of India programme, "Mera Gaon Mera Gaurav". Survey of village was done and farmers were advised to grow different types of crop. A Scientist-Farmer interaction programme was also conducted in which fish farmers of Bahuta, Lahi, Sahawal, Raili, Pokhara and Haidargarh villages participated.

Activities under Tribal Sub-Plan Scheme

Under the Tribal Sub-Plan scheme of the Govt. of India, the Institute undertook a variety of extension programmes and activities for the socio-economic development of tribals in various areas of the country. These activities were aimed at facilitating tribal development through fisheries-based enterprises by providing scientific inputs by the Institute as well as in collaborative mode with other institutions.

During the year under report, two training programmes were organised for tribal farmers including tribal women as per details given below:

S.N.	Title	Venue	No. of participants	Location of participants
1	Opportunities for Tribal Farmers in Fisheries based Enterprises	Aquaculture & Biodiversity Center, Dept. of Zoology, Gauhati University, Guwahati	34	Baksha district of Assam (Villages-Jamguri no. 2, Padmapur, Simala, Katahbari, Majdia, Dumuria, Tetliguri,)
2	Opportunities for Tribal Farmers in Fisheries based Enterprises	Aquaculture & Biodiversity Center, Dept. of Zoology, Gauhati University, Guwahati	30	Baksha district of Assam (Villages-Dumuria, Tetliguri, Barbera, Chechapari, Dhorongapar no. 2, Mankata, Chapatal)
	Total		**64**	

Actvities under TSP

Three awareness programmes for tribal farmers including tribal women organised as per details given below:

S.N.	Title	Venue	No. of participants	Location of participants
1	Livelihood Opportunities for Tribal Farmers in Fisheries based Enterprises	Myorpur, Sonebhadra, UP	84	Distt. Sonebhadra, UP (Villages- Rihandnagar, Babhani, Sukrav tola, Naghira, Padri, Munvatna, Deori, Govindpur, Barven, Kundadeeh, Supa-Chuan, Kusmha, Gadia and Anjani)
2	Fish Seed Production and Hatchery Management	Kataundhi, Sonebhadra, UP	100	Distt. Sonebhadra, UP (Villages- Dhanvara, Katundhi, Rantola, Mahuria, Karamgarh, Bairkhad, Arangpaani, Jharo-khurd, Butbedva, Khairadeeh, Barve, Dhanaura, Ghagra, Darankheed, Ghagri)
3	Opportunities for Tribal Farmers in Fisheries based Enterprises	Tumulpur, Baksha District, Assam	60	Baksha district of Assam (Villages-Dumuria, Tetliguri, Barbera, Chechapari, Dhorongapar no.2, Mankata, Chapatal) *(In collaboration with Dept. of Zoology, Gauhati University, Guwahati)*
	Total		**244**	

Two programmes on technological and infrastructure support for selected tribal farmers for taking up/




Tribal farmer interaction activities

strengthening fisheries based enterprises towards enhancing their livelihoods were continued in Assam in collaboration with Dept. of Zoology, Gauhati University, Guwahati and Haflong Govt. College, Haflong, Assam. Five more tribal beneficiaries were selected in Kulsi and Dimali villages, Kamrup (Rural) district, Assam. Thus, total 10 beneficiaries have been provided technological and infrastructure support in Kamrup (Rural) district Assam. Similarly, four tribal beneficiaries selected in Naben and Longmailai villages, Haflong district, Assam during last year, were supported for undertaking fish culture for livelihood enhancement.

Success story of a tribal farmer Mr. Dharmendra who was provided with a portable FRP Carp hatchery unit alongwith accessories and training, demonstration & continuous technical guidance by the TSP team of the Institute at village - Kataundhi, Block Dudhi, District, Sonebhadra, U.P. was documented based on a field survey of fish seed production, its sale and increase in coverage of other indirect beneficiaries in the region. One portable FRP Carp hatchery unit alongwith accessories was installed at tribal farmers' place in village Anjani, Block Myorpur, District, Sonebhadra, U.P.

Fish Farmers Interaction Meeting at Maharajganj

Under DBT-BBSRC project, a Fish Farmers Interaction Meeting was organised in Maharajganj district of Uttar Pradesh, India on December 17, 2018. The project collaborators from United Kingdom, namely Prof. Kenton L. Morgan, Dr. Chris Hauton, Prof. Dr. Ir Pieter van West and Prof. Md. Abdus Salam from Bangladesh participated in the meeting. The meeting was attended by a total of 135 fish farmers. During the meeting, Prof. Kenton shared the findings of the epidemiological study carried out in 2017 and explained about risk factors associated with fish mortality in carp farms in Maharajganj. Thereafter, Dr. P.K. Pradhan made a presentation on Better Management Practices in carp culture and

management of Epizootic Ulcerative Syndrome, with emphasis on minimizing the risk factors.

Fish seed production

Quality fish seed production is one of the important activity of the institute for societal benefit and livelihood support of the fish farmers of the region. The institute has developed farm cum hatchery facilities at two sites - one at its main campus and another one at ARTU Chinhat, Lucknow. During the reported period institute produced 1076 lakh seed in the form of spawn, fry and fingerlings of Indian major carps & exotic carps. Received a total of Rs. 11.96 as sale proceed of seed.

Media Programme (TV, Radio etc.) for serving stakeholders

The Institute personnel participated/contributed to the following media programmes for reaching out to the stakeholders and providing them technological information and advisory services:

Other Farmer Advisory Services

Date	Place	Topic	Telecast/Broadcast
May 11, 2018	Lucknow Doordarshan	Matsya Palan me Samayaik Karya	Krishi Darshan programme telecasted on May 17, 2018
May 15, 2018	ETV U.P.	Composite Fish Culture	ETV U.P. telecasted on June 6, 2018 under Annadata
August 20, 2018	Lucknow Doordarshan	Matsya Palan me Samayaik Karya	Krishi Darshan programme telecasted on August 27, 2018

Date	Place	Topic	Telecast/Broadcast
September 17, 2018	All India Radio (Akashvani), Lucknow	Composite Fish Culture	Telecasted in Vigyan evam Kisan Programme on dated September 24, 2018
October 29, 2018	All India Radio (Akashvani), Lucknow	Matsya Palan me Samayaik Karya	Vigyan evam Kisan Programme
October 31, 2018	Lucknow Doordarshan	Matsya Palan me Samayaik Karya	Krishi Darshan programme telecasted on November, 2018
January 10, 2019	Lucknow Doordarshan	Live phone in programme	Doordarshan Lucknow on January 10, 2019
March 01, 2019	Lucknow Doordarshan	Matsya Palan me Samayaik Karya	Krishi Darshan programme telecasted on March 6, 2019
March 19, 2019	All India Radio (Akashvani), Lucknow	Matsya Palan se Dugani Aaya	Telecasted in Vigyan evam Kisan Programme on March 25, 2019

Various other technical guidance and advisory services were also provided to different groups of clientele in aqua farmers/college students, agri-clinic/ agri-business entrepreneurs, etc. The institute also participated in several exhibitions, aqua fairs and farmers fairs at various places in the country.

AWARDS AND RECOGNITIONS

Awards and Recognitions

The institute Hindi magazine 'Matsyalok' (6th issue) was awarded 1st prize by the Nagar Rajbhasha Karyanvayan Samiti (Karyalay 3), Lucknow, Ministry of Home Affairs, Rajbhasha Vibhag, Govt. of India for the year 2018-2019.

ICAR-NBFGR, ARTU, Chinhat, Lucknow has been accredited by Agriculture Skill Council of India with Provisional Affiliation for training of Freshwater Aquaculture Worker for the year 2018-2019.

Dr. A. K. Pandey, Principal Scientist was conferred with the following awards:

- Life Time Achievement Award, Ek Nayi Rah Foundation, Etawah, Uttar Pradesh.
- Best Scientist (TOP LIST-25), Education Expo Television-CRS, NOIDA, Uttar Pradesh.
- Life Time Achievement Award, Indian Academy of Environmental Sciences, Haridwar.
- Glory of India Award-2018, International Publishing House, New Delhi.
- International Achievement Award-2018, Education Expo Television-CRS, NOIDA, Uttar Pradesh
- Life Time Achievement Award-2018, Blue Planet Society, Allahabad.
- Education Award for Excellence-2018, Confederaion of Education Excellence (CEE), New Delhi.
- Life Time Achievement Award, Society for Scientific Development in Agriculture and Technology, Meerut.
- Life Time Achievement Award, Society for Science and Nature, Lucknow.

Dr. Rajeev K. Singh was conferred with the following awards:

- Fellowship of the Academy of Environmental Biology during the 38th session held at at Dr. Ram Manohar Lohia Avadh University, Faizabad, (U.P.) on October 3, 2018.
- Best Scientist of the Institute award during the Foundation Day of ICAR-NBFGR.

Dr. Ajey Kumar Pathak, Senior Scientist received Recognition award for outstanding academic contribution and achievements in the field of Fisheries Resource Management on the occasion of Sixth Annual Session of Society of Life Sciences and International Conference on "Advances in Biological and Environmental Research for Human Welfare" organized by the Department of Zoology, Deen Dayal Upadhaya Gorakhpur University, Uttar Pradesh from 16 to 18 November 2018.

Dr. Sullip Kumar Majhi, Principal Scientist was conferred with the following awards:

- Dr B.S. Chauhan Medal (2019) from Zoological Society of India.
- Excellent Research Award (2019) from Combined Society for Educational Research & Development, India.
- Outstanding Scientist Award (2018) from the International Organization of Scientific Research and development, India.
- Best Scientist Award (2018) from Society of Life Sciences, India.

Dr. Mahender Singh, Principal Scientist, received fellowship of the Academy of Environmental Biology (AEB), Lucknow in the 38thAnnual Session of AEB organized at Dr. Ram Manohar Lohia Avadh University Faizabad during 3-4 October, 2018".

Dr. Anutosh Paria, Scientist received best doctoral research award for the year 2017-18 from ICAR-CIFE, Mumbai on 6th June, 2018.

Dr. Rajesh Dayal, Chief Technical Officer received Dr. S.Z. Qasim Medal - 2019 conferred by Bioved Research Institute of Agriculture, Technology & Sciences, Prayagraj (Allahabad) on February 16-17, 2019 during 21st Indian Agricultural Scientists and Farmers' Congress on "Prospects of Rural prosperity and Income Security of Farmers on the occasion of Kumbh Mela-An important step towards Making New India" held at Prayagraj (Allahabad).

Dr. Ajay Kumar Singh, Assistant Chief Technical Officer received "Best Performer Award" from ICAR-NBFGR for the year 2017-2018 during the year 2016-2017 on occasion of annual day of NBFGR, Lucknow.

RESEARCH PROJECTS

Institutional Projects

S. No	Project Title	Personnel	Period
Molecular Biology & Biotechnology Division			
1.	Stress tolerance response in cultivable freshwater fish species	S.K. Srivastava (PI), Ravindra Kumar and Poonam J. Singh	April, 2017 - March, 2020
2.	Systematic review and evolutionary study of Indian Clupeiform fishes	Mahender Singh (PI), T.T., Ajithkumar, Murali S., Teena Jayakumar T.K. and A.K. Mishra	April, 2017 - March, 2019
Fish Conservation Division			
3.	Outreach activity on fish genetic stocks, Phase II NBFGR HQ Component PMFGR Center Component	Kuldeep K. Lal (Project Coordinator), Rajeev K. Singh (Co-coordinator and Lead Centre PI) Vindhya Mohindra, Sangeeta Mandal, Rejani Chandran, Achal Singh, Amar Pal, R.S. Sah and Rajesh Kumar (Personnel, HQ) P.R Divya (PI), V.S. Basheer, A.K. Pandian and Charan Ravi (Personnel, PMFGR Center)	April, 2014 - March, 2019
4.	Signatures of natural selection and genomic diversity in important freshwater fish species, *Tor putitora* and *Clarias magur*	Vindhya Mohindra (PI) and Trivesh S. Mayekar	April, 2014 - March, 2019
5.	Exploration for fish diversity assessment and traditional ecological knowledge in lower Mahanadi basin	Lalit K. Tyagi (PI), Sangeeta Mandal, Trivesh S. Mayekar, Rejani Chandran, A.S. Bisht and Sanjay K. Singh	April, 2016 - March, 2019
6.	Evolutionary significance of hypothalamus-pituitary- gonadal axis in fishes, with special reference to Indian species	A.K. Pandey (PI)	November, 2016 - October, 2018
7.	Fish diversity pattern of fish communities from Luni river basin, Rajasthan, India	A.K. Pathak (PI)	April, 2018 - March, 2021
8.	Exploration and assessment of fish diversity of mid-Himalayan tributaries and wetlands of Ganga River System	K.D. Joshi (PI), A.K. Pathak, Santosh Kumar, Rajesh Dayal, Ajay K. Singh and Ravi Kumar	April, 2017 - March, 2019
9.	Establishing National Germplasm Repository and Museum at NBFGR as an Integrated Resource for AqGR research and societal Awareness **Component I:** Structure, Mechanisms and Resources Integration and **Component II:** Diploid germplasm cryobanking for *ex situ* conservation and multiplication of Aquatic Genetic Resources	Kuldeep K. Lal (Coordinator) Sullip K. Majhi	April, 2018 - March, 2021

S. No	Project Title	Personnel	Period
Fish Health Management & Exotics Division			
10.	Exploring the variation in immunological and disease susceptibility against *Aeromonas hydrophila* in two different stocks of Indian catfish *Clarias magur*	Gaurav Rathore (PI), Chinmayee Muduli, Anutosh Paria and Ranjana Srivastava	November, 2016 - March, 2020
11.	Risk and benefit assessment modeling for exotic species	K.D. Joshi (PI), V.S. Basheer, Aditya Kumar, S.M. Srivastava and Vikash Sahu	April, 2017 - March, 2019
12.	Network project on assessment of anti microbial resistance in fisheries and aquaculture	Gaurav Rathore (PI), Chandra Bhusan Kumar, Anutosh Paria, Chinmayee Muduli, S.M. Srivastava and Vikash Sahu	December, 2017 - March, 2020
Peninsular & Marine Fish Genetic Resources Centre, Kochi			
13.	Exploration and cataloguing of the fish diversity from marine island ecosystems and Cauvery River basin		
	Sub project-1: Survey and collection of fishes from Cauveri River basin	V. S. Basheer (PI), T. Raja Swaminathan, Charan Ravi and Rajool Shanis C. P.	April, 2016 - March, 2019
	Sub project-2: Survey and Collection of fishes from Marine Islands (Andaman & Lakshadweep)	T. T. Ajithkumar (PI), A. K. Pandian and Teena Jayakumar T. K.	April, 2016 - March, 2019
Aquaculture Research and Training Unit			
14.	Livelihood improvement through integrated farming models using indigenous resources	S.K. Singh (PI), L.K. Tyagi and A.K. Yadav	April, 2017 - March, 2019

ICAR Plan fund

S. No	Project Title	Personnel	Scheme	Period
1.	Intellectual property management and transfer/ commercialization of agricultural technology scheme (Up-scaling existing components i.e. Intellectual property right)	Poonam J. Singh (PI)	ICAR Plan NAIF	April, 2017- March, 2020
2.	Network project on agricultural bioinformatics and computational biology: **Sub Project:** Construction of physical map of *Clarias magur*	Ravindra Kumar (PI), Basdeo Kushwaha, Mahender Singh, A. K. Pathak and Murali S.	ICAR-IASRI	April, 2017 - March, 2020
3.	ICAR CRP-Genomics: De-novo gene sequencing of anadromous Indian Shad *Tenualosa ilisha* (Hamilton, 1822)	J. K. Jena (Coordinator) Vindhya Mohindra (PI), Rajeev K. Singh, Basdeo Kushwaha and Labrechai Mog Chowdhury	ICAR- CRP	April, 2015 - March, 2020

S. No	Project Title	Personnel	Scheme	Period
4.	ICAR CRP-Agrobiodiversity: National network on agro-biodiversity management: On-Farm evaluation of prioritized fish genetic resources for conservation aquaculture	Kuldeep K. Lal (PI), S. K. Majhi, Santosh Kumar, Ajay K. Singh, T.T. Ajithkumar, Aditya Kumar and Charan Ravi	ICAR-CRP	April, 2017 - March, 2020
5.	ICAR CRP-Vaccines & Diagnostics: Evaluating the effect of immunization on protection against infection with *Aphanomyces invadans*	P.K. Pradhan (PI), Neeraj Sood and Chandra Bhushan Kumar	ICAR-CRP	October, 2017 - March, 2020
6.	All India network project on fish health	P.K. Pradhan (PI), Gaurav Rathore, Neeraj Sood and Anutosh Paria	ICAR Plan	April, 2017 - March, 2020

Externally-funded projects

S. No	Project Title	Personnel	Scheme	Period
1.	National repository of fish cell lines in NBFGR, Phase II and Access Centre in C. Abdul Hakeem College and Research on Application of cell lines in Vivology, Toxicology and Gene Expression Studies	Basdeo Kushwaha (PI), Ravindra Kumar, Murali S. and Akhilesh K. Mishra	DBT, Govt. of India	May, 2017 - May, 2020
2.	Development of biotechnological approach for production of *Clarias magur* (Hamilton,1822) spermatozoa for aquaculture	S.K. Majhi (PI) and Santosh Kumar	DBT, Govt. of India	January, 2018 - December, 2020
3.	National surveillance program for aquatic animal diseases	J.K. Jena (Coordinator), Kuldeep K. Lal (Co-coordinator), Neeraj Sood (PI), P.K. Pradhan, T. Raja Swaminathan and Gaurav Rathore	NFDB	February, 2013 - September, 2019
	Sub project I: Surveillance of freshwater fish and shellfish diseases in Uttar Pradesh and Haryana	P.K. Pradhan (PI), Neeraj Sood, Aditya Kumar and Gaurav Rathore	NFDB	February, 2013 - September, 2019
	Sub project II: Surveillance program for aquatic animal diseases of ornamental fishes in the states Kerala and Tamil Nadu	T. Raja Swaminathan (PI) and V.S. Basheer	NFDB	April, 2013 - March, 2018
4.	Poverty alleviation through prevention and future control of the two major socioeconomically important diseases in Asian aquaculture	Neeraj Sood (PI), P.K. Pradhan and Vindhya Mohindra	DBT-BBSRC	May, 2016 - May, 2019

S. No	Project Title	Personnel	Scheme	Period
5.	Biocontrol of *Aeromonas hydophila* and *Flavobacterium columnare* infection in *Labeo rohita* through phage therapy and paraprobiotics	Gaurav Rathore (PI) and Anutosh Paria	DBT Twinning project	May, 2018- May, 2021
6.	Exploring our wetlands: Establishing DNA barcodes for finfishes and shellfishes of Ramsar sites in Kerala	P.R. Divya (PI)	KSCS&T	January, 2016 - January, 2019
7.	Molecular taxonomy and phylogeny of Cones (Cone snails) and Strombs (Mollusca, Gastropoda) of the Indian coast	Laxmilatha P. (PI), Ranjit L. (ICAR- CMFRI) and A. Kathirvel Pandian (Co-PI)	DBT, Govt. of India	November, 2015 - November, 2018
8.	Development of vaccines and diagnostic kit for the management of goldfish Herpesviral Hematopoietic necrosis disease in India	T. Raja Swaminathan (PI)	ICAR National Fellow Project	April, 2017 - March, 2022
9.	Quantifying Agrobiodiversity and Ecosystem Services in Godavari River Basin Landscape	Kuldeep K. Lal (Coordinator), Rajeev K. Singh (PI), Lalit K. Tyagi, Achal Singh, Rejani Chandran and Kantharajan G.	Bioversity International	January, 2018 - December, 2018
10.	Setting up of marine ornamental fish village: Way forward to promote livelihood to mangrove dwellers and marine biodiversity conservation at Maharashtra	Kuldeep K. Lal (Coordinator), T.T. Ajithkumar (PI), Charan Ravi and Lalit K. Tyagi	UNDP -Mangrove Cell, Maharashtra	March, 2018 - February, 2021
11.	Establishing Germplasm Resource Center for marine ornamental invertebrates: Harmonizing bioversity conservation and promoting livelihood to the islanders of the Lakshdweep	T.T. Ajith Kumar (PI)	DBT Twinning Project	July, 2018 - June, 2021
12.	Establishment of spermatogonial stem cell line (SSC) from *Etroplus suratensis*	T. Raja Swaminathan (PI), Charan Ravi and P. R. Divya	ICAR-EM	August, 2018 - March, 2020
13.	Understanding genomic mechanism of thermal tolerance using golden mahsheer, *Tor putitora* as model	Vindhya Mohindra (PI), Labrechai Mog Chowdhury and Trivesh Mayekar	NICRA	August, 2018 - March, 2020
14.	To elucidate the unique biochemical adaptational strategies that allow two air-breathing catfishes (*Clarias batrachus* and *Heteropneustes fossilis*) to survive in ammonia enriched toxic waste	Vindhya Mohindra	NASF	August, 2018 - July, 2021
15.	Indian Major Carp Milt Cryobank for Improving Genetic Exchange Between Farms and Commercial Level Quality Seed Production	S.K. Majhi (PI), Santosh Kumar, Aditya Kumar, A.K. Singh and R.S. Sah	NFDB	December, 2018 - November, 2020

Post-Doctoral Schemes

S. No	Project Title	Personnel	Scheme	Period
1.	Assessment of genetic introgression and variation in hatchery bred Indian major carps	Rupesh Kumar (UGC-Rajeev Gandhi Fellow), Rajeev K. Singh (Supervisor)	UGC	December, 2015 - December, 2020
2.	Assessment of biological response of *Tor putitora* (golden mahseer) to hydropower infrastructure and operation in Alaknanda and Bhagirathi river basins	Saurabh Dewan (SERB-National Post Doctoral Fellow), Vindhya Mohindra (Supervisor)	SERB - DST	June, 2017 - May, 2019
3.	Identification and characterization of novel viral etiology from undiagnosed disease outbreaks of fishes using meta-genomic and meta-transcriptomic approaches	Gaurava K. Rai (SERB-National Post Doctoral Fellow), Gaurav Rathore (Supervisor)	SERB - DST	June, 2017 - June, 2019
4.	Molecular characterization of antimicrobial resistant bacteria from ornamental fish	Preena P. G., SERB-National Post Doctoral Fellow, T. Raja Swaminathan (Supervisor)	SERB - DST	April, 2018 – April, 2020
5.	Anti-viral cytotoxic T-cell response in goldfish, *Carassius auratus* to cyprinid herpes virus 2 (CyHV-2) infection and comparative immune gene expression with rohu, *Labeo rohita*	Sweta Das (SERB-National Post Doctoral Fellow), T. Raja Swaminathan (Supervisor)	SERB - DST	July, 2016 - July, 2018

PUBLICATIONS

Research papers

International

1. Baisvar, V.S., M. Singh and R. Kumar, 2019. Population structuring of *Channa striata* from Indian waters using control region of mtDNA. *Mitochondrial DNA Part A: DNA Mapping, Sequencing and Analysis,* 30(3): 414-423.
2. Baisvar, V.S., R. Kumar, M. Singh, A.K. Singh, U.K. Chauhan, A.K. Mishra and B. Kushwaha, 2018. Genetic diversity analyses for population structuring in *Channa striata* using mitochondrial and microsatellite DNA regions with implication to their conservation in Indian waters. *Meta Gene*, 16: 28-38.
3. Bhaskar, R. and V. Mohindra, 2018. Variability in DNA COI sequences reveals new haplotypes in freshwater turtles from northern region of India. *Mitochondrial DNA Part B*: *Resources* 3(1): 317-323.
4. Biswal, J.R., R.K. Singh, K.K. Lal, V. Mohindra, R. Kumar, R.G. Kumar, V.S. Basheer and J.K. Jena, 2018. Molecular and morphological evidences resolve taxonomic ambiguity between *Systomus sarana sarana* (Hamilton, 1822) and *S. sarana subnasutus* (Valenciennes) and suggest elevating them into distinct species. *Mitochondrial DNA Part B: Resources*, 3(2): 838-844.
5. Chowdhury, L.M., A. Kathirvelpandian, P.R. Divya, V.S. Basheer, R. Shanis, C. Mohitha., P. Kumar and G. Krishna, 2019. Molecular identification and phylogenetic assessment of species under genus *Parapenaeopsis* Alcock, 1901, from Indian waters. *Mitochondrial DNA Part A: DNA Mapping, Sequencing, and Analysis*, 30(2): 191-200.
6. Divya, B.K., V. Mohindra, R.K. Singh, P. Yadav, P. Masih and J. K. Jena, 2019. Muscle transcriptome resource for growth, lipid metabolism and immune system in Hilsa shad, *Tenualosa ilisha. Genes and Genomics,* 41(1): 1-15.
7. Divya, P.R., N. Vineesh, A. Kathirvelpandian, V.S. Basheer and A. Gopalakrishnan, 2018. Population structure of Spanish mackerel *Scomberomorus commerson* (Lacepede, 1800) in the Northern Indian Ocean determined using microsatellite markers. *Aquatic Living Resources,* 31(22): 1-10.
8. Dutta, N., R.K. Singh, V. Mohindra, A. Pathak, R. Kumar, P. Sah, S. Mandal, G. Kaur and K.K. Lal, 2019. Microsatellite marker set for genetic diversity assessment of primitive *Chitala chitala* (Hamilton, 1822) derived through SMRT sequencing technology. *Molecular Biology Reports*, 46: 41-49.
9. Dutta, V., U. Sharma, K. Iqbal, Adeeba, R. Kumar and A.K. Pathak, 2018. Impact of river channelization and river front development on fluvial habitat: evidence from Gomti River, a tributary of Ganges, India. *Enviornmental Sustainability*, 1(2): 167-184.
10. Joshi, K.D., S.C.S. Das, R.K. Pathak, A. Khan, U.K. Sarkar and K. Roy, 2018. Pattern of reproductive biology of the endangered golden mahseer *Tor putitora* (Hamilton 1822) with special reference to regional climate change implications on breeding phenology from lesser Himalayan region, India. *Journal of Applied Animal Research*, 46(1): 1289-1295.
11. Kumar, A., P.K. Pradhan, N.K. Chadha, V. Mohindra, V.K. Tiwari, N. Sood and E. Gisbert, 2019. Ontogeny of the digestive tract in stinging catfish, *Heteropneustes fossilis* (Bloch) larvae. *Fish physiology and biochemistry,* 45(2): 667-679.
12. Kumar, R., C. Ravi, S. Das, D. Arathi, V.S. Basheer and T.R. Swaminathan, 2019. Establishment and characterization of a caudal finderived cell line, AOF, from the Oscar, *Astronotus ocellatus. Fish Physiology and Biochemistry,* 45(1): 123-131.
13. Kumari, R., S. Kole, P. Soman, G. Rathore, G. Tripathi, M. Makesh, K.V. Rajendran and M.K. Bedekar, 2018. Bicistronic DNA vaccine against

Edwardsiella tarda infection in *Labeo rohita*: Construction and comparative evaluation of its protective efficacy against monocistronic DNA vaccine. *Aquaculture,* 485: 201-209.

14. Lalramliana, L.S. and M. Singh, 2018. Integrative taxonomy reveals a new species of snakehead fish, *Channa stiktos* (Teleostei: Channidae), from Mizoram, North Eastern India. *Vertebrate Zoology*, 68(2): 165-175.
15. Majhi, S.K., 2018. Germ Cell Transplantation in Teleost Fishes: A viable approach for germline conservation. *International Journal of Genetic Science,* 5(2): 1-6.
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10. अखिलेश कुमार मिश्र, महेंद्र सिंह, बासदेव कुशवाहा एवं रविन्द्र कुमार, 2018. डी.एन.ए. सिक्वेंसिंग (अनुक्रमण) एवं जैविक अनुसंधान में इसकी उपयोगिता, *In:* मत्स्यलोक (सप्तम अंक), रा.म.आ.स.ब्यूरो, लखनऊ. pp 35-39.
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16. अचल सिंह, विन्ध्या मोहिन्द्रा, अमित सिंह बिष्ट, अभिषेक राना एवं कुलदीप कुमार लाल, 2018. ब्यूरो कर्मचारी वर्ग का प्रशिक्षण समय श्रेणी द्वारा अवलोकन, *In:* मत्स्यलोक (सप्तम अंक), रा.म.आ.स.ब्यूरो, लखनऊ. pp 65-67.

Training Manuals

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7. सिंह, एस.के., अखिलेश कुमार यादव, राजेश दयाल, अजय कुमार सिंह एवं के.के. लाल, 2018। जलकृषि उत्पादन पद्वति में आहार का महत्व एवं उनकी बाजार में उपलब्धता। भाकृअनुप–राष्ट्रीय मत्स्य आनुवंशिक संसाधन ब्यूरो, लखनऊ, 01 अंक, pp. 51।
8. सिंह, एस.के., अखिलेश कुमार यादव, संजय कुमार सिंह एवं के.के. लाल, 2018–19। पुनर्चक्रीय जलकृषि पद्धति (री–सर्कुलेशन एक्वाकल्चर सिस्टम)। भाकृअनुप–राष्ट्रीय मत्स्य आनुवंशिक संसाधन ब्यूरो, लखनऊ, 04 अंक, pp. 43।

Technical document

1. Kuldeep K. Lal, Roger W. Doyle, Mohindra Vindhya, Rajeev K. Singh, J.K. Jena and Cherdsak Virapat, Context setting paper. *In:* Regional Expert Consultation, "Genetically Responsible Aquaculture" Sustainability of Genetically Fit Broodstock and Seed of Certified origin in Asian Aquaculture, organised by ICAR-NACA at ICAR-NBFGR, Lucknow, India during February 26-27, 2019.

राजभाषा प्रकाशन

1. सिंह एस. के., 2018। लवणग्रस्त मिट्टी वाले तालाबों में जलकृषिः *कहार*–जन विज्ञान की बहुभाषाई पत्रिका, अंक 5(1), जनवरी–मार्च, 2018ः pp. 6।
2. अखिलेश कुमार यादव, प्रमोद कुमार वार्ष्णेय एवं रूपेश कुमार मिश्रा, 2018। मलजल पोषित मत्स्य पालन। *जिज्ञासा*, अंक 32, वर्ष 2018, भारतीय प्रौद्योगिकी संस्थान दिल्लीः pp. 24–26।

Participation in Seminar/Symposia/Workshop/ Training/Meetings

Abroad

- Dr. K.K. Lal, Director attended an invitation on behalf of search committee, to appear for presentation and interview (for the post of Director General NACA) during the 30th Governing Council meeting of NACA on March 27, 2019 held at Guangzhou in People's Republic of China.
- Dr. Gaurav Rathore, Head, Fish Health Management and Exotics division attended the FAO-NACA Regional Consultation and related study on AMR risk to aquaculture in Asia, and Preliminary consultation on monitoring of AMR in bacterial pathogens in aquaculture and presented the Country assessment report of India on AMR in aquaculture during September 4-7, 2018, at Bangkok, Thailand.
- Dr. Neeraj Sood and Dr. P.K. Pradhan, Principal Scientists attended review meeting at University of Aberdeen, United Kingdom to discuss the progress of project entitled 'Poverty alleviation through prevention and future control of the two major socioeconomically important diseases in Asian aquaculture' funded by Department of Biotechnology, Govt. of India and Biotechnology and Biological Scientific Research Council, United Kingdom during May 12-17, 2018.
- Dr. Neeraj Sood, Principal Scientist attended SAARC Regional Expert Consultation on Transboundary Fish Diseases and their control measures in South Asia at Paro, Bhutan, jointly organised by Agriculture Centre (SAC), Dhaka, Bangladesh and National Research and Development Centre for Aquaculture, Gelephu, Department of Livestock, Ministry of Agriculture and Forests (MoAF), Royal Government of Bhutan during November 8-9, 2018.
- Dr. Neeraj Sood and Dr. P.K. Pradhan, Principal Scientists attended Regional Expert Consultation on 'Genetically Responsible Aquaculture: Sustainability of Genetically Fit Broodstock and Seed of Certified Origin in Asian Aquaculture' in collaboration with Network of Aquaculture Centres in Asia-Pacific, Bangkok during February 26-27, 2019.

In India

Dr. K.K. Lal, Director participated in the following activities:

- Meeting of Advisory Board on GR Management, at ICAR-NBPGR, New Delhi on April 26, 2018.
- Meetings on Agrobiodiversity and Repositories, as expert member at Chennai May 4-5, 2018.
- Meeting with regional representative, Bioversity International and participated in review meeting at DBT at New Delhi during July 3-4, 2018.
- ICAR Foundation Day, Award Ceremony and Directors Conference held during July 16-17, 2018 at NASC Complex, New Delhi.
- Partners Meet on August 2, 2018 for the project Towards Responsible Agriculture for Preserving Agrobiodiversity Landscape at Mumbai.
- Meeting chaired by Mrs. Krishna Raj, Hon'ble MOS, MoAFW at Krishi Bhavan, New Delhi on August 8, 2018.
- Training program at Faculty of Marine Sciences, Annnamalai University, Chennai on August 29, 2018.
- Member of Selection Committee for the engagement of Guest Faculty-Assistant Professor for College of Fisheries, Kishanganj on September 26-27, 2018 at BASU, Patna.
- 50th meeting of Expert Committee on Access & Benefit Sharing on September 10-11, 2018 at NBA, Chennai.
- Personal presentation of suppliers for evaluation by the committee on September 12, 2018 at Coastal Aquaculture Authority, Chennai.
- XXIV Meeting of the ICAR Regional Committee No. IV held at ICAR-IINRG, Ranchi on September 14-15, 2018.

- Review meeting of NBFGR's collaborative research programme for NE region at Haflong, Assam during October 9-11, 2018.
- Delivered lecture in training programme for tribal fish farmers of Baksha district of Assam at Gauhati University, conducted by NBFGR and under TSP scheme during October 9-11, 2018.
- Meeting on Indian Major Carp Milt Cryobank for Improving Genetic Exchange between farms and commercial level Quality Seed production on October 29, 2018 at NFDB, Hyderabad.
- Meeting at Bioversity International on October 30, 2018 at Hyderabad.
- Meeting of Research Advisory and Monitoring Committee (RAMC) of Zoological Survey of India at Kolkata on November 20, 2018.
- Participated in World Fisheries Day celebration, organised by NFDB, Hyderabad on November 22, 2018 at Gyan Bhawan, Patna.
- Attended the consultation at NIAP on November 26, 2018 at NASC, New Delhi.
- Consultation on Invasive Alien Fish Species: Need for a Risk Benefit Assessment and Management framework for healthy freshwater ecosystems" held on December 19, 2018 at WWF-India, New Delhi.
- Directors Conference held during January 31, 2019 to February 2, 2019 at NASC Complex, New Delhi.
- Meeting for setting up of Fish Farmers Interaction Centre and Referral Centre of Aquatic Animal Disease Diagnostics and Informatics on January 22, 2019 at NFDB, Hyderabad.
- 14th Agricultural Science Congress organized by National Academy of Agricultural Sciences and ICAR-Indian Agricultural Research Institute held at NASC Complex, New Delhi during February 20-23, 2019.
- Coordinated and participated in the Indian Council of Agricultural Research (ICAR), New Delhi, India and Network of Aquaculture Centre in Asia Pacific (NACA), Bangkok, Thailand organised "ICAR-NACA Regional Expert Consultation" on Genitically Responsible Aquaculture: Sustainability of Genetically Fit Broodstock and Seed of Certified Origin in Asian Aquaculture" on February 26-27, 2019 at ICAR-NBFGR, Lucknow.

Dr. Ravindra Kumar, Principal Scientist and Head, MBBD participated in following activities:

- 1st National Genetics Congress on Genetics for Sustainable Food, Health and Nutritional Security, Organized by Indian Society of Genetics and Plant Breeding at ICAR-Indian Agricultural Research Institute, New Delhi during December 14-16, 2018.
- Attended Progress Review Meeting of projects related to Fisheries and Animal Science under Network Project on "Agricultural Bioinformatics and Computational Biology" under CABin Scheme held at ICAR-Central Inland Fisheries Research Institute, Barrackpore, from January 10-11, 2019.

Dr. Vindhya Mohindra, Head, FCD participated in following activities:

- 1st National Genetics Congress on Genetics for Sustainable Food, Health and Nutrition Security organized by ISGPB on dated December 14, 2018 at ICAR-Indian Agricultural Research Institute, New Delhi, India.
- XIV Agricultural Science Congress at Mela Ground, NASC Complex, Pusa, New Delhi on February 20-21, 2019.
- BRAQCON 2019 at ICAR-CIBA, Chennai and presented the invited lecture on January 24, 2019.
- Convergence of HRD/Skill Development Programmes and Activities of Fisheries Institutions of the ICAR and DADF meeting on May 2, 2018 at NFDB, Hyderabad.
- Delivered a lecture on "Next generation Sequencing and Applications" at School of Biotechnology, Gauhati University on March 26, 2019.
- Acted as Resource person for CAFT training at CIFE and delivered lecture on "Next Generation Sequencing technologies and applications in Fishes" on December 5, 2018.
- Chaired the Session on Population and Public Health Genomics/ Integrated Medicine/Clinical Genomic and Molecular Medicine at Kalam Center, KGMU, Lucknow on November 20, 2018.

Dr. Gaurav Rathore, Head, FHMED participated in following activities:

- Presentation on "Network program on AMR in Fisheries and aquaculture" during International Conference on Intensifying Food Systems and

Health: Emphasis on Antimicrobial use in Agricultural Systems on April 5, 2018, at Jaipur, Rajasthan, India.

- Delivered a talk on "Methods for antimicrobial susceptibility testing-Advantages: Disadvantages" during FAO-ICAR training on WHONET for data management of Antimicrobial Resistance (AMR) on August 17, 2018 at ICAR-NBFGR, Lucknow.
- Delivered a talk on "Common Shrimp Diseases and their Symptoms" to State fisheries Officers of Haryana in Training Programme on 'Fish Health Management' October 8, 2018 at ICAR-NBFGR.
- Delivered a talk on "Ante-mortem examination of fish" to State fisheries Officers of Haryana in Training Programme on 'Fish Health Management' October 9, 2018 at ICAR-NBFGR.
- Delivered a talk on "Bio-security in Aquaculture and Treatment of fish diseases" to State Fisheries Officers of Haryana in Training Programme on 'Fish Health Management' October 12, 2018 at ICAR-NBFGR.
- Delivered a talk on "Methods for antimicrobial susceptibility testing-Advantages: Disadvantages" during "FAO-USAID-ICAR training on AST and data management using WHONET" on July 23, 2018 at IVRI, Bareilly.
- Presentation on "Awareness on Biodegradable & Non-Biodegradable Wastes" during Swatchta Pakhwara at ICAR-NBFGR on December 29, 2018.
- National assessors training on FAO Assessment Tool for Laboratories and Antimicrobial resistance Surveillance Systems (FAO-ATLASS) at ICAR-CIFT, Kochi during January 21-25, 2019.
- Regional Expert Consultation "Genetically Responsible Aquaculture" Sustainability of Genetically Fit Broodstock and Seed of Certified origin in Asian Aquaculture at ICAR-NBFGR, Lucknow during February 26-27, 2019.
- Meeting of Visiting Standing Committee of Parliament on July 10, 2018 at Clarks Awadh, Lucknow.
- Bioversity International Project meeting at ICAR-NAARM on August 2, 2018 at ICAR-NAARM, Hyderabad.
- First Annual Meeting of INFAAR held at Panjim, Goa during September 21-22, 2018.
- FAO-USAID-ICAR - 2nd Advisory Board Meeting of Indian Network for Fisheries and Animal Antimicrobial Resistance (INFAAR) during October 26-27, 2018 at Bhubaneswar, Odisha.
- 23rd Exotic Committee meeting at Krishi Bhavan on December 11, 2018 at New Delhi.
- NFDB meeting with Vietnam Delegation at Hotel Sheraton, Hyderabad regarding areas of collaboration in fisheries on December 20, 2018 at Hyderabad.
- NAAS workshop on "Need for National policy on fish disease diagnosis and quarantine" on January 29, 2019 at NASC, New Delhi.

Dr. A.K. Pandey, Principal Scientist participated in following activities:

- International Conference on Agriculture, Allied and Applied Sciences during April 28-29, 2018 at Jawaharlal Nehru University Convention Centre, New Delhi.
- National Conference on International Day for Biological Diversity on May 22, 2018 at Uttar Pradesh State Biodiversity Board (UPSBB), Lucknow.
- National Seminar on Research in Environment and Biosciences: Current Scenario and Future Perspective during June 22-23, 2018 at Department of Zoology, D.A.V. Post Graduate College, Dehradun.
- 3rd National Symposium on Fish Parasites during September 8-9, 2018 at Department of Zoology, University of Lucknow, Lucknow.
- International Symposium on Recent Trends in Agriculture, Biodiversity and Social Sustainability during September 30 - October 1, 2018 at Central Regional Centre of Botanical Survey of India, Allahabad.
- National Conference on Current Issues of Environmental Health, Climate Change and its Management & 38th Annual Session of Academy of Environmental Biology during October 3-4, 2018 at Department of Environmental Sciences, Dr. R.M.L. Avadh University, Faizabad.
- Conclave on Multicultural Education in Indian Education System on October 6, 2018 at Confederation of Education Excellence (CEE) & United Service Institution USI), Rao Tularam Marg, New Delhi.

- Agri-World-2018 during October 24-27, 2018 at Indian Council of Food and Agriculture, New Delhi.
- International Conference on Global Research Initiatives for Sustainable Agriculture and Allied Sciences during October 28-30, 2018 at Rajasthan Agricultural Research Institute, Jaipur.
- International Conference on Advances in Biological and Environmental Research for Human Welfare during November 16-18, 2018 at Department of Zoology, Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur.
- National Symposium on Sustainable Development in India: Issues and Challenges during November 27-28, 2018 at Department of Zoology, S.S. Khanna Girls Degree College, Allahabad.
- International Seminar on Recent Trends in Experimental Approaches in Science, Technology and Nature during December 23-24, 2018 at Foot Design and Development Institute, Jodhpur.
- National Seminar on Climate-Smart Aquaculture and Fisheries during January 15-16, 2019 at College of Fisheries, Central Agricultural University (I), Agartala.
- World Conference on Brackishwatwer Aquaculture during January 23-25, 2019 at ICAR-Central Institute of Brackishwater Aquaculture, Chennai.

Dr. K.D. Joshi, Principal Scientist participated in following activities:

- National Seminar on "Fisheries Entrepreneurship" jointly organised in collaboration with Centre for Agriculture and Rural Development (CARD), at ICAR-NBFGR, Lucknow on April 11, 2018.
- Workshop on "Ganga and its Bio-diversity: Developing a Road map for Habitat and Species Conservation" organised by National Mission for Clean Ganga (NMCG), MOWR, RD & GR WWF-India, New Delhi on May 22, 2018.
- XXV Meeting of ICAR Regional Committee No. 1 at SKUA&T, Srinagar, Jammu & Kashmir from June 11-12, 2018.
- Attended preparatory meeting for the Study Visit of Standing Committee of Parliament, at Bank of Baroda office, 23 Vibhuti Khand, Gomtinagar, Lucknow on July 3, 2018.
- Nominated as Nodal Officer for arranging Study Visit of Standing Committee of Parliament held at Lucknow from July 9-10, 2018.
- Meeting of Standing Committee of Parliament on Agriculture held at Hotel Clarks Awadh, Lucknow on July 10, 2018.
- Workshop on Environmental flows for a healthy Ramganga and book releasing ceremony organised by WWF-India at Irrigation Bhawan, Sadar, Lucknow on September 10, 2018.
- Steering Committee Meeting at National Level to oversee and monitor the Tilapia seed and grow out production, at Krishi Bhawan, New Delhi on September 14, 2018.
- Viva-voce Exam of a Ph.D. student at Sam Higginbottom University of Agriculture, Technology & Science, Allahabad on November 1, 2018 as External Examiner.
- Institute Management Committee of ICAR-DCFR, Bhimtal as nominated Member of ICAR on November 27, 2018.
- Delivered lecture on "Importance of alien fishes in RAS: Precautionary measures" in 5 day RAS training conducted by ICAR-NBFGR, Lucknow for state fisheries officials of different states under NFDB on November 30, 2018.
- Workshop on Economic and Social Transformation through GPDP in Indo-Gangetic Plains States organised by Department of Panchayati Raj, MORD, New Delhi held at Hotel Hilton Garden Inn, Lucknow on December 7, 2018.
- Delivered a lecture on "Fishery Based Eco-Tourism (FBET) & Sport Fishery: Potential for livelihood and fish conservation" at ICAR-NBFGR on the occasion of National Productivity Day Celebration on February 12, 2019.
- Delivered lecture on "Circulatory economy: Role of alien fishes in climate change scenario" in the Divisional function (FHME Division) of ICAR-NBFGR on February 14, 2019.
- Meeting organised by WWF-India and State Irrigation Department Uttar Pradesh on Ramganga River Basin Management Plan at Hotel Best Western Levana, Lucknow on March 12, 2019.

Dr. Basdeo Kushwaha, Principal Scientist participated in following activities:

- Seminar on "Powering change: Women in

innovation and creativity" during World Intellectual Property Day celebration at Council of Science and Technology, U.P. Lucknow on April 26, 2018.

- 1st National Genetics Congress on Genetics for Sustainable Food, Health and Nutritional Security, Organized by Indian Society of Genetics and Plant Breeding at ICAR-Indian Agricultural Research Institute, New Delhi during December 14-16, 2018.
- As expert member, to represent NBFGR in expert consultation programme on 'Planning for shaping Departments and Laboratories of the college of Fisheries, Kishanganj during February 7-9, 2019.
- 14th Agricultural Science Congress organized by National Academy of Agricultural Sciences and ICAR-Indian Agricultural Research Institute held at NASC Complex, New Delhi during February 20-23, 2019.

Dr. Neeraj Sood, Principal Scientist participated in following activities:

- Fisheries Entrepreneurship Seminar-2018 organised by Centre for Advanced Research & Development; Uttar Pradesh Fisheries Development Corporation; ICAR-National Bureau of Fish Genetic Resources, Lucknow and Aquatic Biodiversity Conservation Society, Lucknow on April 10, 2018 at ICAR-NBFGR, Lucknow.
- Meeting convened by Office of Kanpur Zoo Horticulture Management and Development Society, Kanpur on June 26, 2018.
- 'Capacity building on Aquaculture' organised by Department of Zoology and Aquaculture, CCS Haryana Agricultural University, Hisar in collaboration with Fisheries Department, Government of Haryana on July 16, 2018.
- Expert Consultation on 'Invasive Alien Fish Species: Need for a Risk Benefit Assessment and Management Framework for Healthy Freshwater Ecosystems' organised by ICAR-NBFGR, Lucknow in collaboration with World Wide Fund for Nature- India on December 19, 2018.
- Experts Meet on Uniform Policy on Fish Disease Diagnosis and Quarantine organized by National Academy of Agricultural Sciences on January 29, 2019.

Dr. V.S. Basheer, Principal Scientist participated in following activities:

- Delivered a lecture on "Cryo-preservation - new techniques for biodiversity conservation in Winter school on Recent Advances in Fishery Biology techniques for biodiversity evaluation and conservation" held at ICAR-CMFRI, Kochi on December 7, 2018.
- Delivered a lecture on "Exotic fishes: Prospectus and problems" in an International training programme conducted by CMFRI-African Asian Rural Development Organisation (AARDO) at ICAR-CMFRI on January 17, 2019.
- Delivered a Keynote address on ornamental fishes in the inaugural ceremony of a "Certificate course in Ornamental Fish Breeding and Culture" organised at St. Aloysius College, Edathua, Alappuzha by Department of Zoology on January 29, 2019 as Chief Guest and Resource person.
- Attended meeting in Kerala State Biodiversity Board on Biodiversity related issues in Kerala on January 5, 2019.
- Attended meeting in Kerala State Biodiversity Board as a subject expert member for developing and planning Biodiversity guidelines in Kerala on March 1, 2019.

Dr. P.K. Pradhan, Principal Scientist participated in following activities:

- Expert Consultation on 'Invasive Alien Fish Species: Need for a Risk Benefit Assessment and Management Framework for Healthy Freshwater Ecosystems' organised by ICAR-NBFGR, Lucknow in collaboration with World Wide Fund for Nature- India December 19, 2018.
- World Brackishwater Aquaculture Conference organized by Coastal Aquaculture and Fisheries Society and ICAR-CIBA, Chennai during January 22-25, 2019.
- Experts Meet on Uniform Policy on Fish Disease Diagnosis and Quarantine organized by National Academy of Agricultural Sciences on January 29, 2019.
- World Fisheries Day celebration on November 22, 2018 at International Convention Centre, Gyan Bhawan, Patna, Bihar organized by NFDB, Hyderabad.
- Aqua-Poultry-Dairy Expo 2018 at ICAR -NBFGR organized by Department of Fisheries,

Government of Uttar Pradesh from December 11-13, 2018.

Dr. L.K. Tyagi, Principal Scientist attended the following activities:

- Coordinated Review workshop of Institute's collaborative NE research programme held at Haflong College, Haflong, Assam on October 9, 2018.
- Meeting of the Screening Committee of Dept. of Biotechnology, New Delhi to screen the proposals received under Biotechnology Based Programme for Societal Development for implementation in Aspirational Districts held on August 29, 2018 at DBT, New Delhi.
- Meeting of the Expert Committee of Dept. of Biotechnology, New Delhi for selection of short listed proposals for implementation of projects in Aspirational Districts held on September 20, 2018 at DBT, New Delhi.
- Meeting of the Sub-Committee of Dept. of Biotechnology, New Delhi to review new proposals on "Biotechnology Based Programme for SC/ST Population and Rural Development" held on June 6, 2018 at DBT, New Delhi.
- Review Meeting of the Schedule Tribe Sub-plan Committee, NASI held on August 20, 2018 at CSIR-CIMAP, Lucknow.
- Partner's Meet of the Bioversity funded project on Quantifying Agro-biodiversity and Ecosystem Services in Godavari River basin Landscape held on August 2, 2018 at ICAR-NAARM, Hyderabad.
- Meeting of the Steering Committee on Biotechnology Based Programme for Societal Development, Department of Biotechnology, Govt. of India held during February 7-8, 2019 at DBT, New Delhi.
- Delivered technical lecture to farmers on 'Fisheries enterprise and modern fish culture' at Indira Gandhi Cooperative Management Institute, Rajajipuram, Lucknow on September 7, 2018.

Dr. S. K. Singh, Principal Scientist attended the following activities:

- Three-days ToT programme organized by ASCI, New Delhi/ATARI, Kanpur at BUAT, Banda, U.P. from October 15-17, 2018.
- Invited as key speaker on Aquaculture led Integrated Farming for small scale rural entrepreneurs in Fisheries Entrepreneurship Seminar-2018 at ICAR-NBFGR, Lucknow organized by Center for Agriculture and Rural Development (CARD), New Delhi on April 10, 2018.
- Invited as key speaker on Integrated Fish Farming Models in Aqua-Poultry-Diary exhibition cum seminar organized at ICAR-NBFGR, Lucknow during December 11-13, 2018.
- Delivered lecture in the National Productivity Week at ARTU, Chinhat for creating awareness about circular economy, productivity & sustainability and minimization of waste, waste utilization, safe disposal, energy saving etc. on February 16, 2019.

Dr. Satish Kumar Srivastava, Principal Scientist participated in following activities:

- Training on "Small Molecule Analysis by NMR Spectroscopy and Mass Spectrometry" at CSIR-CDRI, Lucknow during December 12-14, 2018.

Dr. Rajeev K. Singh, Principal Scientist participated in following activities:

- Delivered Invited Lecture on "Marker Discovery and Genetic Characterization in Indian Fishes" in "International Conference on Advances in Biological and Environmental Research for Human Welfare" organized by Department of Zoology, Deen Dayal Upadhyay University, Gorakhpur, U.P. during November 16-18, 2018.
- Ist National Genetics Congress on Genetics for Sustainable Food, Health and Nutrition Security at New Delhi during December 14-16, 2018.
- National Conference on Current Issues of Environmental Health, Climate Change and its Management held at Dr. Ram Manohar Lohia Avadh University, Faizabad U.P. during October 3-4, 2018.
- 49th Meeting of Expert Committee on Access and Benefit Sharing held at National Biodiversity Authority, Chennai during July 10-11, 2018.

Dr. T. Raja Swaminathan, Principal Scientist participated in following activities:

- Visited and examined the sites proposed for the quarantine facility by M/s Anandha Enterprises Pvt Ltd, Bhimavaram for import of Asian Seabass from Australia at Bhimavaram on April 18, 2018.
- Delivered an invited lecture in the Genomics AFM-18 - National symposium on the Application

of Genomics and Proteomics in Aquaculture, Fisheries and Marine Biology at Satyabama University, Chennai on June 20, 2018.

- Visited and examined the sites proposed for broodstock multiplication centre for SPF - *P. vannamei* by M/S CP Aqua India Pvt Ltd at Kuppili village, Vishakhapatnam on September 6, 2018.
- Delivered a lecture on Fish Cell Culture in the Short Term Training Course on " Cell Line: Development, Maintenance and Applications" at ICAR NBFGR, Lucknow during September 27-28, 2018.
- Visited and examined broodstock multiplication Centre of BMC Blue Aqua for SPF *P. vannamei* at Nellore on November 14, 2018.
- NIAS-DST training programme on Science, Technology and innovation policy at National Institute of Advanced Studies, Bangalore during November 18-30, 2018.
- Consultation on Invasive Alien Fish species Need for a Risk Benefit Assessment Framework for Healthy Fresh Water Ecosystems held at WWF-India, New Delhi on December 19, 2018.
- World Brackishwater Aquaculture Conference (BRAQCON 2019) organized by ICAR- CIBA & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019.
- Fourth meeting of the Expert committee to develop technical designs for construction of Aquatic animal quarantine Unit (AAQU) at Coastal Aquaculture Authority (CAA), Chennai during February 8, 2019.
- Meeting of the committee for monitoring of aquaculture farms and hatchery in order to check the undesirable use of antibiotics and other pharmacologically active substances in the country at CAA, Chennai on February 15, 2019.
- Inspection of quarantine facility of M/S Anandha Enterprises Pvt Ltd, Bhimavaram for import of Asian Seabass from Australia at Bhimavaram on February 27, 2019.
- Disease investigation for important OIE listed diseases in the imported Koi carp stocks at Koi Fish in Kodugurki, Bengaluru on March 5, 2019.
- Visited and examined as a member of Technical and Inspection Committee of Government of Andhra Pradesh for SPF Shrimp Broodstock Multiplication Centres (BMC) for SPF *P. vannamei* and SPF *P. monodon* at Bangarammapeta, Vishakhapatanam on March 12, 2019.
- Fifth meeting of the Expert committee to develop technical designs for construction of Aquatic Animal Quarantine Unit (AAQU) at Coastal Aquaculture Authority (CAA), Chennai on March 22, 2019.

Dr. T. T. Ajith Kumar, Principal Scientist participated in following activities:

- Meeting and exhibition during "International Biodiversity Day" held at Hyderabad organized by the National Biodiversity Authority (NBA) on May 22, 2018.
- Workshop on Marine Biotechnology held at the National Institute of Ocean Technology (NIOT), Chennai on June 26, 2018.
- Meeting and presentation on Development of Ornamental Fish Park at Maharashtra chaired by the Honourable Minister of State for Home, Finance and Planning, Govt. of Maharashtra organized by Mangrove Cell and Mangrove Foundation on June 27, 2018.
- International workshop on Identification of Gobioid fishes held at Vivekanada College, Kanyakumari during August 10-11, 2018.
- Committee meeting for evaluation of overseas SPF broodstock suppliers at Coastal Aquaculture Authority (CAA), Chennai during September 10-12, 2018.
- Steering Committee meeting on AICOPTAX conducted by the Ministry of Environment, Forest and Climate Change held at Noida, New Delhi during October 3-4, 2018.
- Delivered a talk on "Ornamental Aquaculture: Measure towards Conservation of Biodiversity" at the Vellore Institute of Technology (VIT) on October 15, 2018.
- Presented a paper in the International conference on Status and Prospectus of Coral Reefs at Bangaram Island, Lakshadweep during October 22-24, 2018.
- Meeting on Enhancing compliance of non-commercial research under "Biodiversity Act 2002" held at the TDU-FRLHT, Bangalore organized by the National Biodiversity Authority (NBA) on December 20, 2018.
- National workshop on Recent trends in Taxonomy held at Jodhpur organized by Zoological Survey of

India (ZSI) during January 10-11, 2019.

- International conference BRAQCON organised by ICAR-CIBA at Chennai during January 22-25, 2019.
- Delivered a lecture on 'Innovations in Marine Ornamental Aquaculture: Opportunities and Challenges in India' in UGC HRD refresher course on Life Science held at Madras University, Chennai on February 11, 2019.

Dr. Sullip Kumar Majhi, Principal Scientist participated in following activities:

- Delivered a talk as an invited speaker on "Fish farming for sustainable development of rural folk" during "Kalahandi Dialogue-The Global Conclave", held at Bhawanipatna, Kalahandi, Odisha during September 28-30, 2018.
- Delivered an invited lecture on "Assisted reproductive technologies for conservation of fishes" during National seminar on "Climate Smart Aquaculture and Fisheries" held at College of Fisheries, Agartala, Tripura from January 15-16, 2019.
- Delivered an invited lecture on "Cryopreservation of fish milt" during workshop on "Tools and Techniques in Life Sciences" held at DDU Gorakhpur University, Gorakhpur (U.P.) during March 25-26, 2019.

Dr. Achal Singh, Principal Scientist participated in following activities:

- "Management Development Programme for HRD Nodal Officers of ICAR for Effective Implementation of Training Functions" at NAARM, Hyderabad during March 14-16, 2019.
- Delivered lecture in science exhibition at APS Academy, Raebareli Road supported by NAVIC-NGIO under DST, New Delhi. Judged the exhibits on different category of Science, Arts, Music, Literature, Social awareness, Waste uilisation, Financial system-GST, Environments and sports of students from class 1 to 12 of APS Academy on August 6, 2018.
- Delivered Lecture on "Benefit-Cost Ratio Analysis for Aquaculture in changing Scenario" in "National training programme on Recirculatory Aquaculture System (RAS) at ARTU, Chinhat, ICAR-NBFGR, Lucknow on January 23, 2019.
- Delivered lecture on "Mahatma Gandhi: Leadership" on birth anniversary celebration at ICAR-NBFGR on October 2, 2018.
- Delivered invited talk on "Partial least squares factors from fish-climate time series in explaining the variations in climate variables and fish production of India under climate change scenario" at The Academy of Environmental Biology and National Conference on Current Issues of Environmental Health, Climate Change and Its Management at Dr. RML Avadh University, Faizabad, U.P. during October 3-4, 2018.
- Delivered invited lecture as resource person in a training on "Certified Farm Advisor Course" sponsored by MANAGE at ICAR-CISH, Lucknow on October 17, 2018.
- Delivered invited lecture "Benefit-Cost Ratio-Analysis for Aquaculture in Changing Scenario" for ToT Programme on Recirculatory Aquaculture System (RAS) at ICAR-NBFGR on November 30, 2018.
- Participated and delivered a lecture on "मौसम व जलवायु का मत्स्य–कृषि पर प्रभाव" at State level Review Sangoshthi Gramin Krishi-Mausam Seva organised by IMD-Mausam Kendra Lucknow at Hotel Piccadeli, Lucknow on December 20, 2018.
- As member in interview board of ICAR-CISH, Lucknow, for selection of JRF on September 10, 2018.
- As member in interview board of ICAR-CISH, Lucknow, for selection of SRF on November 2, 2018.
- As judge in Jawaharlal Nehru National Science Mathematics and Environment Exhibition at Kendriya Vidyalay, Gomtinagar, Lucknow on December 17, 2018.

Dr. Ajey Kumar Pathak, Senior Scientist participated in following activities:

- National workshop on "Artificial Intelligence in Agriculture: Status and Challenges" organized by IASRI, New Delhi at NASC, New Delhi during July 30-31, 2018.
- "J-Gate@CeRA Regional Ambassador Training Program", jointly organized by Consortium for e-Resources in Agriculture (CeRA), ICAR-DKMA, New Delhi, Mohinder Singh Randhwa Library, Punjab Agricultural University, Ludhiana and Informatics Publishing Limited, Bengaluru at Panjab Agricultural University, Ludhiana on August 27, 2018.

- Workshop of Nodal Officers of ICAR Research Data Repository for Knowledge Management at New Delhi during December 04-05, 2018.
- Interactive meeting-cum-workshop of Scientists in IT/ Computer Application of all ICAR Research Institutes/ NRCs/ PDs/ ATARIs at NASC Complex, New Delhi on March 6, 2019.

Dr. Divya, P.R. Senior Scientist participated in following activities:

- Training programme on "Advanced Statistical Methods and Computational Software for Fisheries Research and Management" held at ICAR-CIFT, Kochi during July 17-26, 2018.
- International conference BRAQCON organized by ICAR-CIBA at Chennai during January 22-25, 2019.
- 1st National Genetics Congress on Genetics for Sustainable Food, Health and Nutrition Security organised by ICAR-IARI, New Delhi, India during December 14-16, 2018.
- Delivered a talk on 'Taxonomy of Fishes using molecular techniques' in the monthly seminar organized by Central Institute of Fisheries Nautical and Engineering Training (CIFNET), Kochi on September 14, 2018.

Dr. Poonam Jayant Singh, Scientist participated in following activities:

- Invited Guest Lecture on "How to start agri-venture", during Model Training Course on "Entrepreneurship Development through Market Driven Production and Processing of Horticultural Crops" at ICAR-CISH on September 11, 2018.
- Delivered lecture on "Agro Bio-Waste Utilisation: an Option for Livelihood" during National Productivity Week on "Circular Economy for Productivity and Sustainability" on February 12, 2019.
- Delivered lecture during a workshop on Agri-Startups on "Innovation Chain from Lab to Land: From Innovation to Industry through IP Protection, Product Development, Marketing and Exit" for National Bank for Agriculture and Rural Development at Bankers Institute of Rural Development, Lucknow on December 18, 2018.
- Utilization of Fish Bio-waste: Connecting Science with Art" lecture delivered at ICAR-NBFGR during Swachhata Pakhwara on September 22, 2018.
- Member of DST - Science Technology and Innovation, Reviewed work of Postdoc Policy fellows of 2016, 2017, 2018 at BBAU, Lucknow on March 6, 2018.
- As a member of Programme Implementation Committee at CIFT, ZTMC Kochi on March 27, 2019.
- 'International Conference on Design for Societal Development at National Institute of Design' at Gandhinagar Campus during February 14-15, 2019.
- Workshop on Manifesto for Social Design at NID, Gandhinagar on February 15, 2019.
- Training on "LC-MS based Proteomics" at CSIR-CCMB, Hyderabad, during October 3-13, 2018.
- Training on "Small Molecule Analysis by NMR Spectroscopy and Mass Spectrometry" at CSIR-CDRI, Lucknow during December 12-14, 2018.

Dr. A. Kathirvelpandian, Scientist participated in following activities:

- Training programme on "Advanced Statistical Methods and Computational Software for Fisheries Research and Management" held at the ICAR-CIFT, Kochi during July 17-26, 2018.
- International conference BRAQCON organised by ICAR-CIBA at Chennai during January 22-25, 2019.
- Delivered a lecture in the training programme on "Clownfish Aquaculture" held at the Coastal and Marine Biodiversity Centre, Mangrove foundation, Airoli, Mumbai conducted by ICAR-NBFGR on March 5, 2019.
- Delivered an invited lecture during awareness workshop entitled "Biodiversity and Bio-resources conservation" in D.K.M. College for Women, Vellore, Tamil Nadu on October 11, 2018.
- Delivered an invited lecture during National Awareness Conference on "Values of Biodiversity and its Conservation" organized by the Department of Advanced Zoology and Biotechnology, Dr. Ambedkar Government Arts College, Chennai on March 8, 2019.

Dr. Sangeeta Mandal, Scientist participated in following activities:

- XIVth Agricultural Science Congress, New Delhi during February 20-23, 2019.

Dr. Rejani Chandran, Scientist participated in following activities:

- Winter School on "Recent Advances in Fishery Biology Techniques for Biodiversity Evaluation and Conservation" at ICAR-CMFRI, Kochi during December 1-21, 2018.
- XIV Agricultural Science Congress at NASC Complex New Delhi during February 20-23, 2019.

Dr. Santosh Kumar, Scientist participated in following activities:

- Workshop on Genetic Improvement of *Clarias magur*: Present status and future prospects held at ICAR-CIFE, Kakinada on March 15, 2019.
- Hindi Sangoshthi on "भारत के दक्षिणी राज्यों में मात्स्यिकी के बढ़ते आयाम" held at ICAR-CIFE, Kakinada on March 15, 2019.
- Farmers Interactive meet on "Genetic Improvement of *Clarias magur*" held at ICAR-CIFE, Balbhadrapuram on March 16, 2019.

Dr. Aditya Kumar, Scientist participated in following activities:

- Consultation on Invasive Alien Fish Species: Need for a Risk-Benefit Assessment and Management Framework for Healthy Freshwater Ecosystems at WWF-India, Lodhi Road, New Delhi jointly organised by ICAR-NBFGR, Lucknow and WWF-India on December 19, 2018.

Dr. Murali S., Scientist participated in following activities:

- "4th India International Science Festival", exhibition organized by Ministry of Science and Technology, Ministry of Earth Sciences in association with Vijnana Bharati held at Indira Gandhi Pratishthan, Lucknow, during October 5-8, 2018.
- Start-up and Entrepreneurship Conclave "Unleashing Potentials in Agriculture for Young Agripreneurs" held at ICAR- National Academy of Agricultural Sciences, New Delhi during October 16-17, 2018.
- "Krishi Kumbh Mela" jointly organised by Department of Agriculture and Uttar Pradesh State Agriculture Produce Marketing Board held at ICAR- IISR, Lucknow during October 26-28, 2018.
- Progress Review Meeting of projects related to Fisheries and Animal Science under Network Project on "Agricultural Bioinformatics and Computational Biology" under CABin Scheme held at ICAR-CIFRI, Barrackpore during January 10-11, 2019.
- 14th Indian Agricultural Science Congress held at ICAR-NASC, New Delhi during February 20-23, 2019.

Dr. Charan Ravi, Scientist participated in following activities:

- XIV Agricultural Science Congress at NASC Complex New Delhi during February 20-23, 2019.

Mr. Trivesh S. Mayekar, Scientist participated in following activities:

- XIV Agricultural Science Congress at NASC Complex New Delhi during February 20-23, 2019.
- "Aqua-Poultry-Dairy-Expo 2018" held at ICAR-NBFGR and displayed ICAR-NBFGR exhibition stall during December 11-13, 2018.

Dr. Anutosh Paria, Scientist attended the following activities:

- Training programme on "Introduction to Analytical Veterinary Epidemiology", jointly organized by ILRI, ICAR-IVRI and ICAR-NIVEDI, Bengaluru during December 3-5, 2018.
- ICAR-NACA school on "Aquatic Animal Epidemiology and Disease Surveillance" held at ICAR-NBFGR, Lucknow during March 1-6, 2019.
- International conference BRAQCON organised by ICAR-CIBA at Chennai during January 22-25, 2019.

Shri Chandra Bhushan Kumar, Scientist participated in following activities:

- ICAR sponsored short course on "One Health with special reference to Fisheries and Aquaculture" at ICAR-CIFE, Mumbai during February 18-27, 2019.
- World Fisheries Day celebration, organised by NFDB, Hyderabad on November 22, 2018 at Gyan Bhawan, Patna.
- Delivered a talk on "Isolation and Identification of Bacteria from Fish" during the training programme on "Fish Health Management" for fisheries officials of Haryana, organized at ICAR-NBFGR, during October 8-12, 2018.
- Delivered an invited talk on "Laboratory waste management" for sensitizing the laboratory

working personnel for minimizing waste and its safe disposal, during National productivity week celebration organized at ICAR-NBFGR during February 12-18, 2019.

Ms. Teena Jayakumar T.K., Scientist participated in following activities:

- Training programme on "Advanced Statistical Methods and Computational Software for Fisheries Research and Management" held at ICAR-CIFT, Kochi during July 17-26, 2018.
- Delivered a lecture on Clown fish taxonomy in the training programme on Clownfish Aquaculture held at the Faculty of Marine Sciences, Annamalai University, Tamil Nadu on August 30, 2018.
- Delivered a lecture on Taxonomy of marine fishes in the Orientation training on establishing germplasm resource centre for marine ornamental invertebrates: Harmonizing biodiversity conservation and promoting livelihood to the islanders of the Lakshadweep held at CMLRE, Kochi on November 24, 2018.
- Delivered a lecture on Identification of Clown fishes in the training programme on Clownfish Aquaculture held at the Coastal and Marine Biodiversity Centre, Mangrove foundation, Airoli, Mumbai on March 5, 2019.

Ms. Chinmayee Muduli Scientist participated in following activities:

- FAO-ICAR training on WHONET organised at ICAR-NBFGR during August 17-18, 2018.

Shri Kantharajan, G., Scientist participated in following activities:

- Training programme on "Geospatial Technologies and Applications" at ISRO-National Remote Sensing Centre, Hyderabad during October 12, 2018 - February 1, 2019.

Technical Personnel

Dr. Rajesh Dayal, Chief Technical Officer delivered

- Lecture on "An account of newly discovered fishes from the Indian region during 2018" in 21st Indian Agricultural Scientists and Farmers' Congress on "Prospects of Rural prosperity and Income Security of Farmers on the occasion of Kumbh Mela- An important step towards Making New India" at Bioved Research Institute of Agriculture, Technology & Sciences, Prayagraj during February 16-17, 2019.

Dr. Ajay Kumar Singh, Assistant Chief Technical Officer participated in following activities:

- International conference BRAQCON organised by ICAR-CIBA at Chennai during January 22-25, 2019.
- "Nikon School Workshop for Wildlife Photography held at Dudhwa National Park" conducted by Nikon India Private Limited on December 16, 2018.

Shri Subhash Chandra, Senior Technical Officer participated in following activities:

- "J-Gate@CeRA Regional Ambassador Training Program", jointly organized by Consortium for e-Resources in Agriculture (CeRA), ICAR-DKMA, New Delhi, Mohinder Singh Randhwa Library, Punjab Agricultural University, Ludhiana and Informatics Publishing Limited, Bengaluru at Panjab Agricultural University, Ludhiana on August 27, 2018.
- Training programme on "Koha for Library staff of ICAR" organized by ICAR-NAARM, Hyderabad during February 21-26, 2019.

Shri S.V. Chaudhary, Senior Technical Officer participated in following activities:

- ICAR-Human Resource Development Training programme on "Professional and Personal Skill Development for Technical and Administrative Staff of ICAR" organized by ICAR-NBAGR, Karnal, Haryana during June 19-21, 2018.
- Training programme on "Koha for Library staff of ICAR" organized by ICAR – National Academy of Agricultural Research Management, Hyderabad during 21-26 February, 2019.

Dr. Akhilesh Kumar Mishra, Senior Technical Officer attended training programme on 'Fish milt cryopreservation for genetic upgradation of brooders' at ICAR-NBFGR Lucknow during March 27-30, 2019.

Shri Amit Singh Bisht, Senior Technical Officer participated in following activities:

- XIV Agricultural Science congress on the theme "Innovations for Agricultural Transformation" at New Delhi during February 20-23, 2019.
- 3rd International Symposium on Aquaculture and Fisheries Education (ISAFE 3) organized by Asian Fisheries Society at ICAR-CIFE, Mumbai during May 16 - 18, 2018.

Shri Sanjay Kumar Singh, Senior Technical Officer, attended the training on "Food and Nutritional Security of Farm Women through Horticulture based Interventions" at ICAR-CISH, Lucknow during November 13-20, 2018.

Dr. Vikash Sahu, Senior Technical Assistant attended the following activities:

- Training program on "WHONET" software for data management of AMR Project, jointly organized by FAO & ICAR at ICAR-NBFGR, Lucknow during August 17-18, 2018.
- Consultation on "Invasive Alien Fish Species: Need for a Risk-Benefit Assessment and Management Framework for Healthy Freshwater Ecosystems" jointly organized by ICAR-NBFGR, Lucknow and WWF-India at WWF-India, Lodhi Road, New Delhi on December 19, 2018.
- Delivered a lecture & demonstrated uses and applications of Microbial Identification System (MIS) Vitek-2 to the trainees & State Fisheries Official of Haryana under NSPAAD training program on October 10, 2018.
- Under Skill India Training Program delivered two lectures to the trainees on Aquatic weeds & insects and their control on March 2, 2019.
- Coordinated one day seminar and awareness program in FHME Division for "NPC and Safe disposal of Laboratory Waste" under "National Productivity Week" on February 14, 2018.

Shri Subhash Chandra, Senior Technical Officer, Shri S.V. Chaudhary, Senior Technical Officer, Shri Ravi Kumar, Senior Technical Officer, Shri Amit Singh Bisht, Senior Technical Officer and Shri Indrajeet Singh, Skilled Support Staff participated in the Onsite Training programme on "Koha Software for Library Automation" organized by CSIR-National Institute of Science Communication and Information Resources (CSIR-NISCAIR), New Delhi held at ICAR-NBFGR, Lucknow from October 29, 2018 to November 02, 2018.

Administrative Personnel

Shri Darvesh Kumar, Administrative Officer attended sensitization training-cum-workshop on 'Implementation of e-Office in ICAR Institutes' organized by ICAR-IASRI, New Delhi during January 23-24, 2019.

Shri Ravi Bhadra, Assistant Finance and Accounts Officer participated in a training programme on 'Administrative and Financial Rules Awareness' organized by ICAR-IIPR, Kanpur during September 26-28, 2018.

Shri Ravi Bhadra, Assistant Finance and Accounts Officer and Smt. Kaneez Fatima, Assistant participated in refresher course on 'Administration and Finance Management' organized by ICAR-NAARM, Hyderabad held at ICAR-CCARI, Goa during July 5-10, 2018.

Shri Ram Sakal Chaurasia, Personal Assistant participated in ICAR-Human Resource Development Training programme on "Professional and Personal Skill Development for Technical and Administrative Staff of ICAR" organized by ICAR-NBAGR, Karnal, Haryana during June 19-21, 2018.

LIBRARY AND INFORMATION SERVICES

The ICAR-NBFGR Library and Documentation Unit acts as a repository of literature and information and provides latest scientific information in the field of fish diversity, conservation, fish genetics, fisheries and related aspects. Library continued to extend its services to users at HQs, Centre/Unit and also to students and researchers from other institutions, State Fisheries Departments, Universities and Colleges.

Resource Development

The library has a total collection of 7583 books and 2655 bound volumes of journals and other reference materials. In addition to these, 32 journals were received on gratis/ exchange basis.

Library Automation

The existing Library Automation software was successfully migrated from LSEase: Library Management Software Package, Version 7.0 to KOHA: Open Source Library System, Version 18.05.05.000 with the technical support from CSIR-National Institute of Science Communication and Information Resources (NISCAIR), New Delhi, which is a fully featured, scalable library management system. On site training on "Koha Software for Library Automation" was also organized for library staff of the institute from October 29, 2018 to November 02, 2018 by CSIR-NISCAIR, New Delhi. The records of books, journals, maps, etc. were entered in the database. Barcoding of books, periodicals and maps for automated circulation was also done. Online Public Access catalogue was made available for library users.

Information and Reference Services

The Library continued information and reference services to its users including locating materials, using the Online Public Access Catalogue (OPAC), using computers to access information, and using basic reference sources. Access to ICAR- Consortium for e-Resources in Agriculture (CeRA) journals and E-Books on agriculture and allied subjects continued through J-Gate Plus platform. The users of the library extensively used the Consortium for e-Resources in Agriculture (CeRA) to access the full text online journals and e-books. In addition to online access to CeRA, the library is providing Document Delivery Services to various institutions.

Technical Reports and Reprography Services

The library and documentation unit provided technical support to bring out departmental publications. This unit also attended to Questionnaires on Bureau's infrastructure and other facilities. The unit continued active reprography services. Comb binding, Spiral binding, and lamination facilities for departmental reports were also provided.

Exchange Services

The Library continued exchange relationship and resource sharing with leading National and International Research Institutes and Development organizations. To highlight the activities of the Bureau, the library sent the NBFGR Annual Report 2017-2018 and other publications to various institutions and organizations including International organizations, Universities, State Fisheries Departments, FFDAs, Krishi Vigyan Kendras, Entrepreneurs and fish farmers.

STAFF ACTIVITIES

New Joining

Scientist		Date of Joining
1.	Shri Kantharajan G. joined as Scientist at ICAR-NBFGR, Lucknow	08.10.2018
Skilled Support Staff		
1.	Shri Mayank Pratap Singh joined as SSS at ICAR-NBFGR, Lucknow on transfer from ICAR-CMFRI, Kochi	08.10.2018
2.	Shri Sushil Kumar, joined as SSS at ICAR-NBFGR, Lucknow on transfer from ICAR-DCFR, Bhimtal	11.10.2018

Relieving

Administrative		Date of Relieving
1.	Shri Abhishek Rana, Administrative Officer relieved from ICAR-NBFGR, Lucknow to join as Senior Administrative Officer at ICAR-CTCRI, Thiruvanthapuram	24.03.2018

Promotions

Technical	
1.	Shri Rajesh Kr, Sr. Technical Assistant to Technical Officer w.e.f. 03.09.2017
2.	Shri K.K. Singh, Technical Assistant to Sr. Technical Assistant w.e.f. 05.09.2017

MACP

Administrative	
1.	Shri Rajan Kr. Malhotra, Jr Clerk 2nd MACP w.e.f. 24.09.2016
2.	Shri P.K. Awasthi, Assistant 3rd MACP w.e.f. 03.12.2018
3.	Shri Ravi Bhadra, AF& AO 1st MACP w.e.f. 06.11.2018

Retirement

Scientist		Date of Retirement
1.	Dr. A.K. Pandey, Pr. Scientist	31.01.2019
Technical		
1.	Shri Ram Bharose, Technical Assistant	31.07.2018

Staff Position

	Research Management/ Director	Scientist	Administrative	Technical	SSS
Sanctioned	01	41	21	38	20
In position	01	34	20	30	20

Institute Management Committee (IMC)

33rd meeting of the Institute Management Committee was held on February 18, 2019. The composition of the IMC is as under:		
1.	Director ICAR-National Bureau of Fish Genetic Resources	Chairman
2.	Director of Fisheries Govt. of Uttar Pradesh, Lucknow	Member
3.	Director of Fisheries Govt. of Bihar Patna, Bihar	Member
4.	Dr. S. Shyama Professor & Director College of Fisheries Panangad, Kochi, Kerala	Member
5.	Shri Mahendra Kumar Bind Prayagraj, U.P.	Non-official Member
6.	Shri Prem Singh Kashyap Badaun, U.P.	Non-official Member
7.	Dr. Gopi Krishna Pr. Scientist & Head ICAR-CIBA, Chennai	Member
8.	Dr. K.V. Rajendran Pr. Scientist & Head ICAR-CIFE, Mumbai	Member
9.	Dr. U.K. Sarkar Pr. Scientist & Head ICAR-CIFRI, Barrackpore	Member
10.	Dr. Sunil Archak Pr. Scientist ICAR-NBPGR, New Delhi	Member
11.	Dr. P. Praveen ADG (M.Fy.) ICAR, New Delhi	Member
12.	AF&AO ICAR-NBFGR	Member
13.	Administrative Officer ICAR-NBFGR	Member-Secretary

Research Advisory Committee

RAC was held on March 18-19, 2019. The composition of RAC is as under:		
1.	**Dr. George John** Ex. Advisor DBT& Ex. Vice Chancellor, BAU Flat No. 5140, Sector-B Pocket-7, Vasant Kunj New Delhi-110 070	Chairman
2.	**Dr. Deepti D. Deobagkar** Professor and Director Bioinformatics Centre SavitribaiPhule Pune University Pune-411007, Maharashtra	Member
3.	**Dr. A.K. Sahu** Former Principal Scientist, ICAR-CIFA, Bhubaneswar 16, Bhimpur Duplex Colony, P.O. Aerodrome Area Bhubaneswar-751020	Member
4.	**Dr. J. R. Dhanze** Consultant, COE-FAB project College of Fsheries (CAU) Lembucherra, Tripura-799210	Member
5.	**Dr. Nirmalendu Saha** Professor Department of Zoology North-Eastern Hill University Shillong-793022	Member
6.	**Dr. Manas Das** Principal Scientist (Retd.), ICAR-CIFRI, Barracpore 5/11, Purbapally P.O. Sodepur, North 24 Pargana Kolkata-700110, West Bengal	Member
7.	**Assistant Director General (M. Fy.)** Indian Council of Agricultural Research Krishi Anusandhan Bhavan-II Pusa, New Delhi-110 012	Member
8.	**Director** ICAR-National Bureau of Fish Genetic Resources Lucknow	Member
9.	**Dr. Gaurav Rathore** Principal Scientist & HOD ICAR-National Bureau of Fish Genetic Resources Lucknow	Member Secretary

DISTINGUISHED VISITORS

The following distinguished guests visited ICAR-NBFGR, Lucknow during the period:

Prof. S.P. Singh Baghel, Hon'ble Minister of Livestock, Minor Irrigation and Fishery, Govt. of Uttar Pradesh, Lucknow

Prof. Kenton L. Morgan, Emeritus Professor of Epidemiology, Institute of Veterinary Science, University of Liverpool, United Kingdom

Dr. Cherdsak Virapat, Director General, Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand

Dr. Graham C. Mair, Senior Aquaculture Officer (Genetic Resources), Food and Agriculture Organisation of the UN, Rome, Italy

Dr. Roger W. Doyle, President, Genetic Computation Ltd, Canada

Dr. R. Mohamad Rofiq, Aquaculture Cooperation Sub Division, Law, Public Relation and Cooperation Division, Secretariat of Directorate General of Aquaculture, Ministry of Marine Affairs and Fisheries, Republic of Indonesia

Dr. Nguyen Van Sang, Director, Research Institute for Aquaculture, Vietnam

Dr. Panya Sae-Lim, Fisheries Biologist, Practitioner Level, Aquatic Animal Genetics Research and Development Division

Dr. Simon J. Wilkinson, Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand

Dr. Yuan Derun, Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand

Mrs. Kamala Adhikari, Senior Fisheries Development Officer, Fisheries Development Office, Banke, Nepal

Ms. Siti N. B. Mohamad, Fishery Officer, International Section, Planning and Development Division, Department of Fisheries, Putrajaya, Malaysia

Dr. Eduardo M. Leano, Coordinator, Aquatic Animal Health Programme, Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand

Dr. Kanonkporn Kessuwan, Department of Fisheries, Kasetsart University Campus, Bangkok, Thailand

Dr. J.K Jena, DDG (Fisheries & Animal Sciences), ICAR, New Delhi

Dr. S. Ayyappan, Former Secretary DARE and Director General ICAR, New Delhi

Dr. P. Pravin, ADG (Marine Fisheries), ICAR, New Delhi

Dr. S.D. Singh, Former ADG (Inland Fisheries), ICAR, New Delhi

Dr. Kailash Chandra, Director, Zoological Survey of India, Kolkata

Ms. I. Rani Kumudini, IAS, Chief Executive, National Fisheries Development Board, Hyderabad

Dr. Gopal Krishna, Director, ICAR-Central Institute of Fisheries Education, Mumbai

Dr. A. Gopalakrishnan, Director, ICAR-Central Marine Fisheries Research Institute, Kochi, Kerala

Dr. A.S. Ninawe, Former Advisor, Department of Biotechnology, Ministry of Science and Technology, Govt. of India, New Delhi

Prof. I.S. Bright Singh, Emeritus Professor, UGC-BSR Faculty, National Centre for Aquatic Animal Health (NCAAH), Cochin University of Science and Technology, Kochi, Kerala

Dr. Dilip Kumar, Former Director, ICAR-Central Institute of Fisheries Education, Mumbai, New Delhi

Dr. A.G. Ponniah, Former Director, ICAR-NBFGR, Lucknow & ICAR-CIBA, ICAR-Emeritus Scientist, ICAR-CMFRI, Chennai Centre, Tamil Nadu

Prof. U. C. Gautam, Vice Chancellor, Banda Agriculture University, Banda, Uttar Pradesh

Dr. George John, Ex Advisor DBT, Govt. of India, New Delhi & Ex VC, Birsa Agricultural University, Ranchi Jharkhand

Prof. Rakesh Kapoor, Director, Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow

Dr. G. Gopikrishna, Head & Principal Scientist, ICAR-Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu

Dr. N. Sarangi, Former Director, ICAR-Central Institute of Freshwater Aquaculture, Bhubaneshwar, Odisha

Dr. A.K. Sahu, Former Principal Scientist, ICAR-Central Institute of Freshwater Aquaculture, Bhubaneshwar, Odisha.

Dr. B. R. Pillai, Director, ICAR-Central Institute of Freshwater Aquaculture, Bhubaneshwar, Odisha.

Dr. Kanta D. Mahapatra, Principal Scientist, ICAR-Central Institute of Freshwater Aquaculture, Bhubaneshwar, Odisha

Dr. Sudhir M. Bobde, Principal Secretary, Fisheries, Govt. of Uttar Pradesh, Uttar Pradesh

Dr. Deepti D. Deobagkar, Professor and Director, Bioinformatics Centre, Savitribai Phule Pune University, Pune, Maharashtra

Dr. V.P. Kamboj, Former Director, CSIR- Central Drug Research Institute, Lucknow

Mohd. W. R. Majumder, Assistant Director, Fish Breeding & Training Center, Roypur, Lakshmipur

Dr. Anup Mandal, Manager (Central Genetics Lab), Rajiv Gandhi Centre for Aquaculture (MPEDA), Ministry of Commerce & Industry, Govt. of India, Tamil Nadu

Mr. Vishwanath T.S., Sr. Executive (Tech), National Fisheries Development Board, Hyderabad

Dr. Anees Ansari, Chairman, Centre for Agriculture and Rural Development, New Delhi

Shri Rajender Prasad Singh, DGM, Fish Development Corporation, Lucknow, Uttar Pradesh

Dr. S. K. Singh, Joint Director, Department of Fisheries, Uttar Pradesh

Dr. Rajesh Bhatia, Regional Technical Advisor on AMR, FAO, New Delhi

Dr. Jyoti Misri, Principal Scientist, Animal Science Division, ICAR, New Delhi

Prof. Iddya Karunasagar, Senior Director (International Relations), NITTE University, Mangalore, Karnataka

Dr. A.K. Sharma, Principal Scientist (Agri. Economics), ICAR-Indian Institute of Sugarcane Research, Lucknow

Dr. Sangeeta Srivastava, Principal Scientist, ICAR-Indian Institute of Sugarcane Research, Lucknow

Dr. Diksha Joshi, Senior Scientist, ICAR-Indian Institute of Sugarcane Research, Lucknow

Shri. K. R. Jyothilal, IAS, Principal Secretary, Department of Fisheries and Ports, Government of Kerala, Kerala

Mr. Suresh Babu S.V., Director, River Basins and Water Policy, WWF, India, New Delhi

Mr. Nitin Kaushal, Associate Director, River Basins and Water Policy, WWF, India, New Delhi

Commitment to societal Initiatives of Government of India and ICAR

World Soil day Celebration

ICAR-NBFGR, Lucknow celebrated World Soil day on December 5, 2018. On this occasion, lectures were delivered by resource persons on topics "Waste Utilization-Kachare se kanchan" by Dr. V.K. Singh, Neem Ratan, Coordinator Navic-NGO, Lucknow; "Empathy in improving organizational behavior" by Sh. Aman Gupta, Coordinator, E3 consultancy firm and "Natural Resources Management" by Dr. L.K Tyagi, Principal Scientist, ICAR-NBFGR, Lucknow. The programme was attended by the staff at headquarters ICAR-National Bureau of Fish Genetic Resources, ARTU Chinhat and 05 staff from ICAR-Central Institute of Subtropical Horticulture, Lucknow. PMFGR Centre, Kochi participated though skype.

Glimpses of World Soil day celebration 2018

International Yoga Day

The International Yoga Day was celebrated at ICAR-NBFGR, Lucknow on June 21, 2018. Dr. Kuldeep K. Lal, Director addressed the participants and narrated about importance of yoga in betterment of performance in all walks of life. The common yoga protocol released by Ayush Ministry, Govt. of India was followed by the participants from 6.30 to 8.00 a.m.

Yoga Day celebration 2018

at administrative block of the institute. The function started with prayer and ended with sankalp. A similar programme was also organised at PMFGR Division of ICAR-NBFGR, Kochi.

Swachh Bharat Activities at ICAR-NBFGR, Lucknow

ICAR-NBFGR, Lucknow has been promoting Swachh Bharat Abhiyan mission to ensure a clean and green campus and contribute in making India more beautiful. The institute has been actively observing and promoting Swachh Bharat Mission since its inception in 2014. In the reporting year, other than the routine monthly activities, the institute Headquarters at Lucknow, PMFGR Centre at Kochi and ARTU at Chinhat observed 2 Swachhta Pakhwadas; 'Swachhta Hi Sewa Pakwada' for 15 days from September 15th to October 2, 2018 and 'Swachhta Pakwada' for 15 days during December 16-31, 2018. A special program to commemorate the birthday of Swachhta icon, "Mahatama Gandhi ji" was also held on October 2, 2018. The summary of the programs are as follows:

1. During 'Swachhta Hi Sewa Pakwada', 15 different cleaning and awareness activities were undertaken by the staff and research scholars of the institute like, mass swachhta pledge, cleaning of office buildings, campus, farm section, guest house etc. As part of green environment imitative, 105 saplings consisting of jackfruit, wood apple, litchi, guava, etc. were planted in the farm area and near Ganga Aquarium. To generate awareness on the importance of waste and clean environment, lectures on "use of Fish Bio-waste" and "Waste Management" was also held. A special lecture on "Mahatama Gandhi ji" was also organised on the occasion of his 149th birthday followed by mass seedling plantation of 135 saplings in the farm area of the institute consisting of bougainvillea, mango, coconut tree, wood apple and ornamental plants.
2. During Swachhta Pakwada, 16 cleaning related programmes and activities were carried out. The Swachhta Pakhwada was kick-started on December 16, 2018 by holding a mass Swachhta Pledge by all the staff and research scholars of the institute. Various cleanliness drives were undertaken by the institute during the pakhwada both in office premises and in public places. A special swachhata program for farmers, "Kisan Diwas" was celebrated with the farmers on December 23, 2018 where lively discussion was held on various aspects of sanitation and cleanliness. Lectures on "Water recycling" and "Effective Waste Disposal" were organised to create awareness about these important issues. To foster a spirit of competition, certain events like Swachhta debate and quiz programs were organised.





Different activities during Swachh Bharat Abhiyaan

Digital India

Cashless transactions

The ICAR-NBFGR, Lucknow continued implementing the digital mode in its financial transactions. During the year under report, out of total 6741 transactions, 95.9% were cashless transactions.

Government E-Marketplace (GeM)

The Institute is implementing Government of India's policy of e-procurement. During the year under report a total of 194 different kind of items amounting to Rs. 111.51 lakhs were processed through GEM. All the tenders were implemented through e-tendering process.

Go Green

As part of 'Go Green' measures, the institute has undertaken a lot of programmes, like mass sapling plantation, reduced use of paper through e-circular, etc. Additionally, the institute has a functional roof top Grid Connected Rooftop Solar Power System with installed capacity of 250 KWp. The system with 6 three phase inverters of 50 KVA (4 nos.), 30 kVA (1 no.) and 20 kVA (1 no.) is contributing towards production of green energy. The solar power system was commissioned under the RESCO Model of implementation.

राजभाषा गतिविधियाँ

हिंदी चेतना मास

संस्थान में 14 सितंबर से 12 अक्टूबर, 2018 के दौरान हिंदी चेतना मास का आयोजन किया गया। इस अवधि में राजभाषा हिंदी के महत्व को ध्यान में रखते हुए कई कार्यक्रमों एवं प्रतियोगिताओं का आयोजन किया गया। हिंदी चेतना मास का उद्घाटन 14 सितंबर, 2018 (हिंदी दिवस) को किया गया, जिसमें संस्थान के सभी कर्मचारियों ने भाग लिया। कार्यक्रम के समापन समारोह का आयोजन दिनांक 12 अक्टूबर, 2018 को किया गया, जिसकी अध्यक्षता डॉ. कुलदीप कुमार लाल, निदेशक, भा.कृ.अनु.प.–रा.म.आ. सं.ब्यूरो, लखनऊ ने की तथा डॉ. शैलेंद्र राजन, निदेशक, भा.कृ.अनु.प.–केन्द्रीय उपोष्ण बागवानी संस्थान, लखनऊ मुख्य अतिथि थे। हिंदी चेतना मास के अंतर्गत कुल 11 प्रतियोगिताओं का आयोजन किया गया, जिसमें संस्थान के सभी कर्मचारियों ने सक्रिय रूप से भाग लिया और विजेताओं को पुरस्कार प्रदान किये गये।

हिंदी चेतना मास की झलकियां

हिंदी कार्यशाला

संस्थान के वैज्ञानिकों, तकनीकी कर्मचारियों, प्रशासनिक कर्मचारियों और कुशल सहायक कर्मचारियों के लिए हिंदी में कुल चार एक–दिवसीय कार्यशाला–सह–प्रशिक्षण कार्यक्रमों का आयोजन दिनांक 28 जून, 2018, 22 सितम्बर, 2018, 12 दिसम्बर, 2018 तथा 30 मार्च, 2019 को किया गया।

हिंदी कार्यशाला का आयोजन

राजभाषा पत्रिका 'मत्स्यलोक' (सप्तम अंक)

राजभाषा पत्रिका 'मत्स्यलोक' के सप्तम अंक का प्रकाशन किया गया। पत्रिका में विभिन्न वैज्ञानिक एवं सामान्य लेखों, रोचक लेखों तथा काव्य रचनाओं को सम्मिलित किया गया है।

राजभाषा पत्रिका 'मत्स्यलोक' का विमोचन

पुरस्कार

संस्थान द्वारा प्रकाशित हिंदी पत्रिका 'मत्स्यलोक' (षष्टम् अंक) को वर्ष 2018–19 के लिए भारत सरकार, राजभाषा विभाग, गृह मंत्रालय, नगर राजभाषा कार्यान्वयन समिति (कार्यालय–3), लखनऊ द्वारा प्रथम पुरस्कार प्रदान किया गया।


भारत सरकार, राजभाषा विभाग, गृह मंत्रालय

प्रमाण पत्र

Ganga Aquarium : Public Awareness on Fish Diversity

(ISO 9001-2008; ISO 14001-2004 certified)

The Ganga Aquarium, established in ICAR-NBFGR, Lucknow campus, during November 2010, is a popular destination for the visitors especially school children. This is a public aquarium and has 46 aquaria that displays more than 100 fish species of both fresh and marine water. The live aesthetic displays serves as an avenue to enhance awareness towards fish diversity and its conservation among public. Recently the aquarium has thrust to display indigenous fish species. Some of the rare attractions are Chitala, Butter catfish, sun catfish and redlined torpedo from Western Ghats and Pengba from Chindwin basin in Manipur. Among marines, saltwater Crab (*Scylla* spp.) and other marine forms like scorpion fish, clownfish, damsels, tangs, sea anemones and starfish are popular. Public also enjoy watching the freshwater fishes like arowana, flower horn, alligator gar, ghost fish, etc.

Revenue from Ganga Aquarium

The Ganga Aquarium is a well known destination of the region among the fish and environment lovers, especially kids. During the period, a total of 19,552 person visited the aquarium with earning Rs. 2.92 lakh from sale of tickets.


टिनफोयल बार्ब
TINFOIL BARB


रैडटेल कैटफिश
REDTAIL CATFISH

LIST OF PERSONNEL

Research Management

Dr. Kuldeep Kumar Lal		-	**Director**
Sl. No.	**Name**		**Designation**
1	Dr. Ravindra Kumar	-	Head of Division (MBB)
2	Dr. Vindhya Mohindra	-	Head of Division (FC)
3	Dr. Gaurav Rathore	-	Head of Division (FHME)
4	Dr. A.K. Pandey	-	Principal Scientist (Retired on 31.01.2019)
5	Dr. Kripal Datt Joshi	-	Principal Scientist
6	Dr. Basdeo Kushwaha	-	Principal Scientist
7	Dr. Neeraj Sood	-	Principal Scientist
8	Dr. V.S. Basheer	-	Principal Scientist (SIC, PMFGR upto January 29, 2019)
9	Dr. Pravata Kumar Pradhan	-	Principal Scientist
10	Dr. Sharad Kumar Singh	-	Principal Scientist (SIC, ARTU)
11	Dr. Lalit Kumar Tyagi	-	Principal Scientist
12	Dr. Achal Singh	-	Principal Scientist
13	Dr. Satish Kumar Srivastava	-	Principal Scientist
14	Dr. T.T. Ajith Kumar	-	Principal Scientist (SIC, PMFGR w.e.f. January 30, 2019)
15	Dr. Rajeev Kumar Singh	-	Principal Scientist
16	Dr. Sullip Kumar Majhi	-	Principal Scientist
17	Dr. Mahender Singh	-	Principal Scientist
18	Dr. T. Rajaswaminathan	-	Principal Scientist
19	Dr. Ajey Kumar Pathak	-	Senior Scientist
20	Dr. Divya P.R.	-	Senior Scientist
21	Dr. Poonam Jayant Singh	-	Scientist
22	Dr. A. Kathirvelpandian	-	Scientist
23	Dr. Sangeeta Mandal	-	Scientist
24	Dr. Rejani Chandran	-	Scientist
25	Dr. Santosh Kumar	-	Scientist
26	Dr. Aditya Kumar	-	Scientist
27	Shri Labrechai Mog Chowdhury	-	Scientist
28	Dr. Charan R.	-	Scientist
29	Dr. Murali S.	-	Scientist
30	Shri Trivesh Suresh Mayekar	-	Scientist
31	Dr. Anutosh Paria	-	Scientist
32	Shri Chandra Bhushan Kumar	-	Scientist
33	Smt. Teena Jayakumar T.K.	-	Scientist
34	Km. Chinmayee Muduli	-	Scientist
35	Shri Kantharajan G	-	Scientist (Joined on October 08, 2018

Technical Staff

Sl. No.	Name		Designation
1	Dr. Rajesh Dayal	-	Chief Technical Officer
2	Dr. S.M. Srivastava	-	Chief Technical Officer
3	Dr. A.K. Yadav	-	Chief Technical Officer
4	Shri Amar Pal	-	Chief Technical Officer
5	Shri S.P. Singh	-	Assistant Chief Technical Officer
6	Shri Babu Ram	-	Assistant Chief Technical Officer
7	Dr. Ajay Kumar Singh	-	Assistant Chief Technical Officer
8	Mrs. Reeta Chaturvedi	-	Assistant Chief Technical Officer
9	Shri Ramashankar Sah	-	Assistant Chief Technical Officer
10	Shri Subhash Chandra	-	Senior Technical Officer
11	Dr. Akhilesh Kumar Mishra	-	Senior Technical Officer
12	Dr. Ranjana Srivastava	-	Senior Technical Officer
13	Shri Ravi Kuamr	-	Senior Technical Officer
14	Shri Amit Singh Bisht	-	Senior Technical Officer
15	Shri Prem Chandra	-	Senior Technical Officer
16	Shri Satyavir Chaudhary	-	Senior Technical Officer
17	Shri S.K. Singh	-	Senior Technical Officer
18	Shri R.K. Shukla	-	Technical Officer
19	Shri B.N. Pathak	-	Technical Officer
20	Shri Samarjit Singh	-	Technical Officer
21	Shri Om Prakash	-	Technical Officer
22	Shri Rajesh Kumar	-	Senior Technical Assistant
23	Shri Om Prakash-II	-	Senior Technical Assistant
24	Dr. Vikash Sahu	-	Senior Technical Assistant
25	Shri Vijay Kumar Singh	-	Senior Technical Assistant
26	Shri Raj Bahadur	-	Senior Technical Assistant
27	Shri Gulab Chandra	-	Senior Technical Assistant
28	Shri B.K. Rao	-	Technical Assistant
29	Shri K.K. Singh	-	Technical Assistant
30	Shri Ram Bharose (Retired on 31.07.2018)	-	Technical Assistant

Administrative Staff

Sl. No.	Name		Designation
1	Shri Darvesh Kumar	-	Administrative Officer
2	Shri Ravi Bhadra	-	Assistant Finance & Accounts Officer
3	Shri Navin Kumar	-	Assistant Administrative Officer
4	Shri Tej Singh Seepal	-	Assistant Administrative Officer
5	Smt. Mamta Chakraborty	-	Private Secretary
6	Shri Ram Sakal	-	Personal Assistant
7	Shri Sandeep	-	Jr. Stenographer

Sl. No.	Name		Designation
8	Smt. Kaneez Fatima	-	Assistant
9	Shri Swapan Debnath	-	Assistant
10	Shri S.N. Srivastava	-	Assistant
11	Shri P.K. Awasthi	-	Assistant
12	Smt. Sunita Kumari	-	Assistant
13	Shri Sajivan Lal	-	Assistant
14	Shri Shreelal Prasad	-	Senior Clerk
15	Shri Vinay Kumar Srivastava	-	Senior Clerk
16	Shri Santosh Kumar Singh	-	Senior Clerk
17	Shri Ram Baran	-	Junior Clerk
18	Shri P.C. Verma	-	Junior Clerk
19	Shri Rajan Kumar Malhotra	-	Junior Clerk
20	Shri Vikrant Gupta	-	Junior Clerk

Supporting Staff

1	Shri Laxman Prasad	-	Skilled Support Staff
2	Shri Dukhi Shyam Deo	-	Skilled Support Staff
3	Shri Anil Kumar	-	Skilled Support Staff
4	Shri Indrajit Singh	-	Skilled Support Staff
5	Shri Prahalad Kumar	-	Skilled Support Staff
6	Shri Chhote Lal	-	Skilled Support Staff
7	Shri Ashok Kumar	-	Skilled Support Staff
8	Shri Dinesh Kumar	-	Skilled Support Staff
9	Shri Balram Babu Bajpai	-	Skilled Support Staff
10	Shri Ashok Kumar Awasthi	-	Skilled Support Staff
11	Shri Sidhnath	-	Skilled Support Staff
12	Shri Ram Lakhan	-	Skilled Support Staff
13	Shri Sunit Kumar	-	Skilled Support Staff
14	Shri Jai Narain Tiwari	-	Skilled Support Staff
15	Shri Anwar	-	Skilled Support Staff
16	Shri Sanjay Kumar	-	Skilled Support Staff
17	Smt. Seema Devi	-	Skilled Support Staff
18	Smt. Raj Kumari	-	Skilled Support Staff
19	Sh. Mayank Pratap Singh	-	Skilled Support Staff
20	Sh. Sushil Kumar	-	Skilled Support Staff

Linkages

A. Local Institutions/Organisations

The Bureau has been sharing its expertise and infrastructure with the following institutions and government departments located in Lucknow:

- Dr. A.P.J. Abdul Kalam Technical University
- Baba Bhimrao Ambedkar University (Central University)
- Lucknow University
- King George's Medical University
- Sanjay Gandhi Post-Graduate Institute of Medical Sciences
- Biotech Park
- Integral University
- Amity University
- Aquatic Biodiversity Conservation Society
- ICAR-Indian Institute of Sugarcane Research
- ICAR-Central Institute of Sub-tropical Horticulture
- ICAR-Central Soil Salinity Research Institute (Regional Station)
- CSIR-Central Institute of Medicinal and Aromatic Plants
- CSIR-Indian Institute of Toxicological Research
- CSIR-National Botanical Research Institute
- CSIR-Central Drug Research Institute
- Department of Fisheries, Government of Uttar Pradesh
- Department of Forests, Government of Uttar Pradesh
- National Informatics Centre
- UP Remote Sensing Application Centre

B. National Institutes and Universities

The Bureau has been collaborating with a number of national research institutions, colleges and universities.

- Anand Agricultural University, Gujarat
- Awdhesh Pratap Singh University, Rewa, Madhya Pradesh
- C. Abdul Hakeem College, Melvisharam, Tamil Nadu
- Centre for Aquaculture Resource & Extension, St. Xavier College, Palayamkottai, Tamil Nadu
- CSIR-Centre for Cellular and Molecular Biology, Hyderabad
- Centre for Marine Living Resources & Ecology, Kochi, Kerala
- Cochin University of Science and Technology, Kochi, Kerala
- College of Fisheries, Assam Agriculture University, Raha, Nagaon, Assam
- College of Fisheries, Central Agriculture University, Lembucherra, Tripura
- College of Fisheries, Chhattisgarh Kamdhenu Vishwavidyalaya, Kawardha, Chhattisgarh
- College of Fisheries, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Ratnagiri, Maharashtra
- College of Fisheries, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttar Pradesh
- College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana
- College of Fisheries, Junagadh Agricultural University, Veraval, Gujarat
- College of Fisheries, Karnataka Veterinary, Animal and Fisheries Sciences University, Karnataka
- College of Fisheries, Kerala University of Fisheries and Ocean Studies, Kochi, Kerala
- College of Fisheries, Odisha University of Agriculture & Technology, Odisha
- College of Fishery Sciences, Sri Venkateswara Veterinary University, Andhra Pradesh
- Delhi University, Delhi
- Department of Life Sciences, Assam University, Silchar, Assam
- Department of Life Sciences, Manipur University, Manipur
- Department of Zoology, Gauhati University, Guwahati
- Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar
- Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences Technology of Kashmir, Jammu & Kashmir
- Faculty of Fishery Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata

- Fishery Research Station, Telangana
- Fisheries Survey of India, Mumbai, Maharashtra
- HNB Garhwal University, Srinagar, Uttarakhand
- ICAR Complex for NEH Region, Barapani, Shillong
- ICAR-Indian Agricultural Statistics Research Institute, Pusa, New Delhi
- ICAR-National Bureau of Agriculturally Important Microorganisms, Kushmaur, Uttar Pradesh
- ICAR-National Institute for Plant Biotechnology, Pusa, New Delhi
- ICAR Research Complex for Eastern Region, Patna
- ICAR-Central Coastal Agricultural Research Institute, Goa
- ICAR-Central Inland Fisheries Research Institute, Barrackpore
- ICAR-Central Institute of Brackishwater Aquaculture, Chennai
- ICAR-Central Institute of Fisheries Education, Mumbai
- ICAR-Central Institute of Fisheries Technology, Kochi
- ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar
- ICAR-Central Island Agricultural Research Institute, Port Blair
- ICAR-Central Marine Fisheries Research Institute, Kochi, Kerala
- ICAR-Directorate of Coldwater Fisheries Research, Bhimtal, Uttarakhand
- ICAR-Indian Agricultural Research Institute, New Delhi
- ICAR-National Bureau of Animal Genetic Resources, Karnal
- ICAR-National Bureau of Plant Genetic Resources. New Delhi
- ICAR-National Institute of Veterinary Epidemiology and Disease Informatics, Bengaluru, Karnataka
- Indian Institute of Remote Sensing, Dehradun, Uttarakhand
- Kerala Forest Research Institute, Thrissur, Kerala
- Kumaun University, Nainital
- National Institute of Oceanography, Goa
- Rajiv Gandhi Centre for Aquaculture, Tamil Nadu
- School of Life Sciences, Dibrugarh University, Dibrugarh, Assam
- School of Life Sciences, NEHU, Shillong
- School of Life Sciences, Rajiv Gandhi University, Itanagar, Arunachal Pradesh
- State Institute of Fisheries Technology, Kakinada, Andhra Pradesh
- Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Tamil Nadu
- Udalguri College, Udalguri, Assam
- Visva-Bharati University, West Bengal
- Wildlife Institute of India, Dehradun
- Zoological Survey of India, Kolkata, West Bengal

C. International

At International level, NBFGR has linkages with following organizations:

- Food and Agriculture Organization of the United Nations, Rome, Italy
- Network of Aquaculture Centers in Asia Pacific (NACA), Bangkok, Thailand
- World Wide Fund for Nature, India, New Delhi
- University of Southampton, United Kingdom
- University of Aberdeen, United Kingdom
- University of St Andrews, United Kingdom
- Swansea University, United Kingdom
- Liverpool University, United Kingdom
- Bangladesh Agricultural University, Bangladesh
- Bioversity International, South and South-East Asia Office

D. Extension and Development Agencies

NBFGR has established relationships with a number of development and extension agencies such as the Department of Fisheries, especially those comprising the north-eastern hill states, besides several NGOs:.

- Marine Products Export Development Authority, Kochi
- North Eastern Council, Shillong, Meghalaya
- State Department of Fisheries, Arunachal Pradesh, Assam, Himachal Pradesh, Kerala, Tamil Nadu, Karnataka, Punjab, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura
- Krishi Vigyan Kendra Thoubal, Manipur
- National Fisheries Development Board, Hyderabad
- Department of Biotechnology, Ministry of Science and Technology
- Department of Science and Technology, Ministry of Science and Technology
- National Biodiversity Authority, Chennai, India
- Department of Animal Husbandry, Dairying and Fisheries, Govt. of India
- University Grants Commission, New Delhi
- Science and Engineering Research Board, New Delhi

APPENDIX-I

Human Resource Development Initiatives

The HRD cell of the ICAR-NBFGR, Lucknow actively encouraged and promoted its staff for attending various training programmes for capacity building and also extended support in organizing training programmes in the institute. The HRD cell organized a training program on "Human Resource Development for Agriculture Research" for all staff "Scientists, Technicals, Administrative & Finance & Skilled Supporting" during period December 4-6, 2018. The trainings acquired by staff from ICAR Institutes & other organisations were as follows:

A. Physical targets and achievements

S. No.	Category	Total No. of Employee	No. of trainings planned for year 2018-19 as per ATP	No. of employees undergone training during April-Sept 2018	No. of employees undergone training during Oct 2018-March 2019	Total number of employees undergone training during April 2018- March 2019	% realization of trainings planned during 2018-19
1	Scientist	34	17	1	4	5	29.41
2	Technical	30	14	4	3	7	50.00
3	Administrative & Finance	20	5	7	0	7	140.00
4	Skilled Support Staff	18	0	0	18	18	100

B. Financial targets and achievements (All employees)

S. No.	RE for HRD 2018-19			Actual Expenditure up to 31 st March, 2019 for HRD			% Utilisation
	Plan	Non-plan	Total	Plan	Non-plan	Total	
	(Lakh Rs.)	Lakh Rs.)	(Lakh Rs.)	(Lakh Rs.)	Lakh Rs.)	(Lakh Rs.)	
1	5.00	0	5.00	4.97	0	4.97	99.40

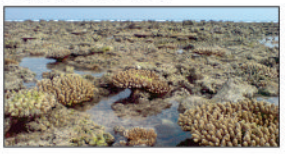
C. Number of trainings organized by HRD cell for various categories of ICAR-NBFGR employees including winter/summer schools and short trainings

S. No.	Category	No. of trainings organized during April 2018 to September 2018	No. of trainings organized during October 2018 to March 2019	Total number of trainings organized during April 2018- March 2019	No. of participants (only ICAR employees)		
					Organizing Institute	Other ICAR Institutes	Total
1	Scientist		1	1	34	3	37
2	Technical		1	1	30	1	31
3	Administrative & Finance		1	1	20	1	21
4	Skilled Support Staff		1	1	18	0	18

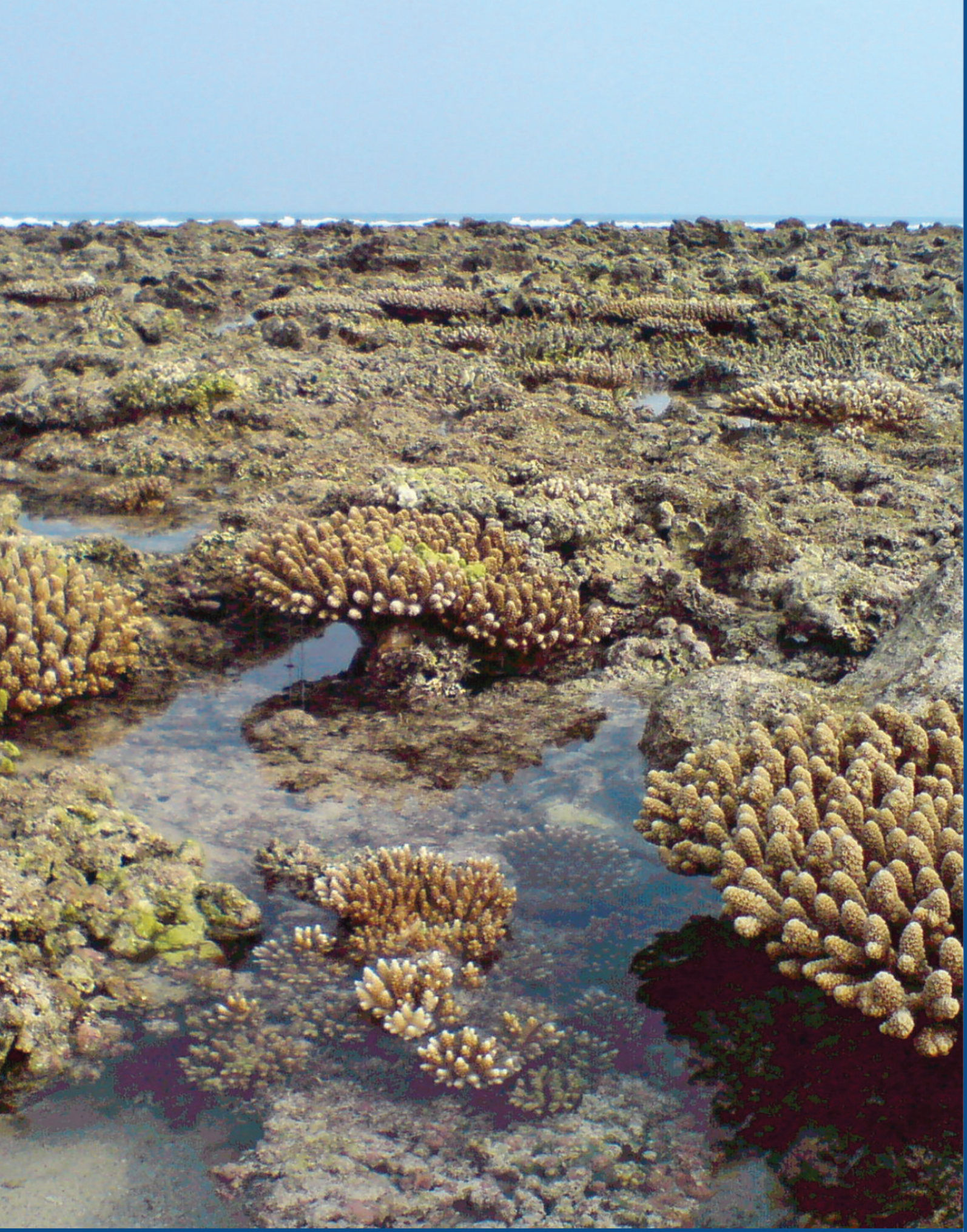
Inner back cover

1. Fishermen setting out in coracles at Srirangapatna, Karnataka
2. Seining a tributary of the Bhavani river near Mettupalayam, Tamil Nadu
3. Cast netting on the Cauvery near Talakadu, Karnataka
4. Fishermen hauling-in gillnets at Talakadu, Karnataka
5. Bhavani river along the Kerala-Tamil Nadu border

Back cover



Exposure of Acropora coral during low tide at Agatti, Lakshadweep



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