ANNUAL REPORT 2019

Simplifying Science for Mainstreaming Biodiversity

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

Front cover

'Simplifying science for mainstreaming biodiversity'

Popularizing science and making scientific knowledge more accessible and understandable to general public for conservation, sustainable utilization and equitable sharing of aquatic biodiversity resources

Description

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2. Documentation of farming practices along the river Godavari
3. Educating advanced culture practices to training participants
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Front & Front Inner cover background

Beach seine fishing at Lakshadweep Island

ANNUAL REPORT

2019

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ICAR-National Bureau of Fish Genetic Resources

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PREFACE

ICAR-National Bureau of Fish Genetic Resources (NBFGR) is a research institute under the aegis of Indian Council of Agricultural Research (ICAR), Department of Agricultural Research and Education (DARE), Ministry of Agriculture and Farmers' Welfare, Government of India mandated to address researchable solutions, sustainable management, utilization of aquatic genetic resources and capacity building thereof. ICAR-NBFGR works upon various dimensions of immense aquatic fauna including exploration, documentation, evaluation, conservation and risk assessment of exotic species and diseases. These multi-dimensional approaches are ably supported by undertaking need-based research through implementing in-house expertise keeping parity to global technological advancements. The output generated through these programmes enables ICAR-NBFGR to provide technical backstopping for fulfilling different national and international obligations of the country. The bureau provides technical inputs to national bodies/departments such as DoF, NBA, MPEDA and international organizations such as FAO, OIE and NACA. The institute is also focussing on translation of the research outputs arising from these strategic research programmes through management of the aquatic genetic resources, expansion in dimension of the culture practices and harmonizing conservation with livelihood. Moreover, the institute is engaged in need of the hour activities under different plans envisaged by Government of India such as "Blue Revolution" and "Climate-resilient Aquaculture" for meaningful and quality increase in production by safeguarding the native stocks and diversifying the aquaculture practices.

During 2019, the bureau continued one of its major programme i.e. exploratory surveys in different aquatic systems including river, reservoir, wetland and marine island situated at different parts of the country to unravel and document the inhabiting species in these systems and their scope of utilization in aquaculture, sports and ornamental purposes. Several exploratory surveys have been made to the river systems such as Ganga and its tributaries, Cauvery, Mahanadi, Godavari and Luni; different brackish water lakes of Kerala and marine islands including Andaman & Nicobar and Lakshadweep islands. The institute has published three species of shrimps, which are new to science and seven new distribution records. The characterization of genetic resources below the level of species is one of the flagship programmes of the institute wherein genetic stock characterization of six important species was completed. Whole genome and transcriptome sequence data was generated for important fish species catla and mining of genes from earlier completed genome of hilsa and magur is being pursued. The institute successfully addressed the long outstanding problem of sacrificing male brooders for catfish breeding through demonstrating partial harvest of testes in *Clarias magur*, which allow recovery of males for future programmes. The successful breeding of two endemic and rare species i.e. *Clarias dussumieri* (second

generation) and *Hemibagrus punctatus* was achieved in captivity. *H. punctatus* was revived for conservation, which was published as extinct since 1998.

Seed quality from carp hatcheries has been considered as risk factor for sustainability of carp aquaculture. An expert consultation on genetically responsible aquaculture was organised jointly by ICAR and Network of Aquaculture Centres in Asia-Pacific (NACA) with international experts to identify the issues and strategies. ICAR-NBFGR and NFDB, joint program was undertaken which implements sperm cryobanking technology for genetic exchange among hatcheries. Moreover, another niche area of institute towards conservation is developing and preserving the fish cell lines and ICAR-NBFGR holds the largest collection of fish cell lines in the world. To document and act as resource centre of aquatic genetic resources, ICAR-NBFGR is in process of housing the "National Fish Museum & Repository". Managing the production loss due to diseases is one among the important aspect in aquaculture and in this line the institute is successful in countrywide implementation of the "National Surveillance Programme for Aquatic Animal Diseases" and addressing the global concern of antimicrobial resistance in fisheries. Further, the institute has formulated strategic research programmes to develop rapid diagnostic methods, therapeutic and preventive measures against economically important trans-boundary aquatic animal diseases and emerging diseases.

On behalf of ICAR-NBFGR, I express my deep sense of gratitude to Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR, New Delhi for his esteemed 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) and Dr. B.P. Mohanty, ADG (Inland Fisheries). I also extend my thanks to Principal Scientists, Dr. Yasmin Basade and Dr. Prem Kumar and other staff at Fisheries Division of ICAR for their cooperation.

I take this opportunity to express my gratitude to Ms. Rajni Sekhri Sibal, Former Secretary, DoF for involving ICAR-NBFGR in various programmes of National Importance. My sincere thanks to Dr. J. Balaji, Joint Secretary (Marine Fisheries), and Shri Sagar Mehra, Joint Secretary (Inland Fisheries) for their constant support to the institute. I am grateful to Ms. I. Rani Kumudini, Former Chief Executive, NFDB, for her guidance and support to ICAR-NBFGR.

I express my heartfelt thanks to Dr. B. Meenakumari, Chairperson, Quinquennial Review Team (QRT) and all the members of QRT for their sense of involvement with the programmes of ICAR-NBFGR. I also acknowledge Chairman of Research Advisory Committee (RAC), Dr. George John and all the esteemed members with gratitude for their valuable and consistent guidance in shaping the institute's programmes.

I convey my thanks to Dr. K.S. Srinivas, Chairman, Marine Product Export Development Authority, Dr. C. Suvarana, Commissioner of Fisheries, Government of Telangana, Dr. M. Sudhakar, Former Director, Centre for Marine Living Resources and Ecology, MoES and Dr. Kailash Chandra, Director, Zoological Survey of India for helping to involve in programmes of mutual co-operation. I place on record my thanks to different organizations, Department of Biotechnology, Mangrove Cell, Maharashtra, Bioversity International and World Wide Fund for Nature, India for supporting some of the new initiatives taken by this institute. I also acknowledge NACA, Bangkok for their engagement with this institute in various programmes 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 2019 of the institute.

June 19, 2020

(Kuldeep K. Lal)
Director

CONTENTS

EXECUTIVE SUMMARY

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

- **Mahanadi River**

  Compiled the information based on exploration and assessment of 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. A total of 99 sites explored in both phases of the projects were mapped on GIS. The data on habitat features i.e. micro-habitat type, riparian and aquatic vegetation, dominant substratum, along with water parameters like temperature, DO, salinity, TDS and turbidity, was analysed and compared with the fish diversity data across the sites and seasons. A total of 115 fish species belonging to 15 orders, 46 families and 81 genera were recorded from these explorations.

- **Tributaries and wetland of Ganga river system**

  Exploratory surveys were conducted to assess the fish diversity in three least studied mid-Himalayan tributaries namely, Gandak, Burhi Gandak and Bagmati of the river Ganga in North Bihar to assess the fish diversity and fisheries parameters. The substratum profile of the rivers gradually changes from gravel, sand and silt laden in up-stream segments to sand, silt and clay laden towards mid and downstream stretches of the rivers. Among these Gandak and Bagmati rivers originate in Himalayan region and are snow-fed while the Burhi Gandak is spring fed. The fish diversity of the rivers is of Gangetic origin, which includes a few stray fishes of coldwater region and majority of the plains. A total of 104 fish species were recorded from the rivers of the region under 8 orders, 24 families and 66 genera. A total of 19 fish species has been added to the previous list (85 species) of fishes. The number of species recorded from the rivers Gandak, Burhi Gandak and Bagmati were 85, 73 and 81, respectively. Besides the rivers, Saraiyamaun wetland also harbours copious fish diversity comprising a total of 55 fish species under 7 orders, 20 families and 35 genera. In general fishery of these resources is under depletion and mostly small-sized fishes formed sizeable fishery.

- **Luni River**

  Conducted exploration to assess fish diversity and habitats in the river Luni from origin at Pushkar valley to the confluence at Rann of Kutchh. A total of 14 sampling locations were selected in the up, mid and downstream stretches of the river, categorised on the basis of altitudinal variation and heterogeneity in habitat morphology. The shallow water pools and slow water riffles were the most commonly observed habitat types in the hilly upstream region of Luni river basin. The salinity of river water in the upstream zone was reported to be <0.5 ppt and thereafter, a rapid rise in the salinity was observed in the midstream regions. A total of 27 fish species belonging to 22 genera of 12 families were collected. Arabian toothcarp (*Aphanius dispar*), was recorded abundantly. The widespread invasion of exotics such as, *Clarias gariepinus* and *Oreochromis mossambicus* of different life stages were also observed.

- **Cauvery River**

  Explorations were conducted in the upper reaches of the Cauvery River (5 stations) in Coorg, and its tributary, the Hemavathi River (6 stations) including the Gorur reservoir to assess various fishery parameters. The survey yielded an addition of 4 more species of freshwater fish bringing a total of 117 species from Cauvery River, belonging to 8 orders, 25 families and 68 genera. Exotic fish, *Clarias gariepinus* was encountered in one of explorations at Gorur Dam. Tilapia was abundant at all landing centres located near reservoirs. The conservation status of the Cauvery River shows

65% of the fishes were of Least Concern Category and 9% Endangered or Critically Endangered. A total of 32 COI sequences were generated from 8 species, *Osteobrama neilli, Dario urops, D. neela, Pethia nigripinna, Labeo cf. nigrescens, L. bata, L. kontius* and *L. calbasu* which were having taxonomic ambiguity. DNA barcoding of *Anabas testudineus* revealed a significant difference between specimens recovered from an aquaculture facility and wild. *D. urops* collected from the headwaters of the Cauvery River in Bhagamandala, represents a new record from this region.

- **Andaman and Lakshadweep Islands**

  Exploratory surveys were conducted to assess the fish diversity of Andaman Islands where 23 species, belonging to 20 genus and 13 families were collected from different locations. This added to the earlier collection resulting in 102 species of marine fishes belonging to 8 orders, 42 families and 75 genera from Andaman Islands. Rare occurrence of a deep sea snake fish/band fish [*Acanthocepola indica* (Day, 1888)], was recorded at Chidiyatapu, Andaman Islands, which is also the first report of the fish from Andaman waters. In Lakshadweep, 179 fish specimens were collected, which yielded 69 species belonging to 32 families. This added to the earlier collection resulted in 90 species belonging to 61 genera and 37 families. Molecular analysis has been done for a few species belonging to the family Mullidae, Blennidae and Gobiidae to confirm the species and nine species of goat fishes were confirmed. The analysis also confirmed 8 species of the family Blennidae and 6 species of the family Gobiidae.

- **Ramsar sites of Kerala**

  Widespread distribution of an alien mussel species in the natural beds of yellow clam and green mussel was observed during explorations. During morphological and molecular analysis using DNA barcoding, the sequence of individuals matched with the sequences attributed to *Mytella charruana*/*M. strigata* with an average match of 99.9-100%. This report forms the first information on establishment of an alien mollusc introduced in Indian waters. Given the adaptability of mytilids to estuarine and coastal conditions and their high reproductive rates in eutrophic conditions, it is highly likely that *Mytella* will be established as an invasive species in Ashtamudi lake. Apart from this, 9 molluscan species from 6 families were recorded from the Ashtamudi lake. Species-specific molecular information of cytochrome oxidase I region of the above species were generated. Mean genetic distance among various species of clams, bivalves and cephalopods were 0.14, 0.18 and 0.136, respectively. Average intra-specific variation was found to be 0-0.009. The study revealed deep intra-specific divergences in *Saccostrea* sp. distributed globally, with intra-specific divergence (>2%) that is likely to represent cryptic species.

- **Rivers of North-Eastern region of India**

  The institute is implementing 'Collaborative research programme on fish germplasm exploration, characterization and development of live fish germplasm resource centres in North-Eastern region of India' under ICAR-North-East (NE) component involving collaborators from various institutions of the NE region. 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 centres of indigenous food & ornamental fishes for resource enhancement, sustainable livelihood generation and cytogenetic characterization of endemic fishes of North-Eastern, India. Projects were undertaken by the collaborating partners in Nagaland, Arunachal Pradesh, Meghalaya, Assam, Manipur and adjoining states.

- **Evolutionary study of Indian Clupeiform fishes**

  Explorations were conducted to assess the species-wise genetic diversity in the fishes of order Clupeiformes. Explorations were carried out in Andhra Pradesh, Kerala, Tamil Nadu, West Bengal, Puducherry, Andaman and Lakshadweep Islands for collection of clupeiform species. A total of 67 specimen of 14 clupeoid species were collected from Tamil Nadu, 93 specimen of 20 species from West Bengal, 50 tissue samples of 7 species from Kerala, 5 specimen of *Sparatelloides* sp. were collected from Bangaram area of Lakshadweep, 20 specimen of 6 species were collected from Andaman, 98 tissue samples and 45 voucher specimens from Andhra Pradesh and Puducherry. COI sequences were generated

from 263 specimens of 28 Clupeiform species collected from Andaman, Andhra Pradesh, Gujarat, Odisha, Tamil Nadu and West Bengal coasts.

- The comparative analysis of species of genus *Dussumieria* was carried out based on 18 morphological measurements, 7 meristic counts, X-ray images and molecular data. Phylogenetic tree showed 9 clades in *Dussumieria* genus with sufficiently high genetic distance among them.

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

- **Evaluation of prioritized fish genetic resources**

  A total of 5 fish species were collected and maintained in captivity at PMFGR, Kochi; 4 species in Nagarjuna Sagar, Telangana and 11 species in NBFGR HQ, Lucknow. Broodstock maintenance and induced spawning of endemic yellow catfish, *Horabagrus brachysoma* and Malabar carp, *Labeo dussumieri* has been accomplished. Broodstock development and induced natural spawning of critically endangered catfish, *Hemibagrus punctatus* was successfully carried out in captivity for the first time and progeny is propagated in captivity. Induced natural spawning trials of endangered catfish, *Clarias dussumieri* were successfully carried out with closed-cycle hatchery production, using F1 generation and F2 generation. The possibility of hybridizing two Indian clariid species *viz. C. magur* and *C. dussumieri* was evaluated.

- Wild collected *Pangasius silasi* was evaluated under cage system. Length-weight relationship and condition factor of captive acclimatized fish specimens was comparable to the wild. Nutritional profile (in collaboration with CIFT) revealed good fillet ability, white flesh, lean fat @ 2% and high PUFA (EPA and DHA) contents. Preliminary success was also achieved in induced spawning of *Ompok bimaculatus* without sacrificing the male, at Telangana (cage reared).

- **Stock characterization**

  Genetic diversity in wild populations of *Tor tor* was studied using two mitochondrial genes, Cytochrome b and ATPase 6/8. The total F_{ST} was found to be significant in both the genes with a value of 0.5787 ($p<0.05$) for ATPase 6/8 and 0.3726 ($p<0.05$) for Cytb, which revealed sub-structuring in the *T. tor* natural populations.

  Sequence variations in two full-length mitochondrial genes, Cytochrome b and ATPase 6/8 were investigated to delineate patterns of gene flow in Indian featherback fish, *Chitala chitala*. Analyses of 403 individuals, collected from 14 rivers (5 river basins) in India yielded 61 haplotypes.

  Genetic diversity and structure of *Anguilla bengalensis* was studied. Analysis of 89 sequences (four locations) of ATPase 6/8 genes revealed 17 haplotypes, while cytochrome b was represented by 18 haplotypes. High haplotype diversity (*Hd*) and low nucleotide diversity (π) was observed for both mitochondrial genes.

  A total of 38 haplotypes were observed by analyzing combined mitochondrial genes (Cytochrome b + ATPase 6/8) in 247 individuals of *Silonia silondia* collected from 6 populations. Average haplotype and nucleotide diversities were 0.8508 and 0.00231, respectively.

  In *Systomus sarana*, genetic diversity in 7 riverine populations studied using two mitochondrial genes, Cytochrome b and ATPase 6/8 sequence analysis of 229 individuals, revealed 55 and 15 haplotypes, respectively. The mean F_{ST} was found to be significant in both genes, 0.16 for ATPase 6/8 and 0.26 for Cytb.

  Mitochondrial sequence variations in two full-length genes, Cytochrome b and ATPase 6/8 were used to reveal patterns of genetic connectivity in *Mugil cephalus*. Analyses of 489 individuals, collected from 8 locations yielded 78 and 54 haplotypes, respectively.

  A total of 166 tissue samples of *Litopenaeus vannamei* individuals collected from 12 different farms of Kochi, Cuddalore, Fatehabad, Hisar, Bhiwani, Rohtak and Nellore were assayed using 13 polymorphic microsatellite markers. Partial genome sequences of certain important fish species were generated through PacBio RSII.

  A total of 439 samples of *Chitala chitala* from 14 locations over a time period of 2000-2017 were examined for length-weight relationship (LWR). *C. chitala* scales from five locations (Bansagar 25; Gomti 24; Son 9; Ken 9; Brahmaputra 2) revealed that the highest age class observed in *C. chitala* was 4+.

In *Mugil cephalus*, a total of 267 individuals, collected from different locations were analysed for LWR. The value of 'b' ranged from 3.414 (Thengapattanam) to 2.38 (Coleroon Estuary). Average value of Fulton's condition factor (K) for *M. cephalus* in selected locations ranged from 0.91 (Coleroon Estuary) to 1.08 (Puducherry). In age and growth analysis for *M. cephalus*, 4+ age classes were recorded from all locations except Marakkanam and Thengapattanam. The back-calculated length for 1+ age class was highest in Thengapattanam and lowest in Mandapam, and for 4+ age class it was highest in Mandapam and lowest in Vellar Estuary.

S. sarana scale study from 6 locations (Narmada 18; Betwa 11; Hooghly 11; Guwahati 9; Son 5; Tons 3), demonstrated the highest age class to be 3+ and highest growth rate was observed in Narmada.

In *S. silondia,* truss network analysis was carried out in natural populations using 12 landmarks. A total of 66 morphometric variables were extracted from digital images of the specimens. The principal component analysis provided twelve principal components contributing up to 94.77% of total variation.

- **Genetic stock assessment**

  Genetic stock identification in *Perna viridis* revealed three distinct genetic stocks in Indian waters using molecular markers *viz.* East coast, West coast and Andaman Islands. In addition, fine-scale genetic structuring was revealed in *P. viridis* from West coast (between Goa and Kollam), using nuclear microsatellite markers. No significant pairwise genetic distance was noted among East coast population (0.004, P>0.01). The total number of alleles per locus ranged from 11 to 33 and the allele size ranged from 120 to 390 bp. Mean value of observed heterozygosity (H_{obs} -0.741) for all populations was closer to the expected heterozygosity (H_{exp}- 0.75).

- Studies using taxonomic observation and molecular tools conclude that the *Sillago sihama* exists as fishery only along Kochi, Mangalore, Goa and Ratnagiri in the West coast of India.

- Attempts were made to develop microsatellite marker panels in, *Thunnus albacares, Scomberomorus commerson* and *Trachinotus blochi*. A total of 203 microsatellite loci in *S. commerson,* 100 loci in *T. albacares* and 200 loci in *T. blochii* were developed using PacBio RSII. Of the 100 microsatellite primer pairs tested in *T. albacares*, 26 loci were polymorphic. These markers provide the first specific nuclear microsatellite panels for easy, quick and economical approach for genetic stock identification of a commercially important marine species.

- The amplicons in *S. commerson* exhibited polymorphism at 47 loci, of which 13 panels were formed using 32 primers. These 32 loci were characterized by genotyping 20 individuals each from the Kochi and Veraval in the Arabian Sea and Chennai along Bay of Bengal coast (n = 3). The number of alleles per locus varied from 4 to 17, while the mean observed and expected heterozygosities ranged from 0.656 to 0.753. Cross-species transferability of microsatellite markers tested in *S. guttatus* showed amplification at 23 genomic sites in *S. guttatus*.

- Of the 45 polymorphic loci, 14 panels of 36 loci were standardized in *T. blochii* using samples from three locations: Mandapam, Kochi and Tuticorin. The genotyped data using 36 loci in *T. blochii* are being analyzed to validate the microsatellite primer panels in this species.

- **Population genomics and mapping signature of *Lates calcarifer***

  Attempts were made to document population genomics and genetic signatures of *Lates calcarifer.* The samples (n=92) of *L. calcarifer* were collected from the commercial catches from 6 locations of East and West coasts of India. The pairwise distance and phylogenetic analysis of generated sequences along with sequences (246) of *L. calcarifer* downloaded from NCBI were analyzed together. One cluster represented sequences from Indian subcontinent and Myanmar, while the other comprised of South-East Asia (Singapore, Malaysia, Thailand, Indonesia and Australia).

- **Quantifying agro-biodiversity and ecosystem services in Godavari River basin**

  The program envisaged to assess impact of agriculture effluents on the aquatic ecosystems and in developing recommendations for sustainable aquatic ecosystems in harmony with agriculture development. Three landscapes were selected in the study *viz.* Adilabad, Karimnagar and West Godavari.

The Land Use Land Cover (LULC) analysis revealed that croplands accounted for about 60-70% of the land use in Karimnagar and West Godavari while in Adilabad it was less than 50%. It was observed that area under cropland increased over the years in Adilabad and Karimnagar. The area under water bodies LULC class increased in 1985-1995 and 1995-2005 compared to that in 1985.

Modeling was done for assessment of the sediment retention ecosystem services at the landscape level in three selected regions of Godavari basin using InVEST. The highest sediment export from Karimnagar was found in 'Croplands', while it was 'Deciduous needle leaf forest' in Adilabad and West Godavari. Results of water analysis indicated that the Zinc concentration was 0.5 mg/l in all ten villages sampled, followed by Chromium (0.025 mg/l). Fish and aquatic insect diversity was documented from the surveyed areas. The phytoplankton and zooplankton density was determined and maximum density was observed in locations with reduced water flow. To understand the food and feeding behaviour and the inter-specific relationship between different species, gut contents were analyzed for 14 fish species.

Farmers perception was recorded for which a total of 5 formats were developed, and field tested, demonstrating effectiveness in capturing the data. The informants included agricultural farmers (60), fishermen (68) and other stakeholders (22) belonging to 24 villages of the selected landscapes. The availability of irrigation water was another cause of concern for differential socio-economics of the people. Majority of the fishermen surveyed, opined that their preferred/target fish species have decreased over time, sizes of the fishes caught have reduced, availability and quality of aquatic habitats including aquatic vegetation, have reduced. Measures suggested by the fishermen for enhancement of aquatic diversity and fisheries resources included ranching of fish seed, maintaining water level (environmental flow) in rivers and reduction in usage of chemicals/ pesticides in agriculture.

The pilot study, indicated that ecosystem services are deeply impacted by anthropogenic activities, particularly, agricultural inputs/chemicals, etc.

- **Genetic introgression and variation in hatchery bred Indian Major Carps**

Individual genotyping was done on 18 polymorphic loci for 244 individuals of *Labeo rohita*, collected from 6 distant hatcheries (Uttar Pradesh and Madhya Pradesh). The riverine genotypes (previous study) were also studied together for comparative analysis. The mean allelic richness for all the hatcheries with all loci was found to be 7.9 while it was 15.152 for rivers with same loci in *L. rohita*. In *Catla catla*,10 polymorphic loci were analyzed for 245 individuals from 6 distant hatcheries of Uttar Pradesh, Madhya Pradesh and West Bengal. The mean allelic richness for the hatcheries and all loci was found to be 3.875, while it was 5.8 for the rivers with same loci. Both *L. rohita* and *C. catla* showed significant drop in number of alleles and their frequencies, allelic richness and also the heterozygosity level while comparing it with wild *L. rohita* and *C. catla*.

- **Variations in immunological and disease susceptibility against *Aeromonas hydrophila***

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. TLR2 gene of Indian magur (*C. magur*) was cloned and characterized. The full-length cDNA of magur TLR2 (mTLR2) comprised of 3063 bp with a single open reading frame (ORF) of 2375 bp encoding 790 amino acids was cloned and characterized. Two microsatellites were detected in the upstream and downstream of mTLR2 cDNA i.e., pentamer penta-repeat (GTTTT) 5 at 69 bp and dimer octa-repeat (AC) 8 at 2862 bp. Phylogenetically, mTLR2 is closely related to pangas and exhibited 83.19% identity at nucleic acid and 77.63% identity at deduced amino acid level respectively. Basal expression analysis of mTLR2 and its downstream signaling molecule (MyD88, NFkβ, IL-1β) showed constitutive expression in all the tissue examined. Highest basal expression of mTLR2 and IL-1β was determined in spleen, MyD88 in gill, NFkβ in anterior kidney. Skin has the lowest basal expression of mTLR2, whereas muscle showed least expression of MyD88, NFkβ and IL-1β. Identified and determined the basal expression of teleost-specific TLR i.e. TLR22 and other two genes namely, interleukin-1 receptor-associated

kinase 4 (IRAK4) and tumour necrosis factor receptor-associated factor 6 (TRAF6) involved in the TLR signaling cascades in *C. magur*.

- Studied immune gene expression in *C. magur* challenged with pathogenic *A. hydrophila*. Significant up-regulation of mTLR2, MyD88, NFkβ expression occurred at 3 to 8 h in response to *A. hydrophila* infection. Expression of immunoregulatory cytokine i.e. IL-1β in various organs was significantly enhanced following *A. hydrophila* infection. Serum parameters were compared between infected and control groups at all time points. A significant decrease in myeloperoxidase, bactericidal activity, bacterial agglutination titer, total protein, albumin and lysozyme was observed in infected group at 3 h post infection which indicates that pathogen is able to suppress host immune response.

Program: Genomic resources for important fishes

- **Construction of physical map of *Clarias magur* genome**

  A total of 1560 BAC clones of *C. magur* genome were revived and isolation of BAC insert DNA were accomplished during the reporting period. A total of 1038 end sequences were mapped on the genome scaffolds of *C. magur* using in-house developed bioinformatics tool, BAC2GENOM, and out of which a total of 913 end sequences were anchored on the scaffolds of the *C. magur* genome. A total of 1077 genes present on those BAC clones were mined and annotated.

  BAC insert DNA fluorescence *in situ* hybridization (FISH) is used as a tool for identification of exact location of the genes on the chromosomes. A total of 16 FISH experiments were conducted for localising the genes on the *C. magur* chromosomes, where a total of 135 genes were mapped.

  FisOmics web portal developed at ICAR-NBFGR under the project had 31176 visitors. The hit counts for individual databases were: FBIS- 44123, FMiR-25896, FishMicrosat-29951, Fish Karyome-40411 and HRGFish-23999. Five genomic resource databases were updated using data available in public domain.

- **Stress tolerance response in cultivable species**

  Low water temperature tolerance limit was determined for *Clarias magur, Labeo rohita* and *Heteropneustes fossilis* which was found to be 10°C, 7°C and 11°C, respectively. Higher water temperature tolerance limit of *H. fossilis* was found to be 38°C. *C. magur* individuals were exposed to 37°C water temperature for 45 days to study the proteome (in muscle, serum, gill, liver and brain) and transcriptome (in muscle and liver tissues) profiles along with control. The *C. magur* and *L. rohita* individuals were also exposed to sub-lethal low temperature (12°C and 10°C, respectively) for 45 days to study the long-term effect of low temperature on blood profiles, hormone level and proteomic expression. Capacity building for analysis of hormones, like cortisol, estradiol, thyroxin, testosterone, tri-iodothyronin was done in *C. magur*.

- **Genome sequencing**

  The gill samples of *Tenualosa ilisha* from marine, brackish and freshwater environment were analyzed for differential gene expression in different environment. It was found that 807 genes were up-regulated and 3080 down-regulated in marine vs freshwater environment and 661 up-regulated and 426 down-regulated in brackish vs freshwater environment. A total of 4 and 12 unique genes in the top 20 and top 50, respectively, were identified as significant core genes.

  Genome size of *Catla catla* has been estimated to be 1.28 GB, with flow cytometer analysis and k-mer analysis of short sequence data. A total of 72.46X (57.06X (74.2 GB) and 15.4X (20 GB) of PacBio and Nanopore) long read data and 73 GB of Illumina short read data, respectively, were generated. The initial draft assembled with long read data of *C. catla* genome contained 1.094 GB, with mean N50 1.70 Mb and longest contig 11.70 Mb. BUSCO analysis showed 95% completeness with 93.7% complete BUSCOs and 1.3% fragmented.

  Transcriptome data was regenerated through PacBio RSII in 4 tissues. Total number of transcripts in brain were 29696, kidney 32244, liver 11721 and muscle 14960, with size ranging from 300 bp to 8.4 kb. A total of 29325 transcripts were annotated with Swiss-Prot database. A total of 4 tissues (brain, liver, kidney and muscle) were sequenced on HiSeq 2000 for generating transcriptome data. Assembly with Trinity resulted a total of 219549 contigs in 255.77 Mbp assembled transcripts.

- **Genomic mechanisms of thermal tolerance in golden mahseer, *Tor putitora***

  A total of 270 COI sequences of *T. putitora* samples were analyzed using Clustal W and BioEdit. Molecular identification of fish specimen was completed based on COI sequencing and it has been confirmed that all samples were *T. putitora*. COI sequences revealed a total of 6 haplotypes, with non-significant genetic distance 0.0004. *T. putitora* samples (214) were collected from Ganga and Mahanadi rivers. Sixty-five truss parameters provided 12 principal components that were contributing significantly ($p<0.05$). PCA classification results revealed that 90.1% and 89% were cross-validated grouped cases correctly classified.

  Total RNA was extracted from the 6 different tissues (brain, muscle, gill, liver and kidney) from two different agroclimatic region, Mahanadi and Ganga (Uttarakhand) and transcriptome profile was generated through sequencing with Illumina. A total of 53497816 reads were generated with 48.2% GC content. In biological processes, highest number of transcripts belonged to DNA integration (2731) and in cellular components, 18496 transcripts fell into integral components of membrane and in molecular function, kinase activity comprising of 7272 transcripts.

- **Biochemical adaptational strategies to survive in ammonia enriched toxic waste**

  The indigenous freshwater catfish (*Clarias magur*) is found in habitat with stagnant water bodies and/or muddy substratum, where oxygen is limited, primarily because of excessive content of nitrogenous wastes such as ammonia. Transcriptome profile of brain, liver and kidney of two different ammonia exposures i.e., 3 h, 9 h and control samples were generated through Illumina HiSeq 2500. A total of 1,41,00,81,896 reads comprising 140 GB bases generated 565,026 transcripts. Final set contained 261735 non-redundant transcripts and selected for downstream annotation. Longest transcript length (bp) was found to be 29,300 bp. In two different conditions i.e., Control, 3 h and 9 h exposure to ammonia, differential gene expression (DGE) pattern showed increasing trend of DGE with exposure time, as higher number were observed in control vs 9 h exposure. The gene ontology (GO) terms for transcripts were extracted and different GO terms identified as; molecular function: 1314, biological process: 1946 and cellular component: 507 categories.

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

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

  NRFC was established with an objective to receive, authenticate, characterize, maintain and distribute fish cell lines on request for R&D works. During the reporting period, four new fish cell lines, namely SREM-1 (*Schizothorax richardsonii*, eye) BBdF-1 (*Barilius bendelisis,* fin) and CMgT-1 (*Clarias magur,* testes) developed in the project and LCF (*Labeo calbasu*, fin) developed in ICAR-NBFGR were included in the repository after proper authentication. With these, the NRFC is currently maintaining 63 fish cell line accessions.

  Fish cell lines are used for various purposes and one of important utility of the cell line is *in vitro* toxicity testing of xenobiotics. Cytotoxicity testing of a heavy metal, sodium (meta) arsenite, was carried out in CMgT-1cell line using two end point assays, *viz.* alamarBlue and Neutral Red (NR) assays. The toxicity expressed in terms of Inhibition Constant 50 (IC50), a value where 50% cell viability decreased, was found to be 6.00 and 10.57 µM, respectively. Similarly, toxicity testing was performed for another heavy metal, mercury chloride, in SREM-1 cell line where IC50 was estimated to be 411.0 and 321.9 µM using alamarBlue and NR assays, respectively. The IC50 value for $K_2Cr_2O_7$ in BBdF-1 cell line using alamarBlue assay was found to be 56.48 µM.

- **Livelihood improvement through integrated fish farming model**

  Survey for new site for fish farming experimentation under the project was undertaken in the district of Barabanki for selection of farmers. Soil sampling of the area was done in both the site in relation to pond-led-farming system. The soil pH was within the range of 7.5-8.2. The water quality from nearest sources was found suitable for aquaculture activities.

- **Establishing National germplasm repository and museum**

  Design of the interpretation centre at the repository was finalized. Design for cell line repository, microbial repository and sperm and DNA repository were finalized and implemented. Equipment's such as Cryo-vessel (1000 L capacity)

and LN_2 vapour storage system were installed for ensuring uninterrupted LN_2 supply for storing fish tissues, cell lines, DNA etc.

Fish specimens from different water bodies (marine, freshwater and brackish water) were procured and preserved to display at the museum. A facility for autoradiography for fish skeleton studies and a separate processing room was established. The online database on the fish fauna of India titled AqGRISI covering information on fish taxonomy, biology, genomics and diesases was finalized and launched.

- **Germplasm cryobanking for *ex-situ* conservation**

  In vitro culture from caudal fin cells of *Channa punctatus, Clarias magur, Heteropneustes fossilis* and *Mastacembalus armatus* were carried out. In the case of *C. punctatus*, cell growth and radiation started from 2nd day and formed complete monolayer after day 25 of the culture. Furthermore, in the case of *C. magur*, cell growth and radiation started from 4th day and formed complete monolayer after day 23 of the culture. In the case of *H. fossilis*, cell growth and radiation started from 4th day and after attaining the monolayer cells were passaged twice and cryopreserved. However, in the case of *M. armatus,* cell growth and radiation started from 4th day and after attaining the monolayer cells were passaged thrice, cryopreserved and stored in LN_2. Caudal fin primary cells of *Labeo rohita, Catla catla, Cirrhinus mrigala, Cyprinus carpio*, and *Carrasius auratus*, were also maintained in the repository.

- **Marine ornamental fish village**

  A total of 10 species of clownfishes; *Amphiprion ocellaris, A. percula, A. frenatus, A. clarkii, A. ephippium, A. sebae, A. nigripes, A. akallopisos, A. perideraion* and *Premnas biaculeatus* were stocked in the hatchery of ornamental fish village in Maharashtra. Successfully developed the broodstock/pair for seven species. Larval rearing and juvenile production was achieved for *A. percula, A. clarkii* and *A. ocellaris* and subsequent batches are being produced.

- **Indian Major Carp milt cryobank**

  Basic facility for cryo-storage of carp milt including Liquid Nitrogen Vapour Storage System, Dry shippers and 1000 L Liquid Nitrogen Storage Tank has been established. The institute supplied 1.5 litre of cryopreserved Indian Major Carp milt to 13 hatcheries across 4 states (Uttar Pradesh, Bihar, West Bengal and Odisha) and produced 37.2 lakh spawn. Investigated the possibility of up-scaling milt cryopreservation through various experiments.

- **Biotechnological approach for production of *Clarias magur* spermatozoa**

  Examined the suitability of assisted reproductive biotechnology treatment with Busulfan, a cytotoxic agent, and warm water, 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*. The spermatogonia cell was harvested from donor *C. magur* and labelled with PKH 26 Cell Linker. Spermatogonial cell were transplanted into recipient (*P. hypophthalmus*) gonads through non-surgical interventions. The transplantation efficiency was observed by distribution of trypan dye throughout the gonads. Spermatogonial cell were transplanted into recipient (*P. hypophthalmus*) gonads through non-surgical interventions. 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.

- **Ornamental fish breeding and culture**

  Prioritised ornamental fish *Dawkinsia rubrotinctus* from Cauvery River, *Halduria fasciata* from Chalakudy River and *Pethia setnai* from Goa were collected and reared at Kochi in fibre glass tank and the stock fed with artificial feed. *D. rubrotinctus*, collected from Cauvery River and the F1 stocks of last year were taken for breeding. The fishes bred within 2-3 days in tub, and after a week, fry were siphoned out into rearing tanks. On an average, 70-100 fry were obtained from each trial. Temperature of water was in the range of 25-28°C, pH in the range of 6.5-7.5 and dissolved oxygen 3.5-5.0 ppm. A total of 12 trials were conducted and nearly 1000 young ones were produced. Wild broodstock of *H. fasciata* were collected from Chalakudy River in Kerala and reared in fibre glass tanks. Artificial feed was given during the rearing period. The fish exhibits clear sexual dimorphism and males and females were

conditioned separately for 2 weeks before being placed in spawning tanks at 1:1 ratio. Spawning was observed within 24-48 hours. Temperature of water was in the range of 24-27.5°C, pH in the range of 6.5-7.5 and dissolved oxygen 3.5-4.6 ppm. A total of 6 trials were conducted and nearly 200 young ones were produced.

- **Germplasm resource centre for marine ornamental invertebrates**

  Exploratory surveys were carried out in eight islands of Lakshadweep-Agatti, Kalpetti, Thinnakara, Bangaram, Parali I, Parali II, Kavaratti and Minicoy. A total of 212 individual ornamental shrimps and 35 sea anemones were collected, besides crabs, nudibranchs and worms. The collected shrimps belong to 7 families, 11 genera and 15 species. Broodstock development was achieved for *Thor hainanensis, Ancylocaris brevicarpalis, Stenopus hispidus, Periclimenella agattii, Saron marmoratus, Lysmata hochi, Gnathophyllum americanum and Urocaridella sp.* and *Urocaridella* sp. Juveniles were successfully raised for *T. hainanensis* and *P. brevicarpalis*, which is the first attempt nationally and globally. In addition, experimental success in juvenile production was achieved for *G. americanum*, *S. marmoratus*, *P. agattii* and *L. hochi*.

- **Spermatogonial stem cell line (SSC) from *Sahyadria denisonii***

  A total of ten numbers of trials of testis tissue explants of *Sahyadria denisonii* was carried out and radiation of cell reported from the explants. Primary culture of *S. denisonii* testicular cells using Ficoll gradient separation of spermatogonial cells was performed using germ cell line media formulated in the lab. Monolayer of testicular cells of *S. denisonii* was established and passaged for 5 times. Monolayer of sertoli cells of the testis of the fish was also established during the course of establishing SSC cells. Approximately, after 4 days of culturing, spermatogonia cells formed colonies. Several SSCs colonies were observed and developed in the co-culture group.

Program: Documentation of fish genetic resources of India

- **Intellectual property management of agricultural technology scheme**

  Prior art search through patent literature was conducted in the field of proteomics for technological advancement. A patent landscape for proteomics and LC-MS based Mass Spectroscopy showed trends in technological advancements that can help for competitive intelligence. Major databases namely, World Intellectual Property Organisation (WIPO), European Patent Office (EPO), and United States Patent and Trademark Office (USPTO), searched with International Patent Classification (IPC) Codes for curated analysis of patents associated in the field of instrumentation provided 3236, 204 and 3418 patents, respectively. An interactive outreach awareness session was organized on the theme "Intellectual Property Rights and Creativity for Innovation" in a rural village.

  Women Self Help Group (SHG) participated in an interaction session on "Co-creating Community Upliftment through design-based intervention for empowerment of women Self Help Groups" on September 26, 2019. An exhibition of handicrafts prepared by women using natural fibre was also organized.

- **Aquatic Genetic Resources Information System (AqGRISI) of India**

  The online database on the fish fauna of India titled AqGRISI covering information on fish taxonomy, biology, genomics and diesases was finalized and launched. AqGRISI provides the ability for user to browse and view the information on various aspects of fish genetic resources native to Indian waters. Presently, this information system covers 3138 native fish species belonging to 247 families and 47 orders.

  Besides providing the information oriented services, the system includes a beautiful photo gallery of fishes and an interactive GIS based point map displaying occurrence information of the Indian fish specimens recorded in the Global Biodiversity Information Facility as well as information documented in global museums or repositories. In addition to these, the system integrates in-house molecular resources like HRGFish (A database of hypoxia responsive gene 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) developed under

the National Agricultural Bioinformatics Grid in ICAR project, which facilitates the user to view the information from these resources.

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

- **Prevention and future control of the two major diseases in Asian aquaculture**

  Rohu and common carp were experimentally infected with *Aphanomyces invadans* and to understand the mechanism of susceptibility and resistance, RNA sequencing of head kidney was carried out. Analysis of RNA-seq data of susceptible rohu revealed 5608 differentially expressed genes (DEGs), out of which, 390 genes were involved in 21 immune pathways. The major affected immune pathways included antigen processing and presentation, leukocyte trans-endothelial migration, IL-17 signaling pathway, T-cell receptor signaling pathway, C-type lectin receptor signaling, platelet activation and toll-like receptor signaling pathway. In the affected pathways, a number of immune genes were found to be down-regulated, suggesting an immune evasion strategy of *A. invadans* in establishing the infection in the susceptible host. On the other hand, a total of 5288 genes were differentially expressed in head kidney of common carp. Out of these, 731 genes were involved in immune pathways. The major affected pathways included antigen processing and presentation, NOD-like receptor signaling pathway, leukocyte trans-endothelial migration, chemokine signaling pathways among others. Importantly, majority of genes in antigen processing and presentation and NOD-like receptor signaling pathway were found to be up-regulated, suggesting that these would be playing an important role in resistance to *A. invadans* infection.

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

  The National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) coordinated by ICAR-NBFGR is being implemented through 31 collaborating centres in 19 states and 3 union territories of the country. First report of red sea bream iridovirus (RSIV) disease (an OIE-listed disease) in sea bass was validated. Four QAAD reports were compiled on the basis of reports received from NSPAAD collaborating centres and submitted to DoF, Ministry of Fisheries, Animal Husbandry and Dairying.

  The positive controls for different pathogens were shared with the collaborating centres as per their requirement. Technical backstopping was provided to Department of Fisheries regarding ban on import of frozen shrimp due to presence of WSSV and IHHNV.

  An ICAR and NACA School on Aquatic Animal Epidemiology and Disease Surveillance was organised at ICAR-NBFGR during March 1-6, 2019 for 12 researchers from 8 Institutes. ICAR-NBFGR also coordinated organization of training programmes for AquaOne Centres of NFDB by RGCA, Nagapattinam; FFSc, Kolkata and SIFT, Kakinada. Further, a TAC meeting was organized at ICAR-NBFGR, Lucknow on December 19, 2019.

  Lead and oral presentations were made during Global Conference on AquaEpi II held in Hua Hin, Thailand during November 4-6, 2019. During the Conference, ICAR-NBFGR won the bid to host AquaEpi III in New Delhi proposed to be held in November, 2022.

- **Surveillance of freshwater diseases in Uttar Pradesh and Haryana**

  Pangas farms in the different districts of Uttar Pradesh were surveyed and sampling was carried out in a total of 33 farms. The major bacterial pathogens associated with diseases in pangas included *Edwardsiella tarda* and motile aeromonad species, namely *Aeromonas hydrophila, A. caviae, A. veronii* and *A. sobria*. In addition, *Saprolegnia parasitica* was identified as the causative agent of large-scale mortalities in pangas farms (n=11) in Azamgarh district. Samples collected from shrimp farms of Haryana were screened for the presence of *Enterocytozoon hepatopenaei* (EHP), WSSV, HPV, IHHNV and MBV were positive for EHP infection and negative for remaining pathogens.

- **Surveillance of ornamental fish diseases**

  A total of 125 ornamental fish samples were collected from 5 districts of Kerala and 2 districts in Tamil Nadu for targeted active surveillance of spring viraemia of carp and koi herpesvirus in ornamental fish and all samples found negative. A total of 78 goldfish samples were also tested for cyprinid herpesvirus -2 (CyHV-2) and 24 samples

found positive for CyHV-2. A total of 85 koi carp samples were also tested for carp edema virus (CEV) and 28 samples found positive for CEV.

During October - December 2019, very high mortality (>80-90%) were reported in intensive oscar, *Astronotus ocellatus* and giant gourami, *Osphronemus goramy* culture systems across Kerala. PCR confirmation and DNA sequencing identified the virions in the tissues of the diseased fish as Infectious Spleen and Kidney Necrosis Virus (ISKNV). An experimental infection of naive oscar fish using supernatant from ISKNV infected AOF cell line developed from fin tissue of oscar caused 100% mortality.

Epizootic ulcerative syndrome (EUS), epizootics was evidenced among estuarine fishes of Kerala, India under post-flood conditions. Six fish species (*Mugil cephalus, Platycephalus sp., Scatophagus argus, Arius* sp., *Planiliza macrolepis* and *Epinephelus malabaricus*) were found to be infected; forming the first confirmed natural case in *E. malabaricus* and *P. macrolepis*. The histological and molecular characterization revealed that the fishes were severely infected with *Aphanomyces invadans*.

- **Antimicrobial resistance in fisheries and aquaculture**

  A total of 97 farms in Barabanki, Varanasi and Bareilly districts of Uttar Pradesh were sampled and 97 fish samples were analyzed for isolation of *Escherichia coli, Aeromonas* spp., and *Staphylococcus* spp. During the course of study, a total of 272 bacterial isolates were analyzed comprising of 82 isolates of *E. coli*, 95 isolates of *Staphylococcus* spp., and 95 isolates of *Aeromonas* spp. A total of 82 isolates of *E. coli* were analyzed for AMR comprising 15 listed antibiotics. Out of these, highest resistance of 26.8% was seen against ampicillin and nalidixic acid, and 20.7% isolates were resistant to ceftriaxone and cefotaxime. Further, a total of 95 isolates of *Staphylococcus* spp. were analyzed for AMR comprising 9 listed antibiotics. Out of these, 47.4% isolates were resistant to penicillin, and 27.7% isolates were resistant to trimethoprim/ sulfamethoxazole. Moreover, a total of 95 isolates of *Aeromonas* were analyzed for AMR for 11 listed antibiotics. Out of these, 11.6% isolates were resistant to cefotaxime. A total of 6.6% of isolates were resistant to ceftazidime.

- **Exotic species in open waters**

  The river Ganga was observed to be under massive invasion of common carp and Nile tilapia. Among the total fish catch from the river at Prayagraj, alien fishes form approximately 26-45% of the total catches. The river Tons also comprised 20-25% alien fishes, dominated by tilapia. Aliens in the river Yamuna form 35-70% of the total catch dominated by tilapia. Alien fishes in the river Gomti in Lucknow indicate considerable invasion, which form 10-20% of the total catches in which common carp forms major share of the total catches, followed by Nile tilapia. Stray samples of silver carp, bighead carp, and grass carp were also caught. Few samples of African magur were also recorded occasionally in the rivers.

  Luxurious population of alien fishes including Nile tilapia and common carp were also observed in Keetham jheel, Agra. Availability of all-sized tilapia specimens clearly reflect about its established population. The fort moat of Lohagarh in Bharatpur, is highly impaired due to high organic load received through city drainages and run-off from the catchments. As a result, the aliens in general and Nile tilapia in particular are flourishing in the moat water. Experimental fishing (50 casts with cast net) yielded almost 100% tilapia catch. The gut contents of African magur of river Yamuna caught near Agra, reveals percent composition of aquatic worms (46%), detritus (43%), insects (7%), and plant matter (4%). Fish sampling in the Periyar lake indicate sizeable occurrence of alien fishes including African magur, common carp and tilapia. Stray samples of African magur were also caught from the Panamaram and Mananthvadi rivers.

- **Host-pathogen-environment interaction of tilapia lake virus disease**

  Samples, collected previously from Ernakulam, Kerala which tested positive for TiLV using RT-PCR, were processed for virus isolation and the virus was propagated in OnH cell line (developed in our laboratory). For establishing an experimental infection, a total of 50 tilapia were procured from a fish farm. From those fish, five fish were randomly selected and screened for TiLV. All the five fish were negative for TiLV in PCR. Thereafter, the supernatant from infected cell line was used for experimental reproduction of TiLV disease.

By 8 days, typical lesions including exophthalmia and abdominal distension were observed in the infected fish, and on post-mortem examination, ascetic fluid was observed in the abdominal cavity.

- **Vaccines and Diagnostics**

  Experiments were conducted on *Aphanomyces invadans*. Paraformaldehyde-killed zoospores alone and in conjunction with adjuvant Montanide™ ISA 763 AVG were used for immunization of rohu juveniles. The fish from immunized and control group were challenged with zoospores of *A. invadans* to determine the relative percent survival (RPS), after 14 days of the booster dose. The results revealed 100% mortality in all the groups, suggesting that immunization with inactivated zoospores did not render protection in immunized rohu. Challenge experiments on rohu after 14 days of booster immunization revealed 60% RPS in immunized group whereas, only 10% RPS was observed after 28 days of booster immunization.

  Three new cell lines including Fantail goldfish gill (FtGG), Fantail goldfish liver (FtGL) and Fantail goldfish brain (FtGB) has been established and characterized from the gill, liver and brain tissue of *Carassius auratus* respectively for the isolation of CyHV-2. All the three cells showed cytopathic effect (CPE) between 3-5 days post-infection (dpi) with CyHV-2 and complete destruction of the monolayer was observed at 8 -10 dpi. The results provide firm evidence that the FtGG cell line is highly permissive for the isolation and propagation of CyHV-2. The newly designed primer set could amplify 942 bp partial sequence of the MCP gene of CyHV-2. The sequences of the MCP gene of CyHV-2 isolated from goldfish in this study were deposited in GenBank (accession numbers KU527546 and KU527547). A GenBank BLAST search on the sequence revealed 100% similarity with CyHV-2 isolate SYC1 strain (KM200722) and CyHV-2 isolate STJ1 strain (JQ815364). Newly designed PCR primer could amplify 100 copy numbers of the CyHV-2 MCP plasmid construct.

- **Therapeutics against major finfish pathoghens**

  The efficacy of different concentrations of commonly used chemicals and antifungal drugs against different stages (zoospores, germination of zoospores and growth of hyphae) of *Aphanomyces invadans* was studied under *in vitro* conditions. Among the disinfectants tested, formalin could potentially inhibit the sporulation at 10 ppm, and significant level of inhibition of the germination of zoospores and growth of hyphae was observed at this concentration. The complete inhibition of spore germination and growth of hyphae could only be detected at the concentration of 100 ppm. On the other hand, H_2O_2 and $KMnO_4$ could inhibit germination of zoospores and growth of hyphae only up to certain extent even at 100 ppm. Two antifungal drugs, fluconazole and amphotercin B also showed inhibitatory effect on different stages of *A. invadans*.

  A total of 34 fish samples collected from fish markets and processed. Bacteriophage were isolated against *A. hydrophila* bacterial strains *viz.* 4P1, 10G1, 10C and 7C. In the diffusion method, all phages had titers $>10^9$ pfu/ml. Among the isolated phages, 10G1 and 7C retained its activity in terms of plaque size and clarity. Out of these two phages, 7C phage was found to have an efficient lytic activity, hence taken up for phenotypic and molecular characterization. Further, 25 fish samples were processed for the isolation of bacteriophages against *Flavobacterium columnare* using standardized protocol. However, till now no bacteriophages against *F. columnare* could be isolated.

Publications

The institute published 47 research papers in different peer reviewed journals, along with various popular articles during the year 2019.

Institute also published an Abstract cum Souvenir (204 pages) entitled One Health & Ecosystem Services.

Expert consultations/ conferences organized

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 brood stock and seed of certified origin in Asian aquaculture" from February 26-27, 2019.

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.

The Indian Council of Agricultural Research, New Delhi and ICAR-National Bureau of Fish Genetic Resources (NBFGR), Lucknow jointly organized a one-day "National Consultation on Genomics and Bioinformatics in Agriculture: The Way Forward" at the National Agricultural Science Centre Complex, New Delhi on November 27, 2019.

ICAR-NBFGR, Lucknow and the Academy of Environmental Biology (AEB) organized a two-days Conference "One Health & Ecosystem Services (OHES-2019)" from November 29-30, 2019 at NBFGR, Lucknow in collaboration with Aquatic Biodiversity Conservation Society (ABCS).

Capacity building programs:

- **NFDB sponsored Skill Development Programme for Farmers and State Officials**

  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 153 participants.

  Two residential training programmes of 5 days duration under NFDB sponsorship for the all India state officials, entrepreneurs and progressive fish farmers were conducted on ToT for Re-Circulatory Aquaculture System (RAS).

- **Skill development training under Rashtriya Krishi Vikas Yojana (RKVY)**

  Two skill development programmes for freshwater aquaculture farmer under RKVY in collaboration with ICAR-ATARI, Kanpur and Agricultural Skill Council of India (ASCI) were conducted, where a total of 40 farmers were benefited.

- **Training Programmes on Clownfish Aquaculture**

  A 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.

  Another training programme on Clownfish Aquaculture was organised at the ICAR-NBFGR hatchery facility at Airoli, Mumbai during November 14-16, 2019 for 30 beneficiaries of Raigad district of Maharashtra.

Farm activities

The institute has been supplying quality IMC seeds to fish farmers, hatchery owners and state fisheries departments of Uttar Pradesh. During the reported period, institute produced 923 lakh seed in the form of spawn, fry and fingerlings of Indian Major Carps, minor and exotic carps.

NEW FISH SPECIES DISCOVERED AND PUBLISHED BY ICAR–NBFGR FROM INDIA (2015-2020)

During 2015 to 2020, a total of 14 new fish species and 6 new distribution records were discovered and published in peer reviewed journals by researchers from ICAR-NBFGR.

Category	North-East India	West India	Central India	Western Ghats	Marine and Island Ecosystem	Total
New to Science	04	01	02	01	06	14
New Distribution Records					06	06
Under Publication			01		08	09

New fish Species: Out of 14, 11 fish species are new to science and first discoveries and descriptions. The 3 species are rediscoveries and re-described. These species were reported and named by explorers in the past but not considered valid due to lack of evidence or specimens. These species, when discovered and validated their original names are resurrected. Such rediscoveries are equivalent to new species discoveries.

New distribution records: Earlier known species but discovered in previously unknown distribution range. These valid species were described for the first time in Indian waters.

In addition, 9 new species and records are in the process of analysis and publication.

Details of the New Species

1		
Name	*Labeo rajasthanicus*	
Location of Discovery/River etc.	Jaismund Lake, Rajasthan	
Ecosystem	Freshwater	
Publication	Indian Journal of Fisheries, 2015	
Use	Commercial food fish, Captive Bred, MPUAT, Udaipur	Re-description/ Rediscovery

2		
Name	*Sphyraena arabiansis*	
Location of Discovery/River etc.	Cochin Fisheries Harbour, Kerala	
Ecosystem	Marine	
Publication	Indian Journal of Fisheries, 2015	
Use	Commercial fishery	

3		
Name	*Chaunax multilepis*	
Location of Discovery/River etc.	Arabian Sea, Kerala	
Ecosystem	Marine	
Publication	Zootaxa, 2016	
Use	Non- commercial / Deep Sea	

4		
Name	*Lamiopsis temminckii*	
Location of Discovery/River etc.	Newferry wharf, Sasson dock and Satpati fisheries harbor, Maharashtra	
Ecosystem	Marine water	
Publication	Zootaxa, 2016	
Use	Commercial food fish / Endangered	Re-description/ Rediscovery

5		
Name	*Rita bakalu*	
Location of Discovery /River etc.	Pranhita River, Bejjur &, Godavari river system, Telangana.	
Ecosystem	Freshwater	
Publication	Hydrobiologia, 2017	
Use	Wild caught food fish	

6		
Name	*Laubuka parafasciata*	
Location of Discovery / River etc	Sala River, tributary of Kaladan River, Mizoram	
Ecosystem	Freshwater	
Publication	Zootaxa, 2017	
Use	Ornamental	

7		
Name	*Pangasius silasi*	
Location of Discovery / River etc.	Nagarjuna Sagar Dam, Krishna River, Telangana	
Ecosystem	Freshwater	
Publication	Hydrobiologia, 2017	
Use	Wild caught food fish, Aquaculture potential, for import substitution	

8		
Name	*Channa stiktos*	
Location of Discovery/River etc.	Tiau River and Kaladan River drainage, Mizoram	
Ecosystem	Freshwater	
Publication	Vertebrate zoology, 2018	
Use	Ornamental	

9		
Name	*Aenigmachanna mahabali*	
Location of Discovery/River etc.	Thiruvalla, Kottayam, Kerala	
Ecosystem	Freshwater	
Publication	Zootaxa, 2019	
Use	Non-commercial	

10		
Name	*Periclimenella agattii*	
Location of Discovery/River etc.	Agatti island, Lakshadweep	
Ecosystem	Marine water	
Publication	Zootaxa, 2019	
Use	Ornamental (Experimental Breeding Success)	

11		
Name	*Pampus candidus*	
Location of Discovery/River etc.	Bay of Bengal and Arabian Sea	
Ecosystem	Marine	
Publication	Zoological studies, 2019	
Use	Commercial food fish	Re-description/ Rediscovery

12		
Name	*Cabdio crassus*	
Location of Discovery/River etc.	Kaladan River, Mizoram	
Ecosystem	Freshwater	
Publication	Zootaxa, 2019	
Use	Ornamental	

13		
Name	*Neolissochilus kaladanensis*	
Location of Discovery/River etc.	Kaladan River, Mizoram	
Ecosystem	Freshwater	
Publication	Mitochondrial DNA, 2019	
Use	Ornamental	

14		
Name	*Urocaridella arabianensis*	
Location of Discovery/River etc.	Agatti island, Lakshadweep	
Ecosystem	Marine water	
Publication	Zootaxa, 2020	
Use	Ornamental	

New Distributional Records in Indian waters

1		
Name	*Bathymyrus simus*	
Location of Discovery/River etc.	Nagapattinam (Tamil Nadu) and Digha (West Bengal)	
Ecosystem	Marine	
Publication	Thalassas, 2019	
Use	Non-commercial	

2		
Name	*Cypselurus opisthopus*	
Location of Discovery/River etc.	Vizhinjam, Kerala	
Ecosystem	Marine water	
Publication	Journal of Ichthyology, 2019	
Use	Commercial food fish	

3		
Name	*Thor hainanensis*	
Location of Discovery/River etc.	Agatti island, Lakshadweep	
Ecosystem	Marine	
Publication	Zootaxa, 2019	
Use	Ornamental (Experimental Breeding Success)	

4		
Name	*Argeiopsis inhacae* with *Stenophus hispidus*	
Location of Discovery/ River etc.	Agatti island, Lakshadweep	
Ecosystem	Marine	
Publication	Current Science, 2019	
Use	Ornamental	

5		
Name	*Leptojulis lambdastigma*	
Location of Discovery/River etc.	Andaman Islands	
Ecosystem	Marine water	
Publication	JMBAI, 2020	
Use	Ornamental	

6		
Name	*Lysmata hochi*	
Location of Discovery/River etc.	Agatti island, Lakshadweep	
Ecosystem	Marine	
Publication	Zootaxa, 2020	
Use	Ornamental (Experimental Breeding Success)	

INTRODUCTION

Brief History

India is blessed with vast and varying topographical features that possess diverse natural resources, which not only maintains ecological integrity and valuable gene pool but also offers immense opportunities for livelihood support. Aquatic genetic resources which is an important component of biodiversity, provides nutritional security to our fast-growing population and thus, has become one of the prioritised areas for both policy makers and researchers over the last two decades. Though, India possesses huge aquatic resources spread across different freshwater, brackish water and marine regions, majority is either unutilized, underutilized or facing serious threats due to anthropogenic and natural environmental changes. In view of this, conservation of aquatic germplasm resources has gained incredible significance in perspective of our fishery resources. Sound scientific knowledge is necessary to document, preserve and understand the genetic resources which can be utilized for nutritional and environmental security of mankind. India is among the few countries which took the lead to accelerate scientific research on fish genetic resource management.

ICAR-National Bureau of Fish Genetic Resources (NBFGR) was established at the end of Sixth Five Year Plan to provide scientific input for management of fish germplasm resources of the country under the aegis of Indian Council of Agricultural Research, by Govt. of India. Since its modest beginning at Allahabad in 1983, ICAR-NBFGR has transformed into a leading institution to address research related to conservation

of aquatic genetic resources. In 1999, ICAR-NBFGR shifted to the sprawling campus of Lucknow complete with administrative and laboratory facilities. Over the years, the institute established new facilities including genomics labs, climate-controlled hatcheries, wet-labs, experimental tanks and ponds to cater the needs of multi-faceted research along with public aquarium, guest house and staff quarters. The institute is now operating with four divisions (three at HQ and one at Kochi) along with a field training unit at Chinhat, Lucknow. In recent years, the bureau has created infrastructure, state of the art facilities and in-house expertise in several research areas including development of genomic databases, molecular markers, genetic characterization, live gene banks, fish germplasm and habitat inventory, risk analysis of exotic species, diagnostics for OIE notified pathogens, aquatic microbes and other areas of germplasm conservation with special focus on prioritized agrobiodiversity fish species of indigenous and exotic origin.

ICAR-NBFGR has consistently worked to develop in-house capacity to generate knowledge and address researchable issues relevant to the changing needs of FGR management in India, with thrust on keeping pace with technological advancements. The institute has seen splendid growth not only in terms of creation of new infrastructure, but also in extension of research programmes in important areas *viz.,* whole genome sequencing, population genetics, transcriptomics, *ex-situ* and *in-situ* conservation, sperm cryobanking, molecular disease diagnostics and therapeutics, national surveillance programme for aquatic diseases, antimicrobial resistance in fisheries and aquaculture, exploration of newer and unexplored geographical areas for assessment of fish diversity, etc. to name a few.

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

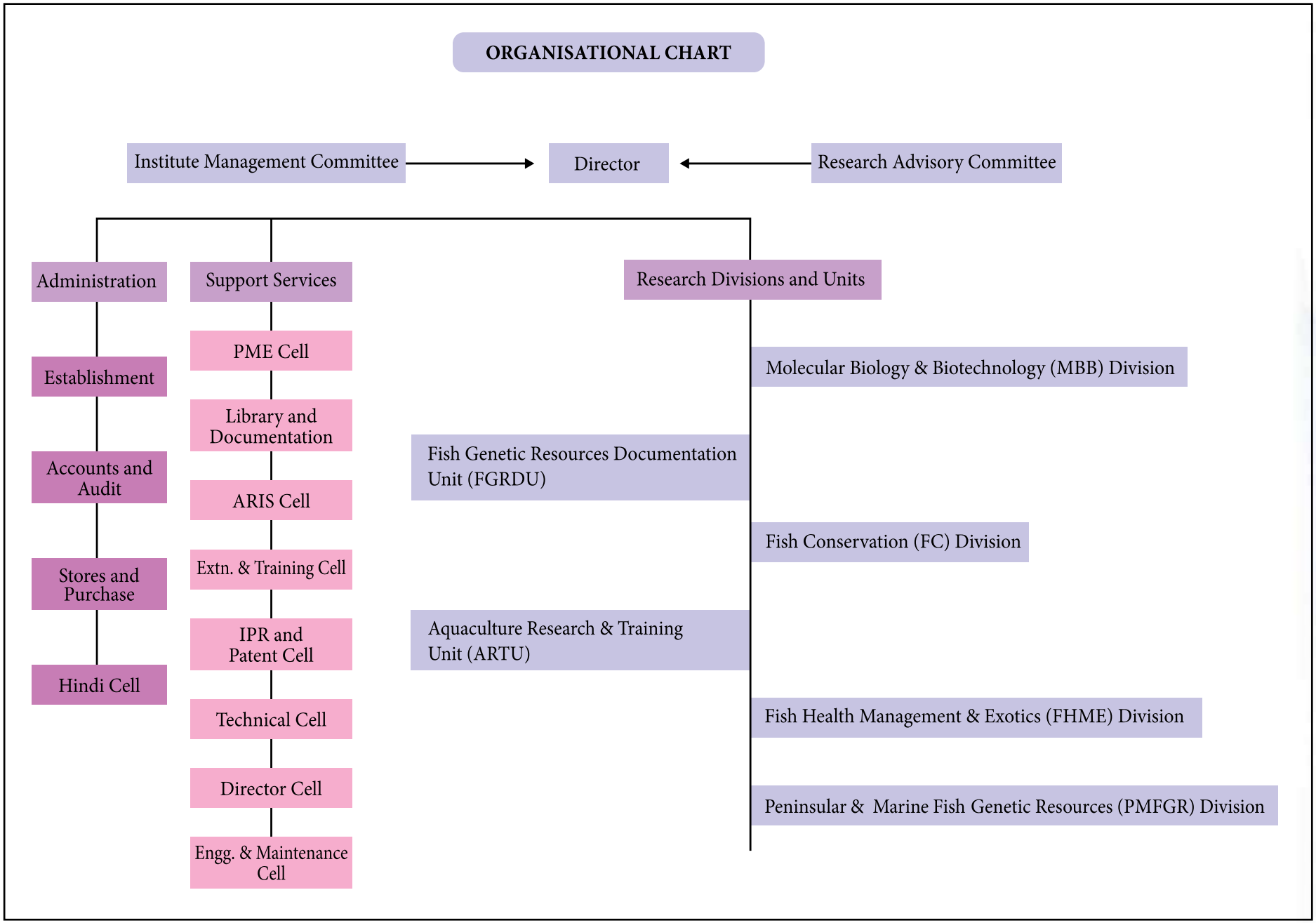
MANDATE

- 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

Staff Position

The overall staff position as on December 31, 2019 is given below:

S. No.	Category of posts	Post created	Staff in position	Post vacant (out of created posts)
1.	Research Management (Director)	01	01	00
2.	Scientific	41	32	09
3.	Technical	38	29	09
4.	Administrative	21	18	03
5.	Supporting	20	19	01
	Total	**121**	**99**	**22**


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

India harbours rich biological wealth that provides ample opportunities for development of various sectors including fisheries. Its a great challenge before the policy makers to safeguard the diverse biological wealth for posterity. Hence, appropriate conservation efforts are necessary to protect this vast biological wealth. Unravelling various components of biological diversity is important for management and conservation of these resources. Lack of knowledge increases the risk of losing important units of biological diversity without even recognising their existence. Exploration is an ongoing activity of ICAR-NBFGR, as part of the scientific research on aquatic genetic resource management. Explorations are useful not only for discovery of new species but also to record range extension of the species from different aquatic resources. 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. Such macro level explorations pave the way to further research on species characterization, evaluation and even domestication of the potential species.

Project: Systematic review and evolutionary study of Indian Clupeiform fishes

Period: April, 2017 - March, 2020

Personnel: Mahender Singh (PI), T.T. Ajith Kumar, Murali S., Teena Jayakumar T.K. and Akhilesh Kumar Mishra

Funding Support: Institutional, ICAR-NBFGR

The aim of the project was to assess the species-wise genetic diversity present in the fishes of order Clupeiformes which are commercially important in terms of food, forage and pharmacological uses. During the period, explorations were carried out in Andhra Pradesh, Kerala, Tamil Nadu, West Bengal, Andaman, Puducherry and Lakshadweep for collection of clupeiform species. In Tamil Nadu, 67 specimens of 14 clupeoid fish species were collected from fish markets at Pattinapakkam and Royapuram and also from the landing centre at Pulicat. The fourteen species included *Dussumieria elopsoides, Encrasicholina* sp., *Hilsa kelee, Ilisha melastoma, Nematalosa nasus, Opisthopterus tardoore, Sardinella brachysoma, S. gibbosa, Stolephorus commersonni, S. indicus, Thryssa dussumieri, T. hamiltonii, T. malabarica* and *T. mystax.* In West Bengal, 93 specimens of twenty species *viz., Coilia ramcarati, Encrasicholina* sp., *Escualosa thoracata, Gonialosa manmina, Ilisha elongata, I. megaloptera, I. melastoma, Pellona ditchella, Raconda russeliana, Sardinella fimbriata, S. melanura, Setipinna phasa, S. taty, Stolephorus* sp., *Tenualosa ilisha, Thryssa kamalensis, T. kamalensoides, Thryssa* sp., were collected. From the landing centres of Kochi, Calicut and Vizhinjam, 50 tissue samples of 7 species namely *Anadontostoma chacunda, Dayella malabarica, Ehirava fluviatilis, Hilsa kelee, Sardinella longiceps, S. melanura* and *Thryssa dayi* were collected. Five samples of *Sparatelloides* sp. were collected from Bangaram area of Lakshadweep. From Andaman, 20 specimens each of species *Amblygaster clupeoides, A. sirm, Anadontostoma selangkat, Hilsa kelee, Sardinella* sp., and *Thryssa setirostris* were collected. A total of 98 tissue samples and 45 voucher specimens of clupeiform fishes were collected from fishing harbour/landing center/ fish market at Vishakapatnam, Kumbhabhishekam, Kakinada, Mathlapatnam, Machalipatnam and Vijaywada areas of Andhra Pradesh and Yanam of Puducherry (Fig.1 & 2). The collected species were *Anadontostoma chacunda, Chirocentrus dorab, Coilia dussumeiri, Coilia* sp., *H. kelee, Ilisha* sp., *N. nasus, O. tardoore, T. malabarica, S. longiceps, Sardinella* sp., *Stolephorus indicus, Stolephorus* sp., *T. setirostris* and *Thryssa* sp. From all explorations, a total of 333 samples of 30 Clupeiformes species, including targeted genera (*Thryssa, Chirocentrus* and *Dussumieria*), were collected. The 30 species collected are *Amblygaster sirm, Anadontostoma selanghat, A. chacunda, Chirocentrus dorab, Coilia dussumieri, C. neglecta, C. reynaldi, Dussumieria elopsoides, Escualosa thoracata, H. kelee, I. melastoma, N. nasus, O. tardoore, R. russeliana, S. albella, S. fimbriata, S. gibbosa, S. longiceps, S. melanura, S. commersonnii, S. indicus, Tenualosa ilisha, Thryssa dayi, T. dussumieri, T. hamiltoni, T. kammalensis, T. malabarica, T. mystax, T. setirostris* and *T. vitrirostris.*

Photographs on graph paper and weight in grams were also recorded for all the specimens. Comparison of morphomeristic characters using classical taxonomy was carried out for the species of the family, Chirocentridae, Dussumieridae and Engraulidae (Fig. 3).

Fig. 1. Fishing in Yanam, Puducherry for collection of Clupeiform fishes

Fig. 2. Exploration in Yanam, Puducherry for collection of Clupeiform fishes

Fig. 3. Tissue collection and morphomeristic data collection of Clupeiform fishes

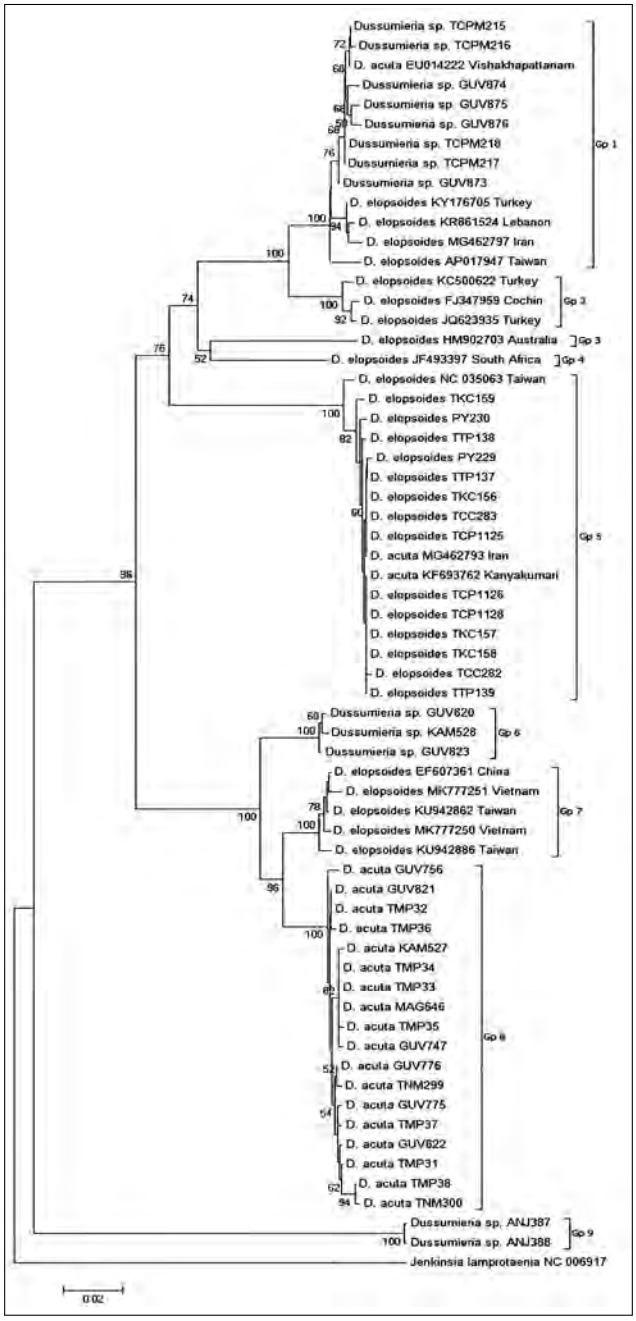


Fig. 4. Neighbour Joining Phylogenetic tree of genus *Dussumieria*

The X-ray images of selected specimens were also generated to count the vertebrae. COI sequences were generated from 263 specimens of 28 Clupeiform species collected from Andaman, Andhra Pradesh, Gujarat, Odisha, Tamil Nadu and West Bengal Coasts. PCR amplification has been completed of 64 cytochrome b gene sequences in 7 targeted clupeiforms to validate the species status as generated by COI data. The comparative analysis of species of genus *Dussumieria* was carried out based on morphomeristic characters including 23 morphological measurements and 7 meristic counts, X-ray images and molecular data. Specimens were added from targeted explorations and some of the specimens were re-sequenced to confirm the results. The analysis included two valid species *D. acuta* and *D. elopsoides* from different geographical locations, as well as nominal species, *Clupea flosmaris*, *Etrumeus albulina*, *D. hasseltii* and *D. productissima*. Phylogenetic tree showed 9 clades (Fig.4) in *Dussumieria* genus with sufficiently high genetic distance among them (Table 1).

Table 1. Genetic distance (%) between 9 clades of *Dussumieria* spp.

	Gp_1	Gp_2	Gp_3	Gp_4	Gp_5	Gp_6	Gp_7	Gp_8
Gp_1								
Gp_2	4.16							
Gp_3	10.07	11.08						
Gp_4	8.59	10.15	8.79					
Gp_5	12.65	12.65	11.87	13.00				
Gp_6	13.27	13.30	12.92	12.05	13.46			
Gp_7	13.66	13.99	14.32	12.75	13.56	4.42		
Gp_8	13.88	14.00	14.24	13.17	14.77	4.77	3.55	
Gp_9	25.45	25.37	23.31	23.83	22.74	22.32	22.98	21.90

Project: Exploration for fish diversity assessment and traditional ecological knowledge in lower Mahanadi basin

Period: April, 2016 - March, 2020

Personnel: Lalit Kumar Tyagi (PI), Sangeeta Mandal, Rejani Chandran, Trivesh Suresh Mayekar, Amit Singh Bisht and Sanjay Kumar Singh

Funding Support: Institutional, ICAR-NBFGR

Project aimed 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. During the year under report, tissue accessions and voucher specimens collected from Mahanadi basin in both phases (upper and lower basins), along with the detailed data about each collection in digital form, were compiled and provided to the ICAR-NBFGR Museum (Table 2).

Table 2. Tissue accessions and voucher specimens submitted to ICAR-NBFGR Museum

Type of material submitted	Mahanadi basin		Total
	Upper	Lower	
Voucher specimens	378	516	894
Tissue accessions	400	448	848
Total	**778**	**964**	**1742**

A total of 99 sites explored in both phases of the projects on Mahanadi - the present project on lower Mahanadi basin (43 nos. sites), as well as, in the previous project on upper Mahanadi basin (56 nos. sites), were mapped on GIS (Fig. 5). The data on habitat features i.e. micro-habitat type, riparian and aquatic vegetation, dominant substratum, along with water parameters like temperature, DO, salinity, TDS and turbidity, was analysed and compared with the fish diversity data across sites and seasons.

The project has completed. Total seven primary seasonal field explorations were conducted in lower basin of Mahanadi including its major tributaries namely, Ib, Tel and Ong. A total of 115 fish species belonging to 15 orders, 46 families and 81 genera were recorded from these explorations (Fig. 6).

The project focused on explorations of some of the least explored rivers/sites (Ib, Tel and Ong). Data

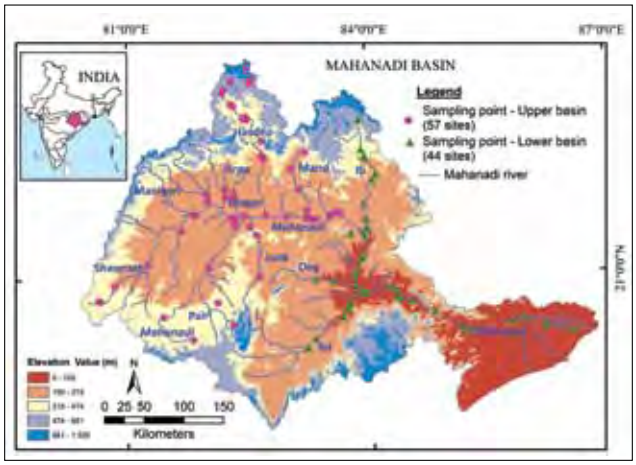


Fig. 5. Sites explored in the Mahanadi basin (upper and lower)

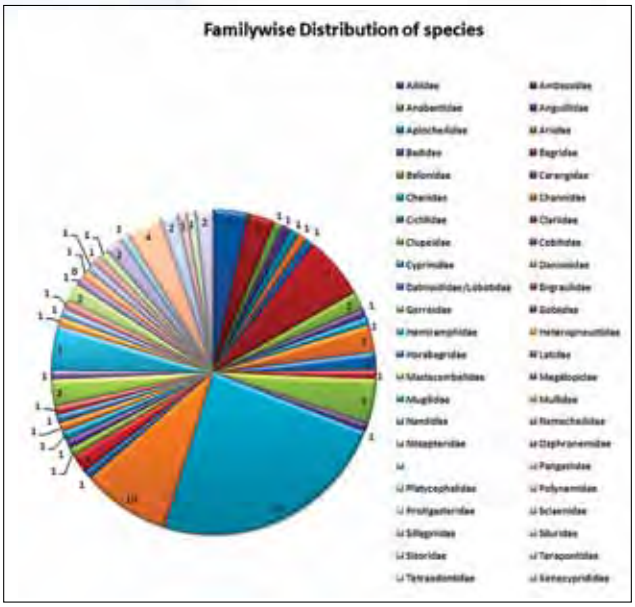


Fig. 6. Family-wise species distribution in lower Mahanadi basin

of this project has been collated with the previous Institute project (on upper Mahanadi basin) to give a comprehensive picture of fish diversity, abundance and habitat of Mahanadi basin including its major tributaries.

Project: Exploration and assessment of fish diversity of mid-Himalayan tributaries and wetland of Ganga river system.

Period: April, 2017 - March, 2020

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

Funding Support: Institutional, ICAR-NBFGR

Project was initiated for exploration of fish diversity in three least studied mid-Himalayan tributaries namely, Gandak, Burhi Gandak and Bagmati of the River Ganga in North Bihar. During the period, fish samples and collected data from the rivers Gandak, Burhi Gandak, Bagmati and Saraiyamaun wetland of North Bihar were analyzed. The districts covered on the catchments of the rivers were East Champaran, West Champaran, Sheohar, Muzaffapur, Samastipur, Vaishali and Darbhanga. Collected samples for fish diversity and related parameters were analysed from 14 sites covering 5 each in the rivers Gandak and Burhi Gandak and 4 in Bagmati (Fig. 7).

All the rivers are left bank tributaries of the river Ganga and traverses 300 to 394 km distance in North

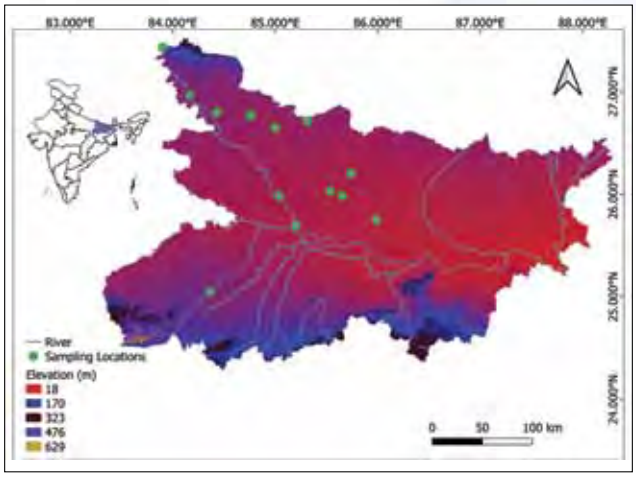


Fig. 7. Map of North Bihar depicting different rivers and elevation levels

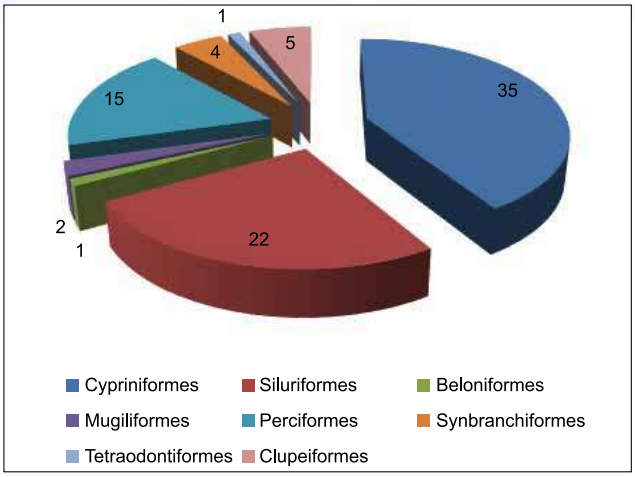


Fig. 8. Order-wise composition of fish species in the river Gandak

Bihar before joining the river Ganga. As the rivers are almost in similar geographic region, 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 laden towards mid and downstream stretches of the rivers. Among these Gandak and Bagmati rivers originate in Himalayan region and are snow-fed while the Burhi Gandak is spring fed. The fish diversity of the rivers is of Gangetic origin, which includes few stray fishes of coldwater region and majority are of the plains. A total of 104 fish species were observed from the rivers of the region under 8 orders, 24 families and 66 genera. A total of 19 fish species has been added to the previous list (85 species) of fishes.

Gandak River

The Gandak River is one of the major rivers of Nepal and enters India at Valmiki Nagar, West Champaran, Bihar. Out of its total 630 km length, the river traverses 300 km in Indian Territory (Bihar). Owing to its origin in Nepal Himalayas and traversing through plains of Nepal, the river harbors rich fish diversity. Among the three rivers studies so far, the maximum fish diversity was recorded from Gandak river, including 85 species under 8 orders (Fig. 8), 24 families and 57 genera. Out of the collected samples from the river, 14 fish species were added to the existing list from previous studies. The species reported for the first time were - *Raiamas bola*, *Chagunius chagunio* (Fig. 9), *Danio devario*, *Bangana dero* (Fig. 10), *Labeo pangusia, Puntius titius, Lepidocephalichthys guntea, Mystus bleekeri, Glyptothorax telchitta, Nangra nangra, Acanthocobitis botia, Pachypterus atherinoides, Parambassis lala* and

Fig. 9. *Chagunius chagunio* (Hamilton, 1822) reported for the first time from river Gandak

Fig. 10. *Bangana dero* (Hamilton, 1822) reported for the first time from river Gandak

Badis badis. Small-sized minnows formed sizeable fishery (60-70% of total fish catch) at Valmikinagar and Dhanaha bridge sites of the river Gandak. The IUCN status of the fishes was Endangered (*Tor putitora*), Near Threatened (8), Not Evaluated (2) and Least Concern (74).

Burhi Gandak River

The river Burhi Gandak originate from the spring of Someshwar hills at an elevation of 300 m in the West Champaran district, Bihar. The total length of river is 320 km. The river harbours a total of 73 fish species classified under 8 orders (Fig. 11), 22 families and 53 genera. Stray samples of alien fishes *Ctenopharyngodon idella* and *Cyprinus carpio* were caught from downstream stretches of the river. On analysis of collected fish samples, 10 fish species were added for the first time in the previously prepared list

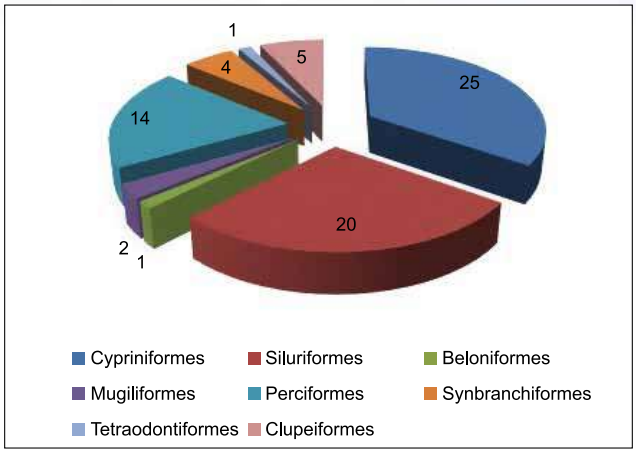


Fig. 11. Order-wise composition of fish species in the river Burhi Gandak

of fish species (63 species) of the river. These species were - *Cabdio morar*, *Oxygaster clupeoides*, *Botia lohachata*, *Somileptes gongota*, *M. bleekeri*, *Nangra viridescens*, *A. botia*, *P. atherinoides*, *Parambassis lala* and *Macrognathus aral*. The fish species of the river belonged to IUCN categories; Near Threatened (5), Not Evaluated (1) and Least Concern (65).

Bagmati River

The river Bagmati that originates in Nepal Himalaya is a snow-fed perennial river and a major tributary of the river Kosi. The length of the river is 589 km and traverses 394 km in state of Bihar while the rest in Nepal. A total of 81 fish species were recorded from the river under 8 orders (Fig. 12), 23 families and 56 genera. Fourteen fish species were identified and added in the list of fishes, for the first time. These were – *R. bola, Danio devario*, *Garra gotyla*, *L. pangusia*, *Puntius cosuatis*, *P. muzaffarpurensis*, *P. sophore*, *Botia lohachata*, *L. guntea*, *M. bleekeri*, *Nangra nangra*, *Colisa fasciatus*, *Macrognathus aculeatus* and *M. aral*. The IUCN categories of the fishes observed were Endangered (*Tor putitora*), Near Threatened (8), Data Deficient (1), Not Evaluated (4) and Least Concern (67).

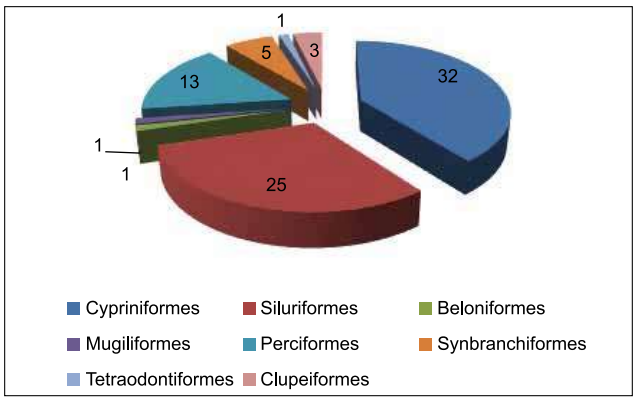


Fig. 12. Order-wise composition of fish species in the river Bagmati

Certain ecologically important fish species collected during the surveys were analyzed for their body length and weight profiles from different locations of the rivers Gandak, Burhi Gandak, Bagmati and wetland Saraiyamaun in Bihar (Table 3).

Table 3. Length and weight ranges of certain fish samples analyzed from different locations

S.N.	Fish species	Range of Body length and weight	
		Length (mm.)	Weight (g)
1	*Acanthocobitis botia* (Hamilton, 1822)	62.16 -76.23	2.47-5.47
2	*Rasbora daniconius* (Hamilton, 1822)	67.21- 97.16	2.58-9.14
3	*Xenentodon cancila* (Hamilton, 1822)	107.20-218.41	1.64- 24.24
4	*Channa punctata* (Bloch, 1793)	45.31-156.27	10.0-44.03
5	*Channa gachua* (Hamilton, 1822)	85.04-115.62	7.26-15.83
6	*Glossogobius giuris* (Hamilton, 1822)	122.51-152.08	11.83-32.30
7	*Notopterus notopterus* (Pallas, 1769)	60.4-93.03	1.54-5.22
8	*Cabdio morar* (Hamilton, 1822)	44.98-77.44	0.79-3.89
9	*Raiamas bola* (Hamilton, 1822)	37.17-73.77	0.51-2.67
10	*Crossocheilus latius* (Hamilton, 1822)	73.93-115.77	3.21-9.86

Saraiyamaun wetland

Saraiyamaun wetland is situated near Bettiah town of West Champaran district, Bihar. The wetland is a ring-shaped oxbow lake, which is about 10 km in length and 270-550 m in width and spreads over 319 ha area. The wetland is under massive anthropogenic pressure and has suffered drastically due to expansion of human settlements around the wetland periphery leading to shrinkage of water spread area, reduction in water level and depletion in the fish diversity. The wetland is also under massive infestation of macrophytes, which is a major causative factor of shrinkage of water spread area. The macrophyte load may gradually lead to succession of the wetland towards land.

The wetland harbours copious fish diversity comprising a total of 55 fish species (Fig.13 a & b) under 7 orders, 20 families and 35 genera. Besides native

species, exotic fishes- grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*) were also caught from the wetland. This indicates the wetland had been stocked with IMC and exotic carps in the past. Most of the fishes caught are of smaller size, because of intensive fishing activities. The wetland provides occupation to approximately 300 fishermen/day. Harpoon fishing is also in vogue in the wetland (Fig. 14). The fishermen population resides in the villages/hamlets located along the banks of the wetland. Besides some agricultural activities, fishing is the main source of livelihood of the fishermen. About 40 fish sellers residing in nearby areas depend on fish produce of the wetland. As per estimates, the minimum catch from the wetland is 500 kg and maximum is 1500 kg/day. The lean fishing season of the wetland is during winters while monsoon is the peak fishing season.

a. *Badis badis* (Hamilton, 1822)

b. *Trichogaster fasciata* Bloch & Schneider, 1801

Fig. 13. Common fishes of Saraiyamaun wetland

Fig. 14. Harpoon- a popular fishing method in Saraiyamaun wetland

At present, there is no provision of regular fish stocking in wetland for stock augmentation (though as per response of the fishers it was being stocked with IMC and grass carp seeds earlier), so the fishing operations depend on the available native species of the wetland. Our preliminary observations indicate decreasing trend in fish catch over the years because the fishing operations are more in the wetland in comparison to the rate of auto-stocking.

Project: **Fish diversity pattern of fish communities from Luni river basin, Rajasthan, India**

Period: **April, 2018 - March, 2021**

Personnel: **Ajey Kumar Pathak (PI), Kantharajan G., Rajesh Dayal and Ravi Kumar**

Funding Support: **Institutional, ICAR-NBFGR**

Project envisages to assess the fish diversity pattern of fish communities in river Luni; the entire river with selected tributaries. Survey and sampling of fish and habitat in the entire stretch of the river Luni from origin at Pushkar valley to the confluence at Rann of Kutchh was done from September to November, 2019. A total of 14 sampling locations were selected in the up, mid and downstream stretches of the river, categorised on the basis of altitudinal variation and heterogeneity in habitat morphology (Fig. 15). The geographical coordinates of all the sampling locations were noted down using Global Positioning System (GPS) and ground control points were collected additionally for land use and land cover mapping. Experimental fishing was done in all the sampling

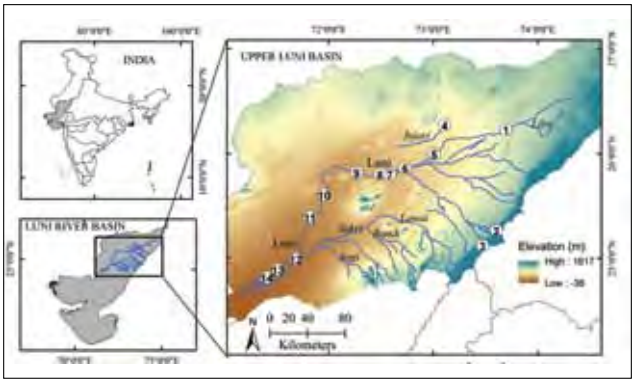


Fig. 15. Map of sampling locations in the up, mid and downstream stretches of the Luni river basin [Upstream: (1) Jaswant Sagar Dam, (2) Desuri, (3) Ranakpur; Midstream: (4) Jodhpur (Jojariya river), (5) Luni village, (6) Dundhara, (7) Samdhari, (8) Jethantri, (9) Balotra, (10) Nakora, (11) Bhatala; Downstream: (12) Gandhav, (13) Doodhwa, (14) Surachand]

Fig. 16. Experimental fishing using cast net

Fig. 17. Tissue and morphomeristic data collection of fishes

Fig. 18. Recording of water quality parameter and land use/ land cover characteristics

locations using various fishing gears like gill nets, cast nets, hapa and push net of different mesh sizes (Fig. 16). The collected fish specimens were processed and data on morphomeristic characters of the specimens were collected (Fig. 17). The habitat characterisation (river bed ecology and water quality analysis) of the river Luni was done for all the sampling locations of up, mid and downstream stretches of the river (Fig. 18).

The shallow water pools and slow water riffles are the most commonly observed habitat types in the hilly upstream region of Luni river basin. The habitat in the midstream segment of the river is slow moving water with presence of shallow and deep pools. A high degree of variation in salinity of the water was observed across different sites/stretches of this river. The salinity of river water in the upstream zone was reported to be <0.5 ppt and thereafter, a rapid rise in the salinity was observed in the midstream regions, where water reaches to the plains (Table 4).

The fish diversity assessment showed distribution of 27 species belonging to 22 genera of 12 families. Cyprinidae was found as the most abundant family in terms of species diversity (12 species) followed by Ambassidae (3 species) (Fig. 19). Arabian toothcarp (*Aphanius dispar*), often called as killifish species, was recorded abundantly from the pools of Luni Village, Dundhara, Balotra and Nakora sites located in the midstream zone. The widespread invasion of exotics such as, African Catfish (*Clarias gariepinus*) and Mozambique tilapia (*Oreochromis mossambicus*) of different life stages were observed in the midstream segment of the river Luni. Apart from fish diversity assessment in the Luni river basin, this basin was extensively surveyed to understand the basin characteristics, general land use pattern and collection of ground control points for different land use/land cover (LULC) classification and change analysis studies (Fig. 18). The Landsat images for the entire Luni basin

Table 4. Habitat and water characteristics in different stretches of the Luni river basin

River Segment	Habitat Diversity	Water Temp. (°C)	Salinity (ppt)	pH	DO (mg/l)	Conduct. (mS/cm)	TDS (ppm)	ORP (mv)
Upstream (3 locations)	Pool; Riffle; Reservoir	24.4-31.5	0.0-0.2	6.6-7.8	2.9-5.6	142-570	71-284	145-247
Midstream (8 locations)	Shallow and Deep pools; Riffles	21.6-31.5	1.3-9.1	7.7-9.2	1.8-8.2	2651-15700	1325-7833	(-310) - 87
Downstream (3 locations)	Deep and shallow water pools	28.2-28.9	2.4-5	8.3-8.5	6.3-9.2	4439-8858	2292-4495	118-140

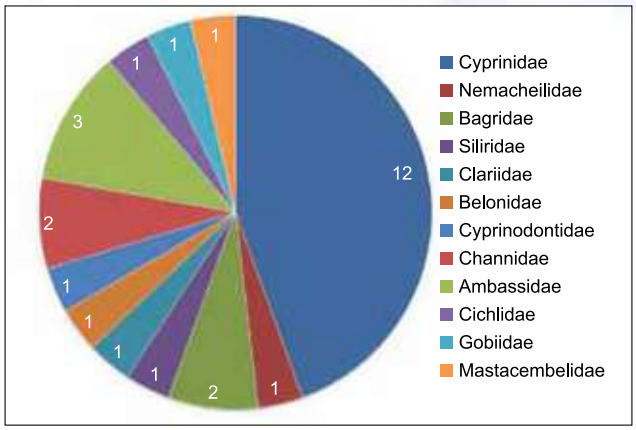


Fig. 19. Family wise distribution of fish species

of different time periods have been downloaded and being processed for LULC mapping and change detection analysis.

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

Sub project-1: Survey and collection of fishes from Cauvery river basin

Period: April, 2016 – March, 2020

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

Funding Support: Institutional, ICAR-NBFGR

Exploratory surveys were conducted in the upper reaches of the Cauvery (5 stations) in Coorg, and its tributary, the Hemavathi river (6 stations) including the Gorur reservoir. Cauvery flows through forested areas with canopy cover extending over the river in the upper stretches. The Hemavathi river, upstream of Gorur reservoir, flows through agricultural land (coffee estates). Sampling was done using cast net, gill net and scoop nets. The survey yielded an addition of 4 more species (with respect to earlier exploration in Cauvery River basin) of freshwater fish bringing a total of 117 species from Cauvery River, belonging to 8 orders, 25 families and 68 genera. Out of the 117 species 25 species were endemic to Cauvery River, 75 native, 4 stocked and 10 exotic species. Cyprinidae was the most abundant family, contributing 49% of the fish fauna of the Cauvery followed by family Bagridae, with 7% of the total species (Fig. 20). Commercially important indigenous species in this stretch of the river included *Hypselobarbus carnaticus*, *Wallago attu*, *Ompok bimaculatus*, and *Cirrhinus ariza*. Interviews with fishermen revealed that destructive fishing practices involving dynamite and sand mining have negatively impacted fish populations in the river and needs to be addressed on a priority basis. The majority of fishing activity in the region was based on gill nets. Exotic fish, *Clarias gariepinus* was encountered in one of explorations at Gorur Dam, but fishermen reported its presence in the catch occasionally. Tilapia was abundant at all landing centres located near reservoirs, with *Oreochromis niloticus* dominating the catch. No specimens of the invasive suckermouth catfish were encountered in this stretch of the river during sampling.

The conservation status of the fish sampled from Cauvery River (Fig. 21) shows 65% of the fishes were Least Concern and 9% Endangered or Critically Endangered. Species richness (Fig. 22) shows that the endemic and native fishes were high and presence of exotic fishes varied from 0-29% at different sites (Fig. 23). Hattihole stream in Coorg was the most species rich, with 37 species, followed by Kushalnagara with 27 species. Heavy silt deposition in the hill streams following heavy rains have negatively impacted species

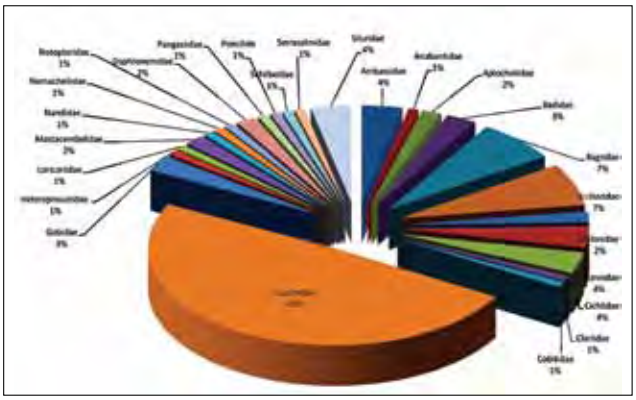


Fig. 20. Family-wise fish composition

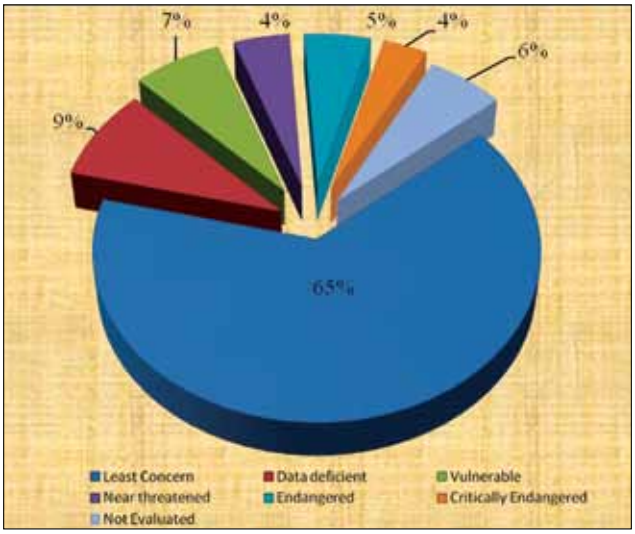


Fig. 21. Conservation status of fish

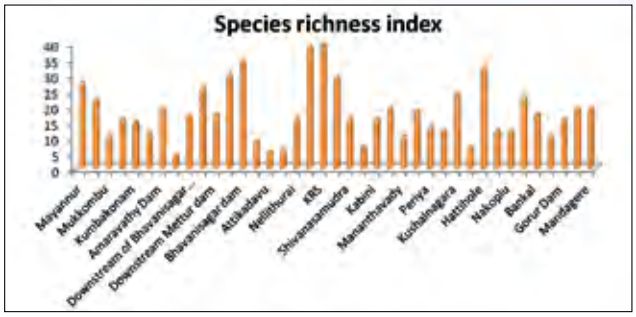


Fig. 22. Species richness of river Cauvery

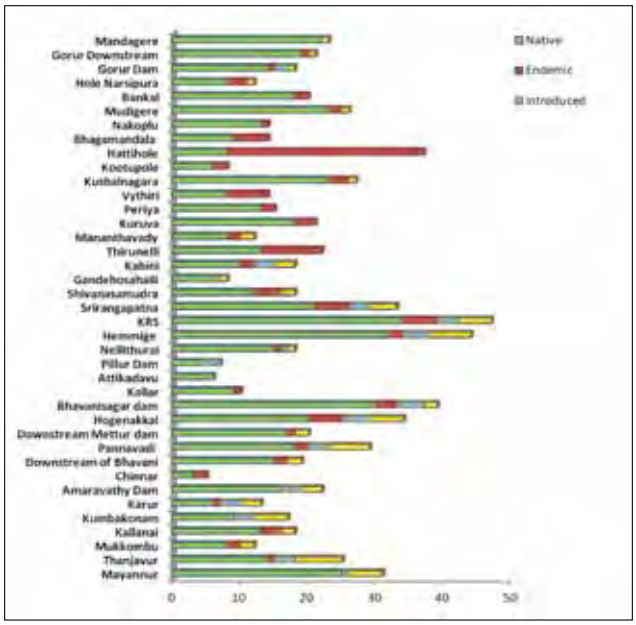
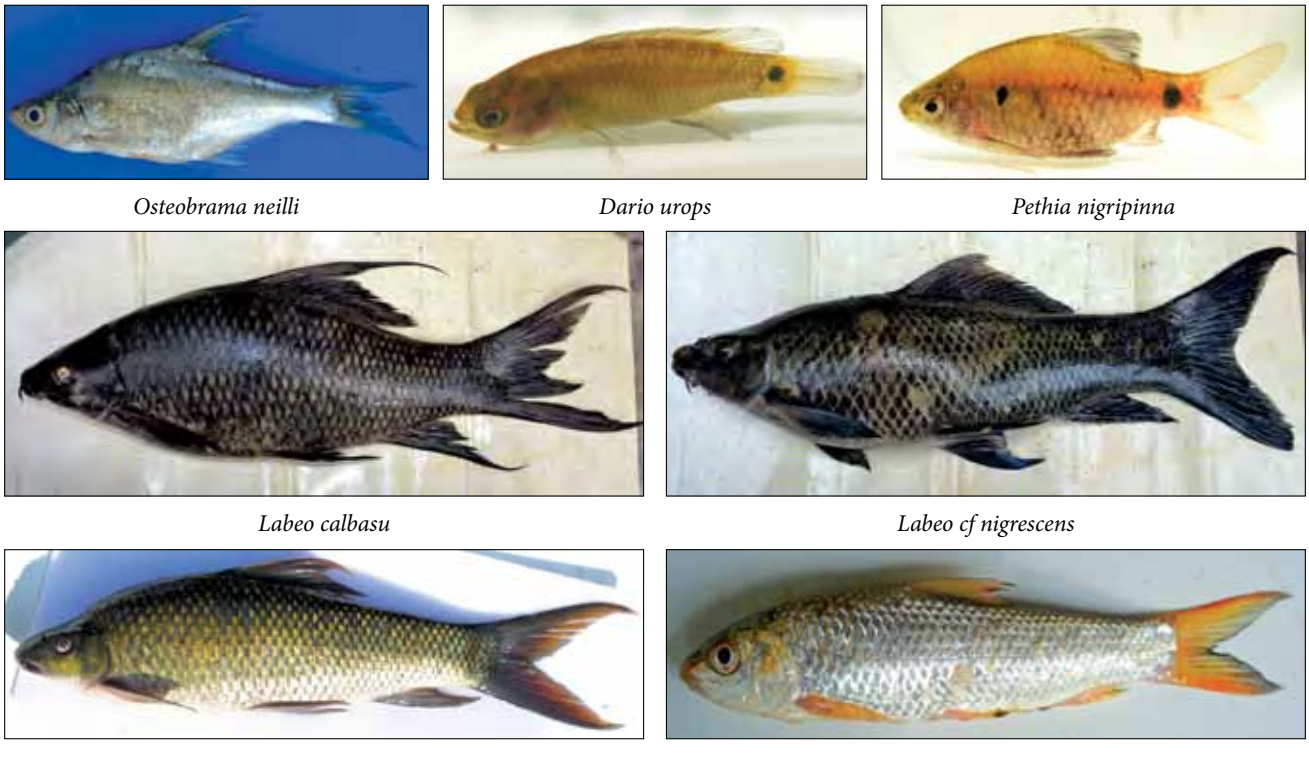


Fig. 23. Endemic, native and exotic fishes of river Cauvery

diversity, especially species found in hard substrates such as Balitorid loaches. Due to strong monsoons in 2019-20 water levels in the river channel were quite high and there was a lot of silt deposition in the rivers.

A total of 32 COI sequences were generated from 8 species, *Osteobrama neilli, Dario urops, D. neela, Pethia nigripinna, Labeo cf. nigrescens, L. bata, L. kontius*, *L. calbasu* which were having taxonomic ambiguity (Fig. 24). *D. urops* from Bagamandala differed from *D. neela* and *D. urops* from Wayanad by greater than 3%. There was no difference in COI sequences of *P. nigripinna* from Wayanad and Coorg, though they slightly differed in colour. Sequences of *O. neilli* differed by greater than 3% from sequences of all other *Osteobrahma* species. Sequences of *L. kontius* show 100% similarity with *L. lankae* from Sri Lanka. Sequences of *L. bata* differed from reported sequences in GenBank by 1.6-1.8%. Sequences generated of *L. cf. nigrescens* differed from all other species of *Labeo* species by more than 4%. Specimens of a *L. calbasu* collected from protected area in the Cauvery differ from *L. calbasu* from the reservoirs by more than 3%. Specimens of *Sperata* collected from the Cauvery river differ from *S. aor* and *S. seenghala* in morphology and meristics.



Osteobrama neilli | *Dario urops* | *Pethia nigripinna*

Labeo calbasu | *Labeo cf nigrescens*

Labeo kontius | *Labeo bata*

Fig. 24. Important fishes of river Cauvery

DNA barcoding of *Anabas testudineus* revealed a significant difference between specimens recovered from an aquaculture facility and wild. *Ompok karunkodu*, described on the basis of a single specimen from the Amaravathi river (Cauvery basin), have been collected (two specimens) from the Cauvery which agree in morphology and meristics with *O. karunkodu*, but lack the dark lateral band seen in the type specimen. Detailed analysis is being carried out to determine if specimens represent *O. malabaricus* or *O. karunkodu*. Specimens of the poorly studied cyprinid species, *Kantaka brevidorsalis,* have been collected from the Cauvery and Bhavani rivers and DNA barcodes for this species have been generated. Molecular analysis of specimens collected from various river basins in the Western Ghats and topotypical specimens from Puducherry suggest *Psuedophomenus cupanus* is a species complex with at least 3 distinct populations in Puducherry and Southern Kerala, Northern Kerala, Northern Karnataka and Goa. *D. urops* specimens have been collected from the headwaters of the Cauvery River in Bhagamandala, which represents a new record from this region. Few individuals of the endangered Western Ghats endemic catfish, *Pterocryptis wynaadensis* were collected from the Cauvery river in Coorg.

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

Sub project-2: Survey and collection of fishes from Marine Islands (Andaman & Lakshadweep Islands)

Period: April, 2016 – March, 2019

Personnel: T.T. Ajith kumar (PI), A. Kathirvelpandian and Teena Jayakumar

Funding Support: Institutional, ICAR-NBFGR

Project envisages detailed documentation of ichthyodiversity from island Ecosystem of country. Twenty three species, belonging to 20 genus and 13 families were collected from different locations of Andaman Islands. This added to the earlier collection resulted in 102 species of marine fishes belonging to 8 orders, 42 families and 75 genera from Andaman Islands. Rare occurrence of a deep sea snake fish/band fish [*Acanthocepola indica* (Day, 1888)] (Fig. 25), was recorded at Chidiyatapu, Andaman Island, which is the first report of the fish from Andaman waters.

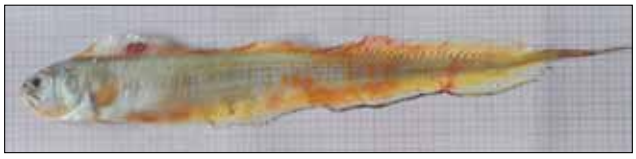


Fig. 25. Band fish (*Acanthocepola indica*) from Chidiyatapu, Andaman Island

Exploratory surveys were conducted in different islands of Lakshadweep. A total of 179 fish specimens were collected from different islands of Lakshadweep, which consisted of 69 species belonging to 32 families. This added to the earlier collection resulting in 90 species belonging to 61 genera and 37 families.

Molecular analysis has been done for a few species belonging to the family Mullidae, Blennidae and Gobiidae to confirm the species. Nine species of goat fishes, *Upeneus molucensis*, *U. sulphurous*, *U. tragula*, *U. vittatus, Parupeneus cyclostomus, P. macronemus, P. barberinus, Mulloidichthys flavolineatus* and *M. vanicolensis* were confirmed. The analysis also confirmed 8 species of the family Blennidae and 6 species of the family Gobiidae.

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

Period : December, 2016 – December, 2019

Personnel: Divya P.R. (PI)

Funding Support: KSCSTE

Considering the importance of the wetland as a biodiversity site, the project aims to make documentation/genetic cataloguing of fishes in Ramsar sites in Kerala. During the exploration in Ashtamudi lake, widespread distribution of an alien mussel species in the natural beds of yellow clam and green mussel was observed (Fig. 26), Morphological and molecular analysis using DNA barcoding, (GenBank accession numbers: MN531546 - MN531553) the sequence of individuals matched with the sequences attributed to *Mytella charruana/M. strigata* with an average match of 99.9-100%. This report forms the first hand information on establishment of an alien mollusc introduced in Indian waters and warrants the need for an in-depth study on this species in Indian waters. *M. strigata* is described as primarily marine, and is capable of tolerating a wide range of salinities from 2 to 40 ppt and a wide range of temperatures (6-36°C). Coupled with their proven tendency to spread quickly, these

fouling species have great potential to survive and establish populations in a non-native environment. The temperatures recorded at the collection sites in Ashtamudi lake ranged from 23 to 25.5°C and salinity ranged from 20 to 24 ppt. Given the adaptability of mytilids to estuarine and coastal conditions and their high reproductive rates in eutrophic conditions, it is highly likely that *Mytella* will be established and be an invasive species in Ashtamudi lake. Apart from this, 9 molluscan species from 6 families were recorded from the Ashtamudi lake: *viz. Marcia recens, Meretrix casta, Villorita cyrpinoides* bivalves *viz. Crassostrea madrasensis, Saccostrea* sp., *Perna viridis* and *M. strigata* and two cephalopods *Uroteuthis duvauceli* and *Sepiella* sp. Species specific molecular information of cytochrome oxidase I region of the above species were generated. Mean genetic distance among various species of clams, bivalves and cephalopods were 0.14, 0.18 and 0.136 respectively. Average intra specific variation was found to be 0-0.009. The study revealed deep intraspecific divergences in *Saccostrea* sp. distributed globally, with intraspecific divergence (>2%) that is likely to represent cryptic species.

Fig. 26. Alien species *Mytella strigata* in the natural beds of *Perna viridis* in Ashtamudi lake

Phylogenetic relationships among 112 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 lake was found to be 0.248. A 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 were generated. The mean genetic distance within fish species, genera, families and orders of various species of Ashtamudi lake were calculated to be 0.26%, 6.6%, 9.8% and 15.8%, respectively. Mean genetic distance among the genus *Portunus, Charybdis* and *Scylla* were 0.14, 0.04 and 0.036, respectively. Phylogenetic analyses among shellfishes including 9 species of molluscs and 10 species of crabs of Ashtamudi lake were also done.

Secondary information was collected for voucher specimens from the three Ramsar sites in Kerala *viz.* Vembanad lake, Ashtamudi lake and Sashtamkotta, with a view to prepare a complete handbook on the fishery resource of Ramsar sites. A handbook has been compiled with information on scientific name, synonyms, taxonomy, diagnostic characteristics, IUCN categorization and NCBI Accession details of the species from this region.

Project: **ICAR-NBFGR collaborative research programme on fish germplasm exploration, characterization and development of live fish germplasm resource centres in North-Eastern region of India**

Period: **November, 2017 – March, 2020**

Personnel: **Lalit Kumar Tyagi (Coordinator), Rejani Chandran and Amit Singh Bisht**

Funding Agency: **ICAR-NE Component**

North-East (NE) component, is implementing 'Collaborative research programme on fish germplasm exploration, characterization and development of live fish germplasm resource centres in North-Eastern region of India' involving collaborators from various institutions of the NE region. 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 centres of indigenous food and ornamental fishes for resource enhancement and sustainable livelihood generation and cytogenetic characterization of endemic fishes of North-Eastern, India. Projects were undertaken by the collaborating partners from various institutions of the NE region of India under this programme (Table 5).

Table 5: Progress made by the collaborating partners from NE region

S. No.	State	Title of Sub-Project	Principal Investigator	Progress during 2019-20
1.	Nagaland	Exploration and characterization of fish germplasm resources, and indigenous knowledge of traditional fishing practices of Dikhu River in Nagaland	Dr. Pranay Punj Pankaj, Assistant Professor, Dept. of Zoology Nagaland University, Nagaland	Explorations were conducted in Dikhu River in Nagaland and sites namely, Lumsami, Akuluto; Sema Settsu; Chuchuyimpang and Moalenden, Longsa were explored for fish germplasm resources. A total of 28 fish species belonging to 9 families were recorded during these explorations. One additional record of species of *Garra* (*G. birostris*) was recorded from this river in Nagaland. Detailed seasonal habitat and water parameters were also recorded and analyzed for each site. Traditional fishing gears and practices of fishing communities were also documented. Two species are under identification and evaluation which might be new to the science.
2.	Arunachal Pradesh	Exploration and evaluation of fish diversity and habitat ecology of Na-mora and Dikal Rivers of Arunachal Pradesh	Mr. Ratul Chandra Bharali, Assistant Professor, Dept. of Zoology Udalguri College, Udalguri, Assam	Explorations in total eight sites of Dikal and Na-mora Rivers (which merges into Bargang River) which meets Brahamputra, were conducted. A total of 16 fish species were recorded during this year and a total of 44 fish species have been recorded so far in the river under this project. Significant reduction of fish fauna in the upper stretches of the river was noticed during the period of exploration. Detailed seasonal habitat and water quality parameters were also recorded and analyzed for each site.
3.	Meghalaya and Arunachal Pradesh	Exploration & evaluation of ichthyofaunal diversity of Khri river, Meghalaya and Subansiri River, Arunachal Pradesh	Mr. Hrishikesh Choudhury, Assistant Professor, Dept. of Zoology Gauhati University, Guwahati	Explorations were conducted in Khri/Kulsi River and number of sampling sites were increased to 10, covering the entire length of 90 km of the Khri/ Kulsi River drainage in Meghalaya and Assam. A total of 78 fish species under 21 families have been collected so far from the Khri River. Additional eight fish species were added in the year 2019-2020 to the total fish species list. *Mystus bleekeri* and *M. carcio* were reported for the first time in the lower stretch (Nagarbera) of Kulsi/ Khri basin.

S. No.	State	Title of Sub-Project	Principal Investigator	Progress during 2019-20
				High Relative Abundance(s) of *Barilius bendelisis* in Upper Khri (in Meghalaya), and *Puntius chola* and *Parambassis ranga* in Lower and Middle stretches (in Assam) were recorded. Complete ban on electrofishing, poisoning and other means of destructive fishing techniques along the upper Khri basin in Meghalaya was observed. One species of the genus *Schistura* (Nemacheilidae) is under review for establishing as a new species from the collection.
4.	Assam	Exploration and Evaluation of fish faunal diversity, distributional pattern and habitat ecology of Langting River, Dima Hasao and Dhansiri River, Karbi Anglong, Assam	Dr. Sarbojit Thaosen, Associate Professor, Department of Zoology Haflong Govt. College, Haflong, Assam	In rivers Langting and Diyung, three explorations were carried out covering eight sites. Total of 46 fish species were recorded from these rivers. One species of *Glyptothorax* is under review from Diyung River which is expected to be a new species. Organized fishing is absent along the stretches of these rivers. It was observed that stream Path, which is a tributary of Langting on the eastern bank, has the richest fish species diversity.
5.	Assam	Development of live germplasm resource centre for indigenous food and ornamental fishes for resource enhancement and sustainable livelihood generation in Assam	Dr. D. Sarma, Professor, Dept. of Zoology, Gauhati University, Guwahati, Assam	**a. Captive Breeding and larval rearing of the selected Indigenous Ornamental Fishes of North East India was carried out:** ***Microphis deocata:*** Domestication and natural breeding of the species was carried out along with successful larval rearing techniques. Three breeding trials with 70% success were carried out in the current year. Brooders are being managed with live feed. ***Channa andrao:*** Species was collected from Manas River basin. Natural breeding of the species was successfully carried out in current year with 80% success. Two breeding trials were carried out in the year and larval rearing is in progress. ***Danio dangila:*** Species was collected from Diyung and Jatinga River of Dima Hasao district of Assam. Brooders were maintained with live feed. Three induced breeding experiments were successfully carried out during the year with 80% breeding success and 65% success in larval rearing. Rearing of larvae is in progress through Artemia, Paramaecium, Microworm, Plankton and Tubifex.

S. No.	State	Title of Sub-Project	Principal Investigator	Progress during 2019-20
				Devario aequipinnatus: Species was collected from Dhansri River, Udalguri district, Assam. Brooders were maintained with live feed. Three induced breeding experiments were successfully carried out during the year with 80% breeding success and 65% success in larval rearing. Rearing of larvae is in progress through Artemia, Paramaecium, Microworm, Plankton and Tubifex. ***Garra annandalei:*** Species was collected from Dhansri River. Five breeding trials have been carried out successfully with 100% breeding success. Larvae is being maintained with live feed. ***Puntius chola*:** Species was collected from Brahmaputra River Basin. Three breeding trials were successfully carried out with 80% breeding success. Larval rearing is in progress. ***Trichogaster chunna*:** Species was collected from Dibru River, Dibru Saikhowa, Assam. As the species is very rare and vulnerable, only few pairs could be collected. One breeding experiment was successfully carried out by maintaining in Aquatic Housing System but breeding success was only 30%. ***Esomus dandrica* :** Species was collected from Brahmaputra River Basin. Two breeding experiments were successfully carried out with 70% success in larval rearing. **b. Captive Breeding and larval rearing of Indigenous food fishes of North East India:** Total 15 field trips were made to collect the broodstock of the two targeted species: ***Clarias magur**:* Total 459 broodstock of *C. magur* were collected from various locations of Assam. Nine breeding trials with 70% success with the method of striping were carried out. Larval rearing is in progress. ***Ompok pabda:*** Species was collected from Morigaon district of Assam. Eight breeding trials with 70% success in larval rearing has been achieved. Larval rearing is in progress. **c. Livelihood enhancement:** Ten women beneficiaries were selected from Village Velakhamar, krishnai and Golpara district of Assam to promote indigenous ornamental fish rearing as an impetus for livelihood enhancement. Ten cisterns {5 X 2.5 X 2.5 feet}, one for each beneficiary as rearing tank was constructed.

S. No.	State	Title of Sub-Project	Principal Investigator	Progress during 2019-20
6.	Manipur	Diversity and germplasm conservation of fishes of river basins in Manipur	Dr. Y. Bedajit Singh, Deputy Director (Instructions), Central Agricultural University (CAU), Imphal	Ten fish species were collected from Jhiri and Barak Rivers in Manipur. *Bangana devdevi* and *Clarias magur* were kept in the broodstock 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 broodstock pond. A total of 1000 *Ompok bimaculatus* were stocked for preparation of broodstock, which will be used for induced breeding in the coming season.
7.	Various parts of NE	Cytogenetic study of selected endemic fishes of North East, India	Dr. Banasri Mech, Assistant Professor, Dept. of Zoology Gauhati University, Guwahati	Fishes were collected from different location sites from Jorai stream of Sonkosh River drainage near Barobisha; Kulsi River at Nagarbera, Brahmaputra drainage, Assam. Chromosome analysis was done for four fish species namely, *Channa andro, Mystus carcio, M. bleekeri* and *Psilorynchus sucatio*.

ICAR-NBFGR, Lucknow has established live fish germplasm resource centres in collaboration with partner organizations in the NE region of the country (Table 6).

Table 6: Details of live fish germplasm resource centres established in NE region

S. No.	Place	Partner organisation	Fish species
1.	Aquaculture and Biodiversity Centre, Department of Zoology, Gauhati University, Guwahati	Department of Zoology, Gauhati University, Guwahati	**Indigenous Ornamental Fishes**: *Microphis deocata* *Channa stewartii* *C. andrao* *Garra annadalei* *Devario aequipinnatus* *Danio dangila* *Puntius chola* *Trichogaster chunna* *Esomus dandrica* **Food fishes:** *Clarias magur* *Ompok pabda* Broodstock of *C. magur* (459), *O. pabda* (130) *O. pabo* (245), *C. stwartii* (85), *M. deocata* (140), *A. crenucoids* (105), *D. aquipinnatus* (50), *D. dangila* (60), *C. andrao* (34), *P. chola* (65), *G. annandelei* (15), have been collected and is being maintained for collaborative work on breeding and maintaining live germplasm at regional centre, Gauhati University.
2.	Central farm, Central Agricultural University, Lamphelpat, Imphal	Central Agricultural University, Lamphelpat, Imphal	**Food fishes**: *Bangana devdevi* *C. magur* *O. pabda*

Program 5.2: Characterization and evaluation of genetic resources, intra-specific diversity and genetic stocks

The genetic variability in natural populations of any important species is essential to be documented so as to plan its use and for conservation of the natural gene pool. Population of a species is composed of genetic stocks which are locally evolving units and develop attributes of significance to the local environments. Intra-specific variability in the species is a useful trait with potential application in domestication and genetic improvement. Inadequate knowledge on genetic stocks of cultivable species of fishes is a major constraint in the intensification of aquaculture. As phenotypic variation and production performance, especially in wild relatives, is not clearly apparent; indirect methods like scale reading for growth and image analysis for the phenotypes is employed for stock identification. Molecular markers serve as useful tool to provide direct assessment of genetic divergence. ICAR-NBFGR has been engaged in population genetic studies of Indian fish species to determine genetic stocks in prioritized cultivable species, potentially cultivable or important exploited stocks from various ecosystems, using standardized molecular markers and biological methods.

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), V.S. Basheer, T.T. Ajith Kumar, Sullip Kumar Majhi, Santosh Kumar, Charan Ravi, Aditya Kumar and Ajay Kumar Singh

Funding Support: Institutional, ICAR-NBFGR

Five species were collected and maintained in captivity at PMFGR, Kochi; 4 species in Nagarjuna Sagar, Telangana and 11 species in NBFGR HQ, Lucknow for broodstock development, captive propagation, evaluation and conservation.

The novel method addresses a critical problem, sacrificing the males for breeding which is bottleneck in conservation of this species and seed production. The spermatozoa cells ($7.9\pm50\times10^{8}$) from sexually matured *Clarias magur* (10) were partially harvested by surgical interventions (Fig. 27). The gametes were artificially inseminated to generate viable progeny.

Fig. 27. Partial harvest of spermatozoa cells by surgery

The males were also successfully reused in the next year. This can be implemented for other catfishes too which needs male sacrificing for seed production.

Broodstock maintenance and induced spawning of two indigenous species; endemic yellow catfish, *Horabagrus brachysoma* and Malabar carp, *Labeo dussumieri* for dissemination to state department has been accomplished. Broodstock development and induced natural spawning of critically endangered catfish, *Hemibagrus punctatus* (Fig. 28) was

Fig. 28. Broodstock development and induced spawning of *Hemibagrus punctatus*

successfully carried out in captivity for the first time and progeny is propagated in captivity. Induced natural spawning trials of endangered catfish, *Clarias dussumieri* were successfully carried out with closed-cycle hatchery production, using F1 generation and F2 generation. Experiments were also conducted for successful rearing of larval stages.

In India, there are two clariid species *viz. C. magur* and *C. dussumieri* and both are considered to be declining in wild. The possibility of hybridizing two clariid species was evaluated. This study was done in PMFGR, Kochi using *C. dussumieri* females and cryopreserved milt (2017) of *C. magur* transferred from Lucknow to Kochi. Hybrid seeds were produced and are being reared and will be developed as brooders (Fig. 29). *C. magur* is available in Indo-Gangetic plain and its co-generic species *C. dussumieri* is endemic to Malabar area. Spawning cannot be induced in *C. magur* in captive condition and sperm suspension is made after sacrificing males for commercial seed production. However, spawning can be induced in *C. dussumieri* in captive condition and sacrifice of male is not always required.

Fig. 29. Hybrids produced from female *Clarias dussumieri* and male *Clarias magur*

Wild collected *Pangasius silasi* (Fig. 30) was evaluated under cage system. The fish was successfully acclimatized to the pelleted feed. The fish is prone to ectoparasite attacks during the stress periods. Acclimatized fishes were PIT tagged and average growth rate was found to be 76.2 g weight and 1.99 cm length /month during 9 month period. Length-weight relationship and condition factor of captive acclimatized fish specimens is comparable to the wild. Nutritional profile (in collaboration with CIFT) revealed good fillet ability, white flesh, lean fat @ 2% and high PUFA (EPA and DHA) contents.

Fig. 30. *Pangasius silasi*

Preliminary success was also achieved in induced spawning of *Ompok bimaculatus* without sacrificing the male, at Telangana (cage reared). This could open way for further work on up-scaling the natural breeding for commercial seed production.

Two earthen ponds (50 m x 40 m & 20 m x 40 m) were renovated and 8 cages with the dimension 4 m x 4 m x 1.5 m were installed at Kerala University of Fisheries and Ocean Studies (KUFOS). Three nursery ponds (8 m x 4 m size) with lining were constructed. A hatchery shed (50 feet x 20 feet size) was established (Fig. 31b). Further, a wet-lab cum hatchery was created in ICAR-CMFRI campus for breeding and larval rearing. Small RAS was also constructed for larval rearing of catfishes.

Fig. 31. Facilities developed at KUFOS; a. Cages installed, b. Hatchery

Project: Outreach activity on fish genetic stocks-Phase II

Period: April, 2014 - May, 2020

Personnel: Rajeev K. Singh (PI), Vindhya Mohindra, Achal Singh, Sangeeta Mandal, Rejani Chandran, Amar Pal, Rama Shankar Sah and Rajesh Kumar

Funding Support: Institutional, ICAR-NBFGR

There is a emerging need for documenting aquatic genetic resources and variability for food, aquaculture and trade. Under the Phase II of the project, eight commercial/ phylogeographical/evolutionary valued fish species were investigated for genetic variability analysis. The data generated through molecular markers, as well as, morphological descriptors will provide baseline information of genetic variability existing in natural populations.

Genetic Structure of Natural Populations

Tor tor

Genetic diversity in wild populations of *T. tor* was studied using two mitochondrial genes, Cytochrome b and ATPase 6/8. Sequence analysis of 139 individuals, collected from 6 different locations revealed 12 and 7 haplotypes, respectively. Mantel tests identified a positive relationship between pairwise geographical and genetic distances. AMOVA results pointed out maximum genetic variation within populations. The total F_{ST} was found to be significant in both genes with a value of 0.5787 ($p<0.05$) and 0.3726 ($p<0.05$) for Cytb and ATPase respectively, which revealed sub-structuring in the *T. tor* natural populations (Fig. 32). Microsatellite genotyping was done at 15 loci. The

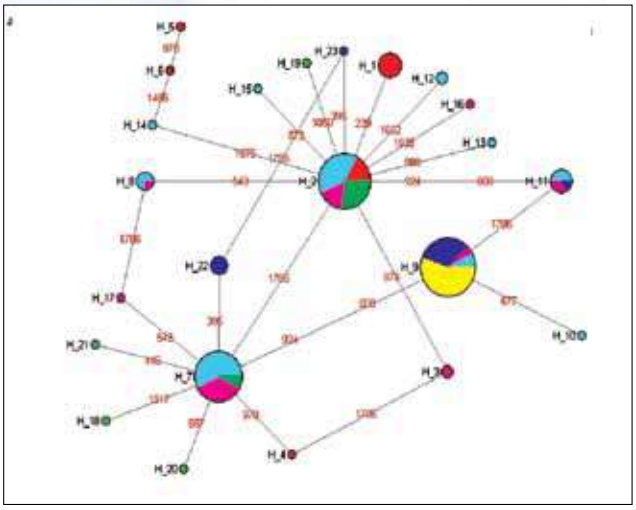


Fig. 32. Median joining haplotype network in *Tor tor*

PIC value of the loci ranged from 0.722 to 0.908. The observed and expected heterozygosities ranged from 0.5899 (TTO80) to 0.8921 (TTO211) and from 0.5775 (TTO659) to 0.8780 (TTO288), respectively. Overall F_{ST} 0.03901, for 15 loci was found to be significant. Maximum number of private alleles was reported from different sites of river Narmada.

Chitala chitala

Sequence variations in two full-length mitochondrial genes, Cytochrome b and ATPase 6/8 were investigated to delineate patterns of gene flow in Indian featherback fish [*Chitala chitala* (Hamilton, 1822)]. Analyses of 403 individuals, collected from 14 rivers (five river basins) in India yielded 61 haplotypes. Hierarchical analysis identified 19.01% variance among and 80.99% variance within groups and populations, indicating a moderate level of gene exchange (Fig. 33).

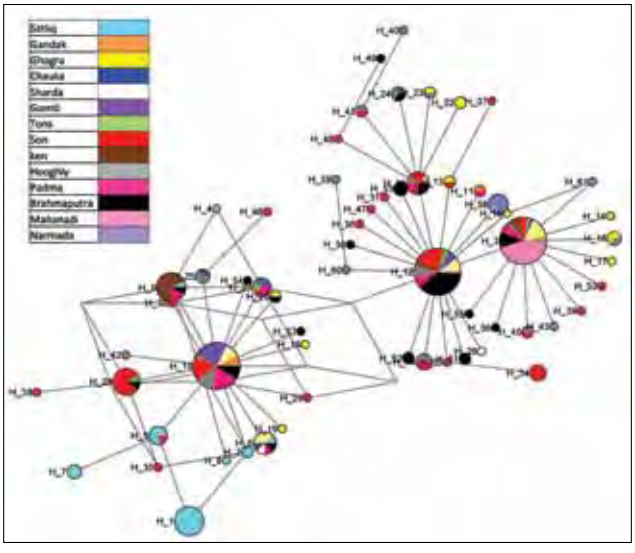


Fig. 33. Median joining haplotype network of concatenated genes in *Chitala chitala*

A total of 54.44% pairwise genetic differentiation tests were found to be significant. The mean coefficient of genetic differentiation (F_{ST}) was observed to be significant 0.26 ($p<0.05$), which revealed that the natural populations are sub-structured. The patterns of genetic variability indicated the presence of four genetic stocks of *C. chitala* in Indian rivers. Genetic diversity analysis of *C. chitala* at 32 polymorphic loci, resulted into highest number of alleles at locus Chc304 (28), while lowest at Chc155, Chc783 and Chc6. Mean number of alleles was maximum in river Ghaghra. H_{obs} ranged from 0.3382 (Teesta) to 0.5161 (Gandak), while H_{exp} range was 0.3831 (Son) - 0.6030 (Ghaghra).

Anguilla bengalensis

Anguilla bengalensis, a catadromous eel, is *a* valuable species due to its delicacy and therapeutic potential. It is important to document genetic diversity and structure for proper scientific management of this species. Analysis of 89 sequences (four locations) of ATPase 6/8 genes revealed 17 haplotypes, while cytochrome b was represented by 18 haplotypes. High haplotype diversity (*Hd*) and low nucleotide diversity (π) was observed for both mitochondrial genes. Analysis of molecular variance (AMOVA) revealed that 19.77% and 15.19% variance among populations within groups using ATPase 6/8 and Cytochrome b gene, respectively. The populations of *A. bengalensis* demonstrated low level of genetic differentiation. Individual genotyping data at 29 polymorphic microsatellite loci was analysed. Number of alleles ranged from 3 locus (*Abg345SF*) to 16 (*Abg308*). Observed heterozygosity ranged from 0.7226 (Godavari) to 0.5383 (Ganga), while H_{exp} varied from 0.5747 (Ganga) to 0.5057 (Ken). Mean coefficient of genetic differentiation was 0.01.

Silonia silondia

In *Silonia silondia,* a commercially important food fish, study was conducted to delineate natural genetic structure using mitochondrial genes. A total of 38 haplotypes were observed by analysing combined mitochondrial genes (Cytochrome b+ ATPase 6/8) in 247 individuals of *S. silondia* collected from 6 populations. Average haplotype and nucleotide diversities were 0.8508 and 0.00231, respectively. Genetic structure analysis showed that the predominant cause of genetic variation was within populations. Analysis of combined mitochondrial genes in 6 populations of *S. silondia* resulted in three

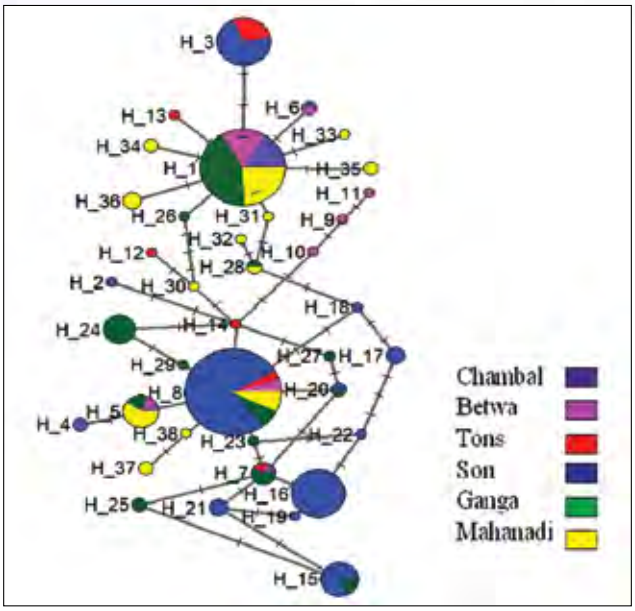


Fig. 34. Haplotype networking in *Silonia silondia*

management units (Fig. 34). Microsatellite analysis at 21 loci (6 populations) revealed mean F_{ST} to be 0.03. Mean number of alleles per locus varied from 12.19 (Son) to 6.14 (Chambal). AMOVA analysis showed variance, 3.75 (among groups) and 11.40 (among individuals within populations).

Systomus sarana

In *Systomus sarana*, genetic diversity in seven riverine populations was studied using two mitochondrial genes, Cytochrome b and ATPase 6/8. Sequence analysis of 229 individuals (7 riverine locations), revealed 55 and 15 haplotypes, respectively. AMOVA results pointed out maximum genetic variation due to variation in within populations, 83.40% and 73.63% for ATPase 6/8 and Cytb, respectively. The mean F_{ST} was found to be significant in both genes, 0.16 for ATPase 6/8 and 0.26 for Cytb. The analysed results revealed the existence of sub-structuring in the *S. sarana* natural populations. Microsatellite genotyping was done for 23 loci. A total of 18 alleles were observed at locus Lr382, while 5 at Lr1756. The observed and expected heterozygosities ranged from 0.2898 (Son) to 0.4152 (Bhagirathi) and from 0.4342 (GodavariS) to 0.5547 (GodavariR), respectively.

Mugil cephalus

Mitochondrial sequence variations in two full-length genes, Cytochrome b and ATPase 6/8 were used to reveal patterns of genetic connectivity in *Mugil cephalus*. Analyses of 489 individuals, collected

from 8 locations yielded 78 and 54 haplotypes, respectively. Mean coefficient of genetic differentiation for Cytb was 0.15, while 0.095 for ATPase 6/8 gene. Hierarchical analysis identified 6.35% and 10.95% variance among groups, while within population variance contributed to most of the variation. The results revealed that the natural populations are sub-structured. Microsatellite genotyping was done for 510 samples at 19 polymorphic loci. Highest H_{exp} was observed (0.7893) in Hooghly, while lowest (0.648) in Karwar. Observed heterozygosities ranged from 0.4836 (Mahanadi) to 0.6339 (Mangalore). The results showed that maximum percentage (95.76%) of variation was within individuals, with 1.43% among groups.

Litopenaeus vannamei

Tissue samples from 166 *L. vannamei* individuals collected from 12 different farms of Kochi, Cuddalore, Fatehabad, Hisar, Bhiwani, Rohtak and Nellore were assayed using 13 polymorphic microsatellite markers. No evidence of large allele dropout or band stuttering were detected at any locus. The genotyping on more microsatellite loci is being done for genetic diversity assessment.

Genome sequences (partial) for various species through PacBio RSII

Under the project period, partial genome sequences for *Anguilla bengalensis, Cirrhinus mrigala, Clarias batrachus, C. dussumeiri, Lates calcarifer, Litopenaeus vannamei, Macrobrachium rosenbergii, Ompok bimaculatus, Scomberomorus commerson, Silonia silondia, Thunnus albacares, Tor putitora, T. tor, Tranchinotus blochii, Catla catla, Chitala chitala* and *Tenualosa ilisha* were generated through PacBio RSII, installed at the institute. High quality genomic DNA (10 µg) was sheared using the Covaris S220 fragmentation system (Covaris, Inc. USA) and the SMRT bell library (1.5 kb) was constructed. The SMRT sequencing was done on PacBio RSII using P6C4 chemistry. Following the removal of low-quality reads and redundant sequences, the circular consensus (CCS) reads were clustered using CD-HIT and assembled through CAP3 using default parameters. The generated data have been used to identify the validated microsatellite panels for determining genetic diversity parameters and to determine the population structure in the natural populations of the species. Genome resources generated for other species will be useful for future studies in population differentiation studies.

Length Weight Relationship

A total of 439 samples of *C. chitala* from 14 locations over a time period of 2000-2017 were collected. The value of 'b' ranged from 2.24 (Gomti) to 3.24 (Son). A comparative study of two notopterids, *Notopterus notopterus* and *C. chitala* revealed that Fulton's condition factor and relative condition factor was found to be greater for *N. notopterus* than *C. chitala* in common sites of collection (Gomti and Son). Spatial variations across different locations in rivers were also studied in both species. It was found that both the species have adapted well to changing water quality and habitat deterioration prevalent in inland water bodies.

In *M. cephalus,* a total of 267 individuals, collected from Puducherry, Marakkanam, Vellar Estuary, Mandapam, Coleroon Estuary, Thengapattanam and Mahanadi were analyzed for LWR. The value of 'b' ranged from Thengapattanam (3.414) to Coleroon Estuary (2.38). Average value of Fulton's condition factor (K) for *M. cephalus* in selected locations ranged from 0.91 (Coleroon estuary) to 1.08 (Puducherry). The differences in the length–weight data of *M. cephalus* between locations could be due to the differences in body size group, maturity condition, life stages, body health, habitat conditions and the collection time. High K value in the locations indicates that the nutritional conditions of fishes of these rivers are good.

Age and Growth Analysis

In age and growth analysis for *M. cephalus,* 4+ age classes were recorded from all locations except Marakkanam and Thengapattanam. The back-calculated length for 1+ age class was highest in Thengapattanam and lowest in Mandapam, and 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 classes for all locations. Rate of linear growth (C_l) and growth constant (C_{lt}) decreased for all populations with increase in age. *C. chitala* scales from five locations (Bansagar 25; Gomti 24; Son 9; Ken 9; Brahmaputra 2) revealed that the highest age class observed in *C. chitala* was 4+. Highest growth rate was observed in Bansagar location. *S. sarana* scale study from 6 locations (Narmada 18; Betwa 11; Hooghly 11; Guwahati 9; Son 5; Tons 3), demonstrated the highest age class to be 3+ and highest growth rate was observed

in Narmada. High age class is indicative of population to be dominant of brooders of these species.

Shape Morphometry

In *S. silondia,* truss network analysis was carried out in natural populations using 12 landmarks. A total of 66 morphometric variables were extracted from digital images of the specimens. The principal component analysis provided twelve principal components contributing up to 94.77% of total variation. Canonical discriminant function analysis provided three significant functions, explaining 95.80 % of total variation (Fig. 35). Cross-validation results by discriminant analysis of morphometric traits explained that 80.2% of the specimens were correctly classified into their original populations.

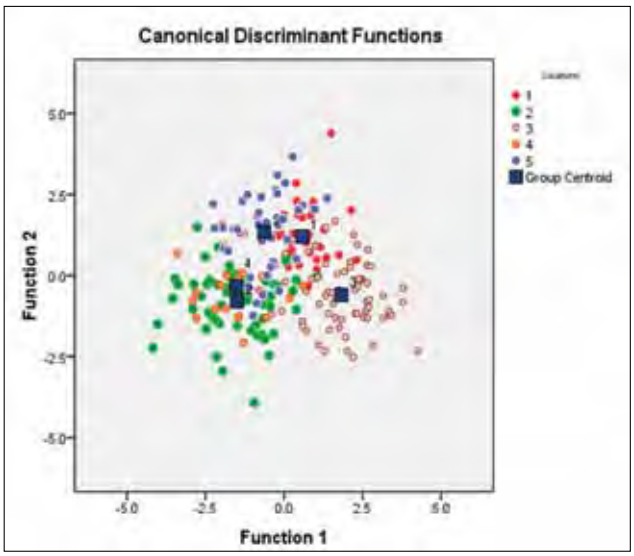


Fig. 35. Specimens distribution from five locations (1. Betwa, 2. Son, 3. Ganga, 4. Mahanadi-Ib, 5. Mahanadi-Hirakud) as per canonical discriminant function in *Silonia silondia*.

Project:	**Outreach activity on fish genetic stocks-Phase II**
Sub-Project:	**Candidate species: *Perna viridis* and *Sillago sihama***
Period:	**April, 2015 - March, 2019**
Personnel:	**Divya P.R. (PI), Basheer V.S., Kathirvelpandian (Upto July, 2019) and Charan Ravi**
Funding Support:	**Institutional, ICAR-NBFGR**

Unsustainable anthropogenic activities and changing climate scenario are creating challenges for sustainable fish stock management. The current scenario warrants scientific intervention to utilize the fishery in a sustainable manner for which, genetic stock structure information is vital. In the project genetic stock structure study of commercially important species was undertaken.

Perna viridis

Genetic stock identification in *P. viridis* revealed three distinct genetic stocks in Indian waters using molecular markers *viz.* East coast, West coast and Andaman Islands. In addition, fine-scale genetic structuring was revealed in *P. viridis* from west coast (between Goa and Kollam) (pairwise $F_{ST:}$ 0.019, P<0.01), using nuclear microsatellite markers. No significant pairwise genetic distance was noted among east coast population (0.004, P>0.01). The total number of alleles per locus ranged from 11 to 33 and the allele size ranged from 120 to 390 bp. Mean value of observed heterozygosity (H_{obs} - 0.741) for all populations was closer to the expected heterozygosity (H_{exp} - 0.75). Bottleneck analysis indicated genetic stability of species in the wild. *P. viridis*. Being an important aquaculture species, the findings of the present study strongly suggest the need for adoption of stock specific rehabilitation and relaying programmes of the species from Indian waters.

Sillago sihama

Taxonomic observation and molecular tools helped us to conclude that the so called *S. sihama* exists as fishery only along Cochin, Mangalore, Goa and Ratnagiri in the west coast of India. Analysis of data generated using mitochondrial ATPase gene, cyt b gene and truss morphometric measurements for the *S. sihama* collected from west coast revealed unit stock of *S. sihama* in Indian waters, whereas nuclear microsatellites was capable enough to detect fine scale structuring of *S. sihama*.

Validation of polymorphic microsatellite marker panels in *Thunnus albacares, Scomberomorus commerson* and *Trachinotus blochi*

Narrow barred spanish mackerel (*Scomberomorus commerson*), yellowfin tuna (*Thunnus albacares*) and silver pompano (*Trachinotus blochi*) are commercially important marine fishes. Attempts were made to develop microsatellite marker panels in, *T. albacares, S. commerson* and *T. blochi*. 203 microsatellite loci in *S. commerson,* 100 loci in *T. albacares* and 200 loci in *T. blochi* were developed using Third Generation Sequencing technology in PacBio RSII, based on

Single-Molecule Real-Time (SMRT). Of the 100 microsatellite primer pairs tested in *T. albacares*, 26 loci were polymorphic, 31 monomorphic, while 43 primers either didn't amplify or yielded unspecified products. 12 panels of 26 primers were developed in *T. albacares*. The polymorphic 26 microsatellite loci were characterized, by genotyping 20 individuals each from three locations in Arabian Sea (Kochi) and Bay of Bengal (Visakhpatnam and Andaman Islands). The number of alleles per locus varied from 7-16, with a mean value of 8.7. The mean observed and expected heterozygosities were 0.73 and 0.77 respectively. The Polymorphic Information Content (PIC) was highly informative, ranging from 0.623 to 0.924. The loci were useful in differentiating the stock of yellow fin tuna of the Indian mainland (Kochi, Visakhpatnam) from Andaman Islands. These markers provide the first specific nuclear microsatellite panels for easy, quick and economical approach for genetic stock identification of a commercially important marine species. The study also gives the preliminary information on the structuring of the yellowfin tuna in Indian region using nuclear markers.

The amplicons in *S. commerson* exhibited polymorphism at 47 loci, of which 13 panels were formed using 32 primers. These 32 loci were characterized by genotyping 20 individuals each from the Kochi and Veraval in the Arabian sea and Chennai along Bay of Bengal coast (n = 3). The number of alleles per locus varied from 4 to 17, while the mean observed and expected heterozygosities ranged from 0.656 to 0.753. The polymorphic information content (PIC) were highly informative, 85% loci with PIC value 0>0.75. This suite of markers provides the first species specific nuclear multiplex microsatellite marker panels (32 loci) for *S. commerson*, which would allow assessment of different populations structures with more specificity. The overall F_{ST} was 0.04784 (P<0.01) for all three populations. AMOVA results indicated 3% of the variance among populations, 15% among individuals within populations and 82% within individuals. Cross-species transferability of microsatellite markers tested in *S. guttatus* showed amplification at 23 genomic sites in *S. guttatus*.

Of the 45 polymorphic loci, 14 panels of 36 loci were standardized in *T. blochii* using samples from three locations: Mandapam, Kochi and Tuticorin. The genotyped data using 36 loci in *T. blochi* are being analysed to validate the microsatellite primer panels in this species.

Project: Population genomics and mapping signatures of natural selection in Asian Seabass in India

Period: April, 2019 - April, 2022

Personnel: Rajeev K Singh (PI), Sangeeta Mandal, Rejani Chandran and L. Mog Chowdhury

Funding Support: DBT

Project aims to document population genomics and genetic signatures of *Lates calcarifer* which is an important candidate species for culture in our country. The samples (92) of *L. calcarifer* were collected from the commercial catches from 6 locations of east and west coasts of India (Fig 36). Tissue samples (muscle and fin clips) from each fish, were collected and fixed in 95% ethanol and stored at 4°C.

Mitochondrial gene COI was amplified using universal primers. The amplicons were purified and sequenced bidirectionally. Sequence editing and

Fig. 36. Collection locations of Asian Seabass

multiple sequence alignment were conducted for estimation of sequence divergence. The pairwise distance and phylogenetic analysis of generated sequences along with sequences (246) of *L. calcarifer* downloaded from NCBI were analysed together. One cluster represented sequences from Indian subcontinent and Myanmar, while the other comprised of Southeast Asia (Singapore, Malaysia, Thailand, Indonesia and Australia) (Table 7, Fig. 37).

Table 7. Details of Cytochrome oxidase I (COI) gene sequence downloaded from NCBI

S No	Country	No. of sequences	NCBI Accession Number
1	Taiwan	7	MK617152, MK777481, KJ573940 - J573944
2	Bangladesh	11	MG969518, MH087052, MK572284, MN171369, KJ573900 - KJ573905
3	Malaysia	8	KJ573927 - KJ573933, KY849521
4	Australia	28	DQ108012, DQ108013, DQ108014, DQ108026, DQ108027, EU189376 - EU189379, KU496216 - KU496230, KX781858, KX781875, KY213962, KJ669498
5	Indonesia	7	KU692587, KJ573921 - KJ573926
6	India	147	KC508497, KC508497 - KC508501, JF919740 - JF919828, KJ573906 - KJ573920, KJ573892 - KJ573899, KJ573945 - KJ573962
7	Myanmar	5	EF609378 - EF609382
8	Singapore	6	KJ573934 - KJ573939
9	China	26	GU459269 - GU459275, GU459303 - GU459305, EU595178 - EU595186, FJ237999 - FJ238005

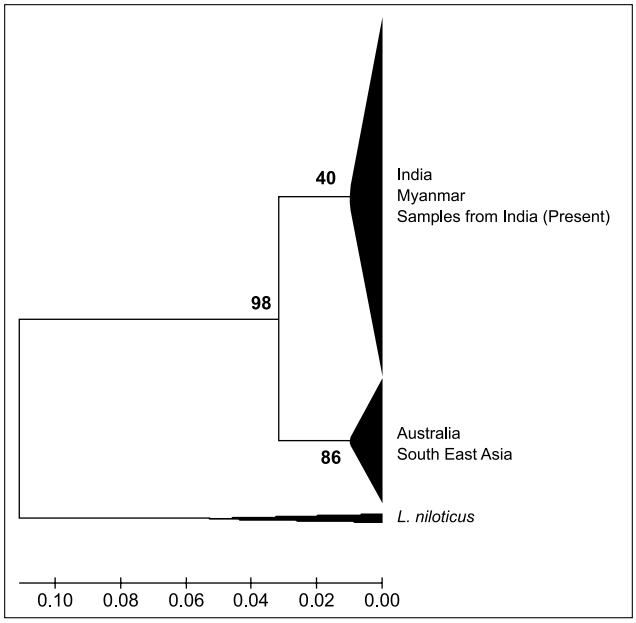


Fig. 37. Neighbour Joining tree presenting two distinct clusters

About 10 µg high quality genomic DNA (high molecular weight and purity) was isolated using Phenol-chloroform method and purified with AMPure PB beads (Beckman Coulter, Inc., CA). The quality check of the DNA was carried out through agarose gel electrophoresis as well as on DeNovix (DeNovix Inc.). The HMW gDNA was sheared using Covaris S220 fragmentation system (Covaris, Inc. USA) as per manufacturer's recommendations. The fragmented DNA was processed to construct 1.5 Kb SMRT bell library. A small insert library was sequenced on PacBio RS II using SMRT technology. The clustering and assembly of high-quality CCS reads resulted in dinucleotides (79.42%), trinucleotide (8%), 159 tetra-repeats (9.8%), and 2.43% were with larger repeat motifs. A total of 6961 sequences were found to contain more than one repetitive region. In general, most dinucleotide repeats were (AC)n, (GT) n, (TG)n, while, (AAT)n, (TTA)n, (ATA)n repeats in trinucleotide, and (TCTA)n, (AGAT)n, (TATAG)n in tetranucleotide motifs.

Out of 213 primers tested, 110 loci (51.6%) resulted in amplification, of which 39 (36%) exhibited polymorphism. A total of 32 were monomorphic, while multiple amplifications were obtained at 39 loci. The polymorphic primers are being validated for use in deciphering genetic diversity.

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), Lalit Kumar Tyagi, Achal Singh, Rejani Chandran and Kantharajan G.

Funding Support: Bioversity International

The program envisaged to assess impact of agriculture effluents on the aquatic ecosystems and in developing recommendations for sustainable aquatic ecosystems in harmony with agriculture development. Three landscapes were selected in the study *viz.* Adilabad, Karimnagar and West Godavari.

Assessment of Ecosystem Services of Selected Regions

Land Use Land Cover (LULC) Analysis

The LULC classes were studied using the LULC data of the three selected landscapes obtained from Bhuvan (Indian Geo-Platform from ISRO). The changes in the acreage under different land use classes over the last three decades were analysed. The results revealed that croplands accounted for about 60-70% of the land use in Karimnagar and West Godavari while in Adilabad it was less than 50%. It was observed that area under cropland increased over the years in Adilabad and Karimnagar, while it decreased from 5735.13 km^2 (1985) to 5330.42 km^2 (2005) at West Godavari. The area under water bodies LULC class increased in 1985 - 1995 and 1995 - 2005 in this landscape compared to that in 1985.

Sediment Delivery Ratio

Preventing soil erosion and maintaining water quality are important ecosystem services of any landscape. Therefore, there is need to quantify the sediment delivery from landscape so that conservation practices can be designed accordingly. Modeling was done in Sediment Delivery Ratio module of InVEST model for assessment of the sediment retention ecosystem services at the landscape level in three selected regions of Godavari basin. The highest sediment export from Karimnagar was found in the LULC category 'Croplands', while it was 'Deciduous needle leaf forest' in Adilabad and West Godavari. The maximum area in Adilabad was under cropland (46.8%) followed by deciduous needle leaf forest (32.8%). However, the sediment loss was highest from Cropland (55.37%) followed by fallow (34.4%). Thus, cropland contributed maximum to sediment export in all three landscapes studied.

Documenting Diversity and Water Quality

Physico- chemical parameters were recorded to determine the quality of river water (Fig. 38.). The fish (60 species) and aquatic insect diversity was documented from the surveyed areas. The phytoplankton and zooplankton density was determined and maximum density was observed in locations with reduced water flow *i.e.*, Cheggaon, Kovvur and Paidimetta (Fig. 39). The results revealed the presence of heavy metals, antibiotics and few pesticides in river water; however nitrates were found to be higher in some locations such as Kovvur, Cheggaon and Sri Ram Sagar project dam.

Fig. 38. Recording of water quality parameters

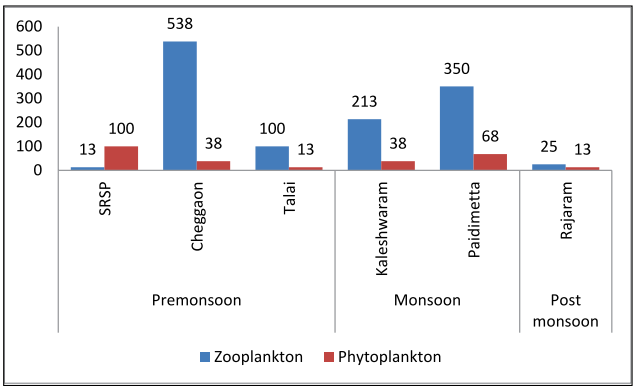


Fig. 39. Spatial Variation in Phytoplankton and Zooplankton density

Fish gut content analysis

To understand the food and feeding behaviour and the interspecific relationship between different species in the landscape under study, gut contents were analysed. Fishes with different feeding pattern were prioritised. The gut material from 14 fish species was removed, preserved and identified under the microscope for confirming the food habits. Gut

Fig. 40. Collection of fish gut

content analysis exhibited the fishes as planktivore (6), omnivore (5) and carnivore (3). The major diet component of analysed fish species were in accordance with observations made by earlier workers (Fig. 40).

Analysis of Heavy metals, Antibiotics and Pesticides

The presence of heavy metals *viz.* Chromium, Lead, Copper, Mercury and Arsenic was recorded in all water samples collected from ten villages during the survey period. Results indicated that the Zinc concentration was 0.5 mg/l in all ten villages, followed by Chromium (0.025 mg/l). Copper was the lowest among the heavy metals analyzed (Fig. 41).

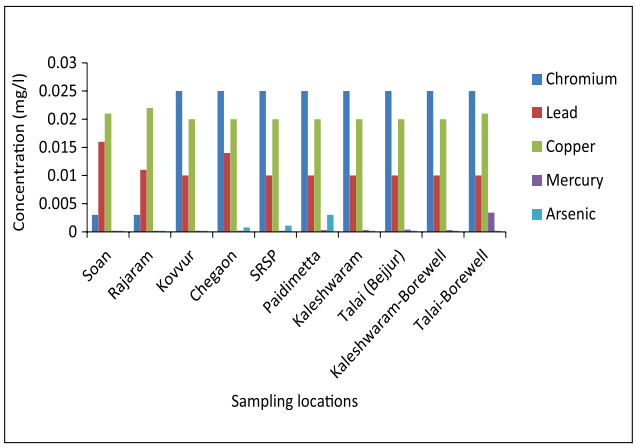


Fig. 41. Distribution of heavy metals (mg/l) in various sampling sites

Socio-Economic Profiling

A total of 5 formats were developed, and field tested, demonstrating effectiveness in capturing the farmer's data. The informants included agricultural farmers (60), fishermen (68) and other stakeholders (22) belonging to 24 villages of the selected landscapes (Fig. 42). The availability of irrigation water was another cause of concern for differential socio-economics of the people.

Fig. 42. Interaction with farmers and filling up of the questionnaire

People's perception about aquatic diversity and habitats

Majority of the fishermen surveyed, opined that their preferred/target fish species have decreased over time, sizes of the fishes caught have reduced, availability and quality of aquatic habitats including aquatic vegetation, have reduced. Few fishermen in Kukkalagudur village in Karimnagar landscape reported an increase in these parameters. Major causes for above changes perceived by the fishermen were: habitat loss/sedimentation of water bodies, water and environmental pollution, reduced productivity of rivers due to low plankton density and over fishing. Few fishermen also perceived that pollutants resulting from the chemicals used in agriculture get mixed with run-off water and reach rivers, which sometimes cause fish mortality. Measures suggested by the fishermen for enhancement of aquatic diversity and fisheries resources included ranching of fish seed, maintaining water level (environmental flow) in rivers and reduction in usage of chemicals/pesticides in agriculture.

The pilot study, indicated that ecosystem services are deeply impacted by anthropogenic activities, particularly, agricultural inputs/chemicals, etc. More surveys from larger number of villages are required to authenticate the results and develop appropriate policies.

Project: Assessment of Genetic Introgression and Variation in Hatchery Bred Indian Major Carps

Period : December, 2015-December, 2019

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

Funding Support: UGC

Project aims to develop baseline quantified data on genetic introgression and variation in Indian major carp species from selected hatcheries with the help of molecular markers such as microsatellites. Automated genotyping was done for 18 loci of *Labeo rohita*. The primers used for amplification, were labelled with FAM/HEX/NED. Individual genotyping was done on 18 polymorphic loci for 244 individuals of *L. rohita*, collected from 6 distant hatcheries (Uttar Pradesh and Madhya Pradesh). The riverine genotypes (previous study) were also studied together for comparative analysis. The mean allelic richness for all the hatcheries with all loci was found to be 7.9 while it was 15.152 for

rivers with same loci in *L. rohita*. Overall, significant reduction in the mean number of alleles at all the loci in hatchery bred *L. rohita*, was seen, ranging from 16.903 (wild) to 7.472 (hatcheries). The comparative genetic parameters such as, mean number of alleles per locus, mean inbreeding coefficient (F_{is}), Heterozygosities (observed and expected) are shown in Fig. 43.

In *Catla catla*, 10 polymorphic loci were analyzed for 245 individuals from 6 distant hatcheries of Uttar Pradesh, Madhya Pradesh and West Bengal. The mean allelic richness for the hatcheries and all loci was found to be 3.875 while it was 5.8 for the rivers with same loci. The mean number of alleles in hatchery ranged from 6.9 to 4.2 in *C. catla*.

Both *L. rohita* and *C. catla* showed significant drop in number of alleles and their frequencies, allelic richness and also the heterozygosity level while comparing it with wild *L. rohita* and *C. catla*. The Inbreeding coefficient (F_{is}) was higher in the hatchery samples in comparison with wild samples for the both *L. rohita* and *C. catla*. The current results will help in appropriate decision making for the genetic management in the respective hatcheries, depending upon the magnitude of introgression or genetic bottlenecks.

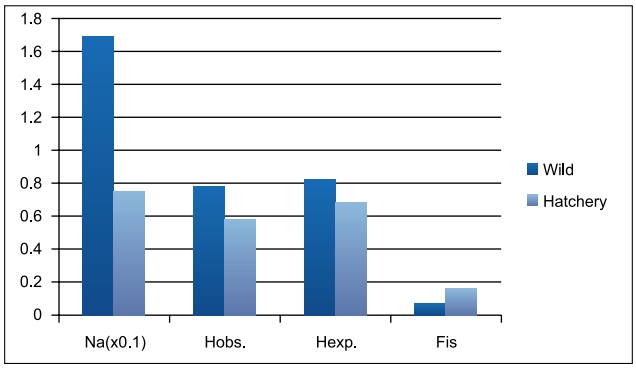


Fig. 43. Comparative illustration of genetic parameters in *Labeo rohita* from wild and hatchery

Project: **Exploring the variation in immunological and disease susceptibility against *Aeromonas hydrophila* in two different stocks of Indian catfish *Clarias magur***

Period: November, 2016 - March, 2020

Personnel: Gaurav Rathore (PI), Chinmayee Muduli, Rajeev Kumar Singh, 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.

TLR2 gene of Indian magur (*C. magur*) was cloned and characterized. The full-length cDNA of magur TLR2 (mTLR2) comprised of 3063 bp with a single open reading frame (ORF) of 2375 bp encoding 790 amino acids having a theoretical pI value of 6.11 and molecular weight of 90 kDa. Structurally, it comprised of signal peptide (1-42 aa), one leucine-rich repeat region (LRR) at N-terminal (LRR1-NT; 95-118 aa) and C-terminal (LRR-CT; 557-610 aa), five LRRs in between, one trans-membrane (TM) domain (609-631 aa) followed by cytoplasmic TIR domain (651-750). Two microsatellites were detected in the upstream and downstream of mTLR2 cDNA i.e., pentamer penta-repeat $(GTTTT)_5$ at 69 bp and dimer octa-repeat $(AC)_8$ at 2862 bp. Phylogenetically, mTLR2 is closely related to pangasius and exhibited 83.19% identity at nucleic acid and 77.63% identity at deduced amino acid level respectively. Basal expression analysis of mTLR2 and its downstream signaling molecule (MyD88, NFkβ, IL-1β) showed constitutive expression in all the tissue examined. Highest basal expression of mTLR2 and IL-1β in spleen, MyD88 in gill, NFkβ in anterior kidney. Skin has the lowest basal expression of mTLR2, whereas muscle showed least expression of MyD88, NFkβ and IL-1β. Identified the teleosts-specific TLR i.e. TLR22 and other two genes namely, interleukin-1 receptor-associated kinase 4 (IRAK4) and tumour necrosis factor receptor-associated factor 6 (TRAF6) involved in the TLR signaling cascades in *C. magur*. The transcript levels were determined in 12 different tissues of healthy *C. magur* using qRT-PCR. Among the tested tissues, spleen appeared to be the organ with highest level of mRNA expression for TLR22. Similarly, the level of mRNA expression for IRAK4 was higher in spleen and kidney. The TRAF6 expression was found to be higher in kidney tissues and along with tissues facing the external organs such as gills, intestine and skin. The least basal expressions

for all these three genes were in muscle followed by heart and stomach. The basal level expression of these important immune sentinels will be useful in delineating stocks with comparatively better health profile.

Immune gene expression in *C. magur* challenged with pathogenic *Aeromonas hydrophila*

Apparently healthy magur (~60g) were randomly divided into two groups i.e. control (PBS injected), and *A. hydrophila* injected. Each group consisted of 40 fish and were separately maintained in 250 l FRP tanks. For bacterial infection, fish were intra-peritoneally (i.p.) injected with *A. hydrophila* (1×10^6 cfu/fish) in 100 µl of PBS. The control group was injected with 100 µl of PBS and kept separately. After 3 h, 8 h, 24 h, 72 h and 144 h of injection, respectively, gill, liver, spleen, intestine, kidney tissue from control and injected groups were collected into RNAlater and stored at -80°C until RNA extraction. Three fish as biological replicates were sacrificed each time point. Gene expression profiles of mTLR2, MyD88, NFkβ and IL-1β was studied at each time point. Serum innate immune parameters were also studied in both the groups. Significant up-regulation of mTLR2, MyD88, NFkβ expression occurred at 3 to 8 h in response to *A. hydrophila* infection. Expression of immunoregulatory cytokine i.e. IL-1β in various organs was significantly enhanced following *A. hydrophila* infection. Serum parameters were compared between infected and control groups at all time points. A significant decrease in myeloperoxidase, bactericidal activity, bacterial agglutination titer, total protein, albumin and lysozyme was observed in infected group at 3 h post infection which indicates that pathogen is able to suppress host immune response. Total anti-protease and α-2 macroglobulin remained significantly increased at 3 h, 8 h and 24 h post infection compared to control. Total serum protein concentration and serum bactericidal activity was significantly higher at 24 h in infected group as compared to control.

Program 5.3: Genomic resources for important fishes

ICAR-NBFGR is a pioneer institute in the development of genomics and bioinformatics research relevant to Indian fisheries sector. Presently, the institute is leading an ICAR-Consortium Research Project on Genomics and Agrobiodiversity platforms. The institute is also one of the domain partners in the Network Project for Agricultural Bioinformatics and Computational Biology Scheme of ICAR implemented through CABin Division of ICAR-IASRI, New Delhi. *De novo* whole genome sequencing of four finfish species, viz. catla, rohu, magur and hilsa, and one oomycete fish pathogen has been completed under this activity. The institute is also working on understanding and predicting possible impacts of abiotic stresses on fishes. Farmed organisms are susceptible to a wide range of stressors like temperature, oxygen, nitrogen, salinity, etc. that can pose a major threat to thriving aquaculture industry with considerable economical repercussions. The institute has been working to elucidate unique biochemical adaptational strategies that fishes employ against abiotic stresses like thermal and ammonia stress, through genomic and proteomic studies. It is expected that the genomic studies in relation with proteomic expression analysis and physiological responses will be helpful for better understanding of the biological processes in aquaculture species, ultimately resulting in stock improvement, management and conservation of fish diversity. Knowledge of the genomic mechanisms can provide technologies or methodologies for fast selection of economically important adaptive traits and improvement of the target species.

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 Kumar Pathak and Murali S.**
Funding Support:	**ICAR - IASRI**

The physical map of a species represents the structural genome/genes organization on individual chromosome pairs. The present study aims to generate physical map of *Clarias magur* using BAC clones insert DNA. During the reporting period, a total of 1560 BAC clones (from Plate IDs 008, 009, 010, 011, 012 and 013) of *C. magur* genome were revived and isolation of BAC insert DNA were accomplished. End sequencing of 1560 clones was generated using T7 forward and pbRP1 reverse primers.

A total of 1038 end sequences were mapped on the genome scaffolds of *C. magur* using in-house developed bioinformatics tool, BAC2GENOM (earlier named as BACPipe) (Fig. 44), and out of which a total of 913 end sequences were anchored on the scaffolds of the *C. magur* genome. A total of 1077 genes present on those BAC clones were mined and annotated (Fig. 44).

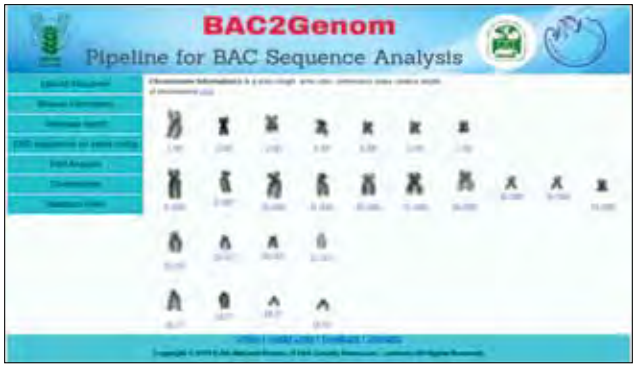


Fig. 44. Webshot of BAC2GENOM bioinformatic pipeline

BAC insert DNA fluorescent in situ hybridization (FISH) is used as a tool for identification of exact location on the chromosomes. A total of 16 FISH experiments were conducted for localising the genes on the *C. magur* chromosomes (Fig. 45a), where a total of 135 genes were mapped with FISH. The mapped genes can be viewed on the chromosome of *C. magur* using BAC2GENOM server (Fig. 45a, b). The whole DNA probes of *C. magur* male and female

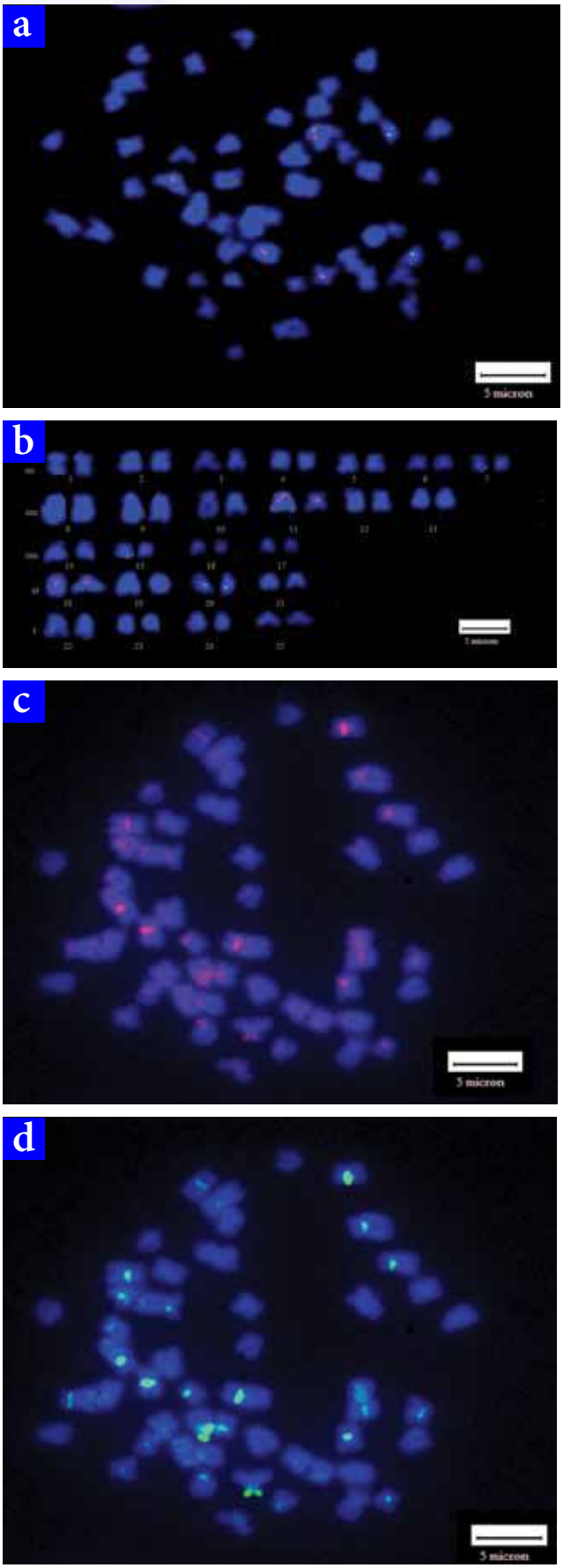


Fig. 45. Localization of: (a, b) 010L11 & 010P19 clones and (c, d) whole male and female DNA on metaphase spread of *C. magur* using FISH

were also constructed using fluorescein 12-dUTP and tetramethyl rhodamine-5-dUTP fluorophores through direct labelling nick translation. The probes were mapped on both the male and female *C. magur* chromosome complements using FISH, where most of the fluorescent signals were observed on several chromosome regions (Fig. 45c, d).

FisOmics web portal developed at ICAR-NBFGR under the project had of 31176 visitors. The hit counts for individual databases were: FBIS - 44123, FMiR - 25896, FishMicrosat - 29951, Fish Karyome - 40411 and HRGFish - 23999. Five genomic resource databases were updated using data available in public domain. FishMicrosat was updated by 690 records and presently contains 15374 records of 200 species; FMiR was updated by 95 records of 95 species to contain 2432 records of 2432 species; FBIS was updated by 3442 records with a total of 38797 records of 1834 species; Fish Karyome was updated by 61 records to contain 1256 records of 987 species; and HRGFish by 922 records to contain 1891 records of 65 species (Fig. 46). High Performance Computing Cluster access was provided to RGCA institute.

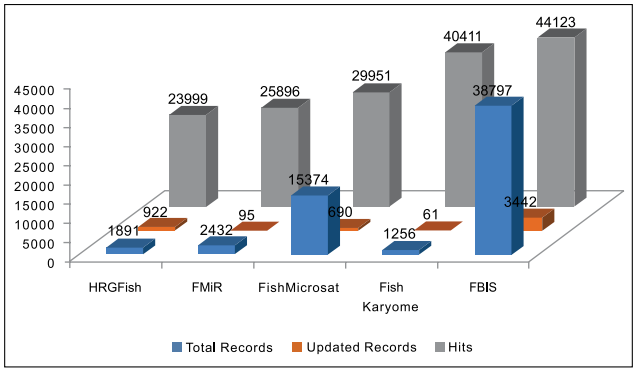


Fig. 46. Fish genomic resource database updation

Project: Stress tolerance response in cultivable freshwater fish species

Period: April, 2018 - March, 2020

Personnel: Satish Kumar Srivastava (PI), Ravindra Kumar and Poonam J. Singh

Funding Support: Institutional, ICAR-NBFGR

The project aims to estimate the critical limits of abiotic stress like temperature in fishes and also investigate the biological changes taking place in the organisms during exposure to these abiotic stresses. The proteomic expression and physiological responses will be helpful for better understanding of the biological processes in aquaculture species resulting in stock improvement, management and conservation of fish diversity. Low water temperature tolerance limit was determined in the specimens of *Clarias magur* (38-52 g), *Labeo rohita* (51-65 g) and *Heteropneustes fossilis* (35-42 g) which was found 10˚C, 7˚C and 11˚C, respectively. High water temperature tolerance limit of *H. fossilis* (33-40 g) was found to be 38˚C.

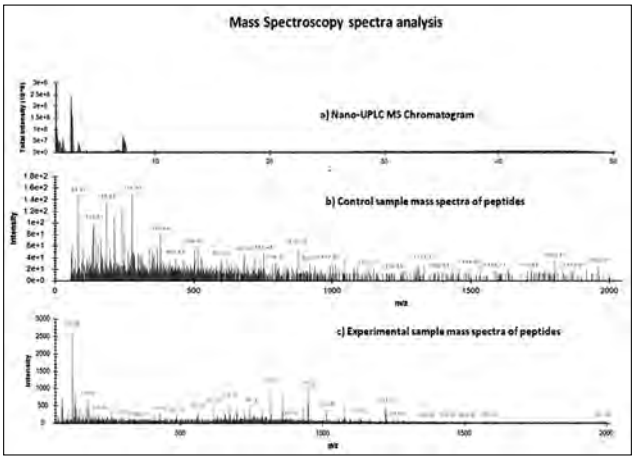


Fig. 47. SDS-PAGE of muscle, brain, gill, liver and serum after exposure at 37°C temperature for 45 days

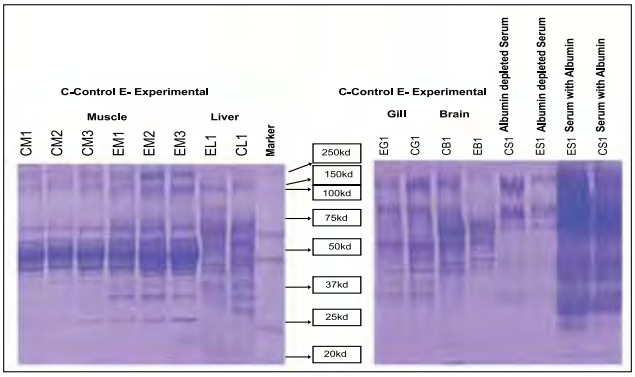


Fig. 48. (a) Nano-UPLC chromatogram of elutant; (b) Representative mass spectra of tryptic peptides of control sample; (c) Representative mass spectra of tryptic peptides of experimental sample

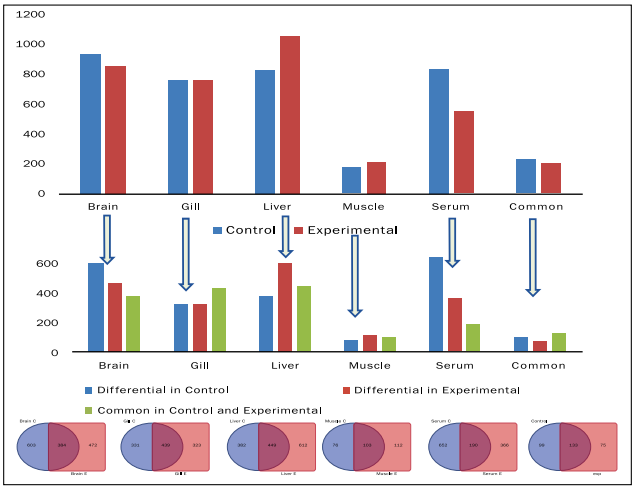


Fig. 49. Comparison of proteins expressed in control and experimental samples for brain, gill, liver, muscle, serum, and common proteins

C. magur (40-65 g) specimens were exposed to 37°C water temperature for 45 days to study the proteome (in muscle, serum, gill, liver and brain) and transcriptome (in muscle and liver tissues) profiles along with control. For proteome profiling, samples were homogenized in tris with protease inhibitor and homogenate supernatant run on 1D-SDS-PAGE (Fig. 47). The proteins extracted from tissues were subjected to LC-MS/MS with Synapt G2 Q-TOF equipped with an electrospray ionization (ESI) source in positive mode for peptide fingerprint data (Fig. 48). Albumin was depleted from serum before subjecting to LC-MS/MS. The raw data acquired from the instrument was processed using PLGS software 3.0.2 for differential and commonly expressed proteins (Fig. 49). Tissue specific proteome study will bring clarity on pathway specific metabolism adapted by fishes for ameliorating stress. The *C. magur* (38-52 g) and *L. rohita* (41-74 g) specimens were also exposed to sub-lethal low temperature (12°C and 10°C, respectively) for 45 days to study the long-term effect of low temperature on blood profiles, hormone level and proteomic expression. Capacity building for analysis of hormones, like cortisol, estradiol, thyroxin, testosterone, tri-iodothyronin was done in *C. magur*.

Project: ICAR-CRP Genomics: De novo genome sequencing of anadromous Indian Shad, *Tenualosa ilisha* (Hamilton 1822)

Period: July, 2015 - March, 2021

Co-ordinator: Joykrushna Jena

Personnel: Vindhya Mohindra (PI), Rajeev Kumar Singh, Basdeo Kushwaha and L. Mog Chowdhury

Funding Agency: ICAR, New Delhi

Identification of genes involved in adaptability to varying salinity in Hilsa, *Tenualosa ilisha*

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

KEGG Orthology assignments in marine vs freshwater data, revealed a total of 1781 (36.03%) gill transcripts with significant matches and were assigned to five main categories which included 252 KEGG pathways. Metabolism retained the maximum number of transcripts (786), followed by an organismal system (441), environmental information process (294), cellular processes (124) and genetic information process (84). A total of 4 and 12 unique genes in the top 20 and top 50, respectively, were identified as significant core genes. KEGG pathway visualization showed 9 genes: act1, actn2b, tnnnc2, tpm3, hgfa, vegfaa, vwf, actnn1b and ttn2 which were correlated with focal adhesion, muscle cell differentiation and actin-binding, with significant p-value of 9.79e-07, 6.41e-06 and 9.79e-07 respectively (Fig. 50).

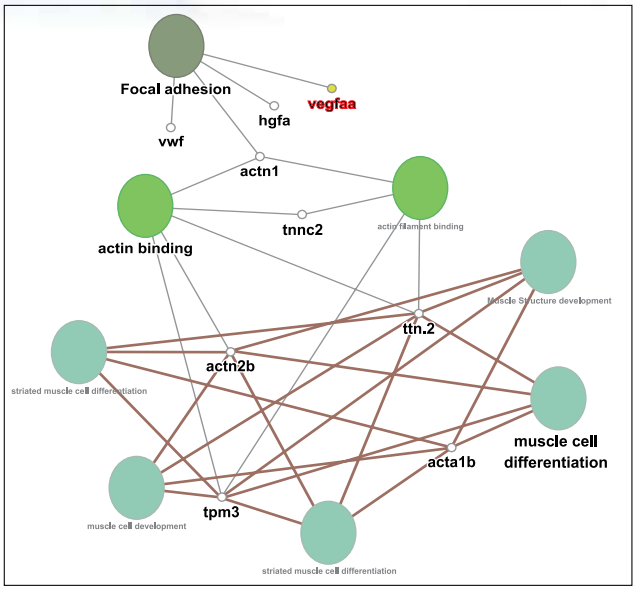


Fig. 50. Gene enrichment and identification of significant core genes for gene expression profiles for osmoregulation in marine and freshwater habitats in *Tenualosa ilisha*

Whole genome sequencing of Indian major carp, *Catla catla*

Genome size estimation

Genome size has been estimated to be 1.28 GB, with flow cytometer analysis and k-mer analysis of short sequence data (Fig. 51).

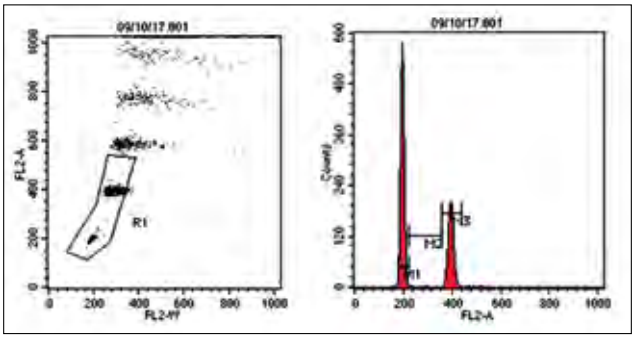


Fig. 51. Genome size estimation of *Catla catla* with flow cytometer analysis

Sequencing and assembly of *C. catla* genome

A total of 72.46X (57.06X (74.2 GB) and 15.4X (20 GB) of PacBio and Nanopore) long read data and 73 GB of Illumina short read data, respectively, were generated. The initial draft assembled with long read data of *C. catla* genome contained 1.094 GB, with mean N50 1.70 Mb and longest contig 11.73 Mb. BUSCO analysis against eukaryota_odb9 database showed 97% completeness with 96.3% complete BUSCOs and 0.7% fragmented. Three contigs were found to have mitochondrial sequences and upon assembly, whole mitochondrial genome was found to be 16,884 bp.

Characterization of assembled genome

GC content was found to be 40.5% with 391.99 Mb covering the repeats. Out of which, total interspersed repeats were 81.82%, retroelements 49.68% and DNA transposons 36.50%. Total number of identified SSRs were 435149 with 3414 contigs containing SSRs.

Transcriptome data generation in *C. catla*

Long reads- PacBio RSII: Transcriptome data was regenerated through PacBio RSII in 4 tissues. Total number of Transcripts in brain were 29696, kidney 32244, liver 11721 and muscle 14960, with size ranging from 300 bp to 8.4 kb (Fig. 52). After removing redundant sequences using CD hit analysis, 53004 transcripts were obtained. Complete ORF was predicted for 52713 transcripts. A total of 29325 transcripts were annotated with Swiss-Prot database.

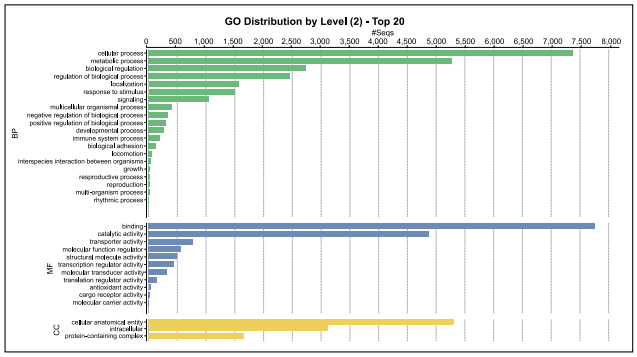


Fig. 52. Gene Ontology classification of long read transcriptome profile of *Catla catla*

Short reads- Illumina

A total of 4 tissues (brain, liver, kidney and muscle) were sequenced on HiSeq2000 for generating transcriptome data. Assembly with Trinity resulted a total of 219549 contigs in 255.77 Mbp assembled transcripts. Further overlap with CAP3 resulted in a total of 136158 unigenes with a total of 126.18 Mbp assembled reads. A total of 34548 transcripts were functionally annotated with blast hits. Top 10 terms in biological process category from GO annotation were identified (Fig. 53).

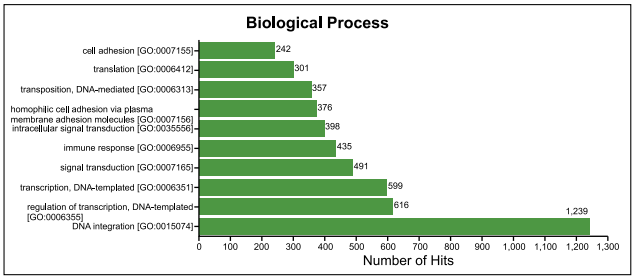


Fig. 53. Top 10 terms in biological process category from GO annotation

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

Period: August, 2018 to March, 2021

Personnel: Vindhya Mohindra (PI) and L. Mog Chowdhury

Funding Support: 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 for aquaculture use. The isolated *Tor putitora* populations found in diverse climatic regimes such as high-altitude

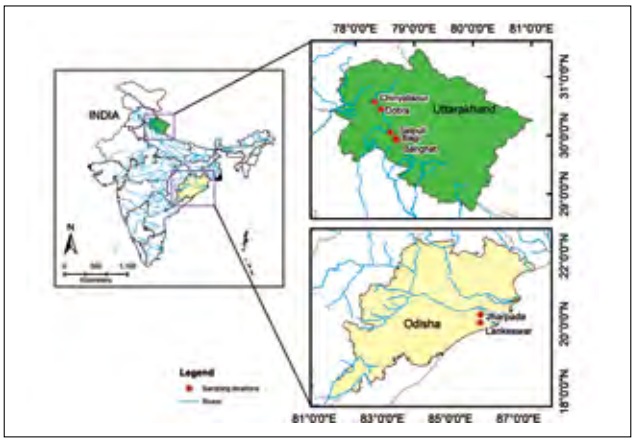


Fig. 54. Collection areas for *Tor putitora* samples for present study

Himalayas and central plateau (Fig. 54) 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 thermal tolerance.

Mitochondrial Sequence analysis

COI Sequences of *T. putitora* samples from Ganga river system (Nayar, Ganga and Bhagirathi river) and Mahanadi river system revealed a total of 6 haplotypes, with non-significant genetic distance of 0.0004, between the river systems (Fig. 55). Sequence analysis of ATPase 6/8 genes containing 842 bp resulted in 11 haplotypes with FST of 0.67488. Balancing selection was observed at 628 bp with observed heterozygosity of 0.086777 and FST of -0.04762 (p=0.03514). Sequence analysis of Cytochrome b 1141 bp mitochondrial gene from individuals of two populations showed 13 haplotypes with FST of 0.64666 and balancing selection at 10 loci.

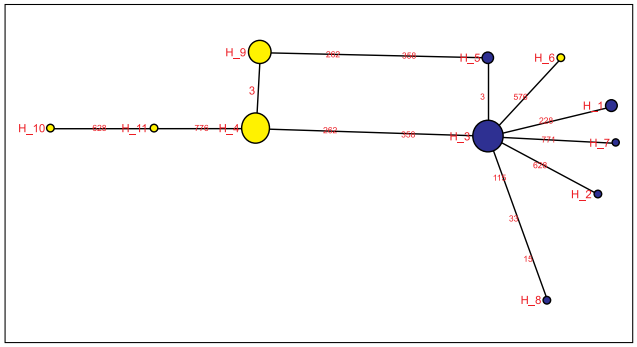


Fig. 55. Network analysis for haplotypes in Ganga (yellow) and Mahanadi rivers (Blue)

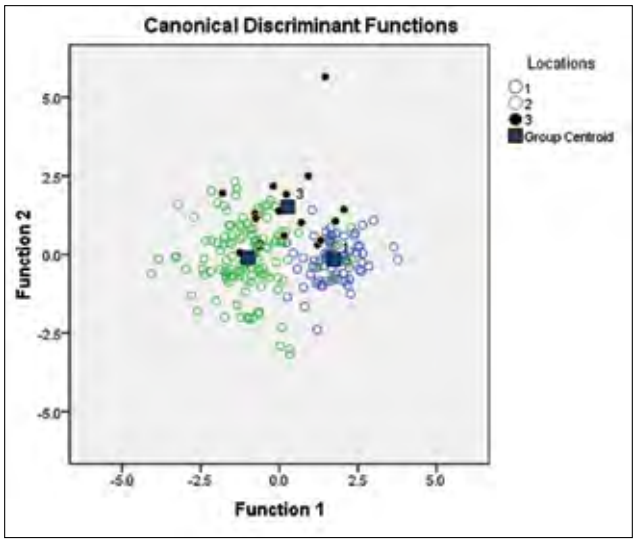


Fig. 56. Classification results for predicted group membership for truss network analysis

Landmark based truss analysis

214 specimens of *T. putitora* collected from Ganga and Mahanadi rivers, 65 truss parameters provided 12 principal components on the basis of eigen value (Kaiser Criteria), which were contributing significantly ($p<0.05$). Classification for predicted group membership revealed 90.1% and 89% were cross-validated grouped cases correctly classified (Fig. 56).

Generation of transcriptome profile from two diverse populations

Total RNA was extracted from the 6 different tissues (brain, muscle, gill, liver and kidney) from two different agro-climatic region Mahanadi and Ganga (Uttarakhand) and transcriptome profile was generated through sequencing with Illumina. A total of 953497816 reads were generated with 48.2% GC content. The cleaned reads were assembled using Trinity with default setting and 579828 transcripts were generated. Assembled transcripts were clustered using CD-hit-est and final set contained 397452 non-redundant transcripts and were selected for Differential gene expression (DGE) analysis. Longest transcript length (bp) were found to be 66644 bp.

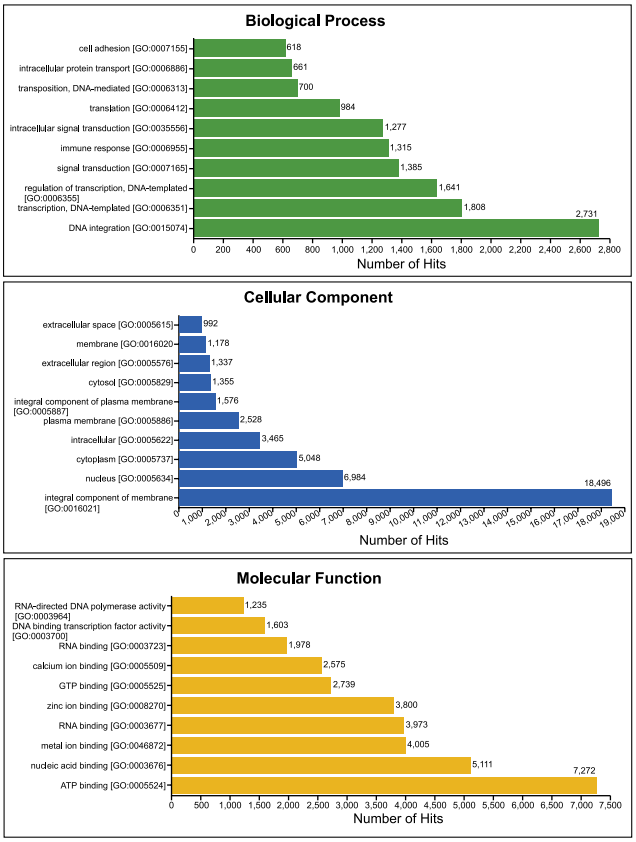


Fig. 57. The top 10 terms in biological, cellular and molecular function categories of transcriptome in *Tor putitora* from two climatic conditions

Initially a total of 96697 transcripts were annotated against UniProt. The gene ontology (GO) terms for transcripts were analysed and total number of different GO terms were identified in molecular function, biological process and cellular component in biological processes (Fig. 57). Highest number of transcripts belonged to DNA integration (2731), in cellular components, 18496 transcripts fell into integral components of membrane and in molecular function kinase activity, comprised of 7272 transcripts.

DGE in *T. putitora* from two climatic conditions

DGE patterns were studied in gill, brain, muscle, liver and kidney from two climatic conditions (Table 8).

Table 8. DGE between Upper Ganga regions and Mahanadi for different tissues

Tissues/ transcripts	Down regulated	Up regulated
Gill	906	947
Brain	725	609
Muscle	756	1098
Liver	634	1030
Kidney	1583	1123

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 and L. Mog Chowdhury

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

The indigenous freshwater catfish Clarias batrachus (*Clarias magur*) is found in habitat with stagnant water bodies and/or muddy substratum, where oxygen 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 mud peat during summer. This catfish is known to be tolerant to hazardous high ambience of ammonia. Since no other fishes can tolerate such a high ambient ammonia, it is important to elucidate whole set of adaptive genes, factors and regulatory molecules as well as signaling pathways operative in this catfish and their expression patterns.

Generation of transcriptome profiles in different tissues from different exposure condition to 25 mM ammonium chloride in *Clarias magur*

Initial transcriptome profile analysis of brain, liver and kidney of two different ammonia exposures i.e., 3 h, 9 h and control samples were generated through Illumina HiSeq 2500. A total of 14100,81,896 reads comprising 140 GB bases generated 565,026 transcripts. Final set contained 261735 non-redundant transcripts and selected for downstream annotation. Longest transcript length (bp) were found to be 29,300 bp (Table 9).

Table 9. Differentially expressed transcripts in control vs 3 and 9 h of ammonium chloride treatments in *Clarias magur*

Tissues	Control vs 3 h		Control vs 9 h	
	Down	Up	Down	Up
Brain	268	315	387	686
Liver	246	633	797	589
Kidney	489	219	505	288

Read summary of transcriptome analysis of *C. magur* brain

To establish a brain differential expression, transcriptome analysis of magur brain tissues of two different condition i.e., Control, 3 h and 9 h exposure to ammonia were carried out using Illumina HiSeq 2500. A total of 37.29 GB data of sequencing reads were generated. A total of 3730,47,264 pair-end reads were generated with 334,084 assembled transcripts (Table 10 & 11)

Table 10. Raw read summary of transcriptome analysis of *Clarias magur* brain

Sample Name	Number of reads(R1+R2)	Number of bases (GB)	GC%
CM Brain	93,668,824	9.36	46.99
EM3 Brain	151,727,638	15.17	46.49
EM9 Brain	127,650,802	12.76	46.78

Table 11: Read alignment and expression summary of transcripts of *Clarias magur* brain

Sample Name	Number of Filtered reads (paired end)	Number of Reads aligned (paired end)	% align-ment	Number of transcripts with FPKM >=1.0
Control Brain	31,493,767	23,798,517	75.57	32,482
3 h treatment	52,587,675	39,691,536	75.48	31,560
9 h treatment	48,176,993	36,134,579	75.00	31,475

Differential gene expression analysis of brain tissue

In two different conditions i.e., Control, 3 h and 9 h exposure to ammonia, Differential gene expression (DGE) pattern showed increasing trend of DGE with exposure time, as higher number were observed in control vs 9 h exposure (Table 12).

Table 12: Differential gene expression between control and after short term treatments with 25 mM ammonia chloride concentration of brain tissue of *Clarias magur*

Treatments	Down regulated transcripts	Up regulated transcripts
CM vs EM3 Brain	268	315
CM vs EM9 Brain	387	686
EM3 vs EM9 Brain	640	670

Gene Ontology

The gene ontology (GO) terms for transcripts were extracted and different GO terms identified as; molecular function: 1314, biological process: 1946 and cellular component: 507 categories.

Program 5.4: *Ex situ* and *in situ* conservation

India is a biodiversity rich country evidenced by presence of four out of the thirty-four globally listed biodiversity hotspots. More than 31,000 native fish species have been reported globally with more than 3100 species in India. Climate change, massive anthropogenic activities, environment degradation and over-exploitation have created a stress on ecology and loss of biodiversity. In order to conserve biological diversity, for its sustainable use, Convention on Biological Diversity (CBD) was enacted giving due emphasis to *ex situ* and *in situ* conservation. Since, India is a party to CBD, the Biological Diversity Act, 2002 of India was enacted to meet the obligations under CBD. It is well known and documented fact that aquatic genetic resources are facing serious threats from the multiple stressors including natural and anthropogenic resulting in stock and size depletion, shift in geographical areas etc. ICAR-NBFGR is striving to preserve the native Indian fish genetic material, regeneration of depleting germplasm of both conservation and aquaculture value, stock enhancement of wild relatives and populations. The major activities of the institute in this area have been species–specific sperm cryopreservation protocol development, surrogate broodstock development, tissue banking, captive breeding, diploid cell banking, cell line development etc. of important fish species. One of the means to conserve biodiversity and species is to actively involve local stakeholders in its management. The institute has initiated several programs in this regard that provide employment opportunities to local people in fish rearing and breeding activities, which are helpful in minimizing pressure on aquatic resources and lead to biodiversity conservation.

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: DBT

National Repository of Fish Cell Line (NRFC) with a large collection of fish cell lines, is one of a kind repository. It was established with an objective to receive, authenticate, characterize, maintain and distribute fish cell lines on request for R&D works. During the reporting period, four new fish cell lines, namely SREM-1 (*Schizothorax richardsonii*, eye) BBdF-1 (*Barilius bendelisis*, fin) and CMgT-1 (*Clarias magur*, testes) (Fig. 58) developed in the project and LCF (*Labeo calbasu*, fin) developed in ICAR-NBFGR were included in the repository after proper authentication. With these, the NRFC is currently maintaining 63 fish cell line accessions. Two more cell lines, CyCKG, (*Cyprinus carpio*, fin) and PSF (*Etroplus suratensis*), were received from PMFGR Centre, ICAR-NBFGR, Kochi, which will be included in repository after characterization and authentication. Five new cell lines namely CMgB-1 (*Clarias magur*, barbels), CMgM-1 (*Clarias magur*, muscle), DDaF-1 (*Dario dario*, fin), LRF (*Labeo rohita*, fin) and ZFiM-1 (*Danio rario*, muscle) have been cultured for more than 25 passages and are being characterized for deposition.

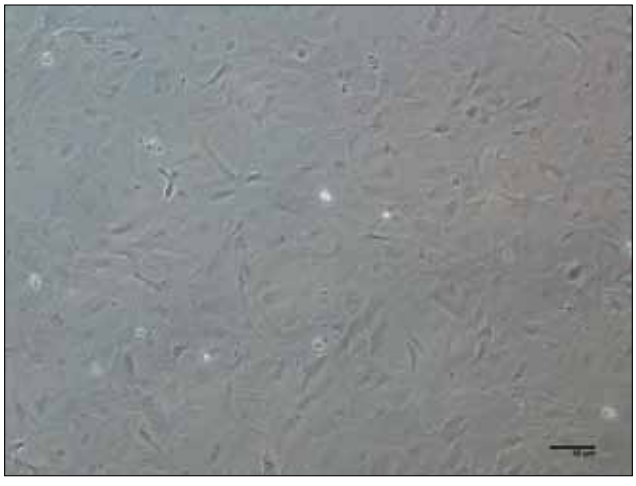


Fig. 58. CMgT-1 cells at passage 21

Fish cell lines are used for various purposes and one of important utility of the cell line is *in vitro* toxicity testing of xenobiotics. Cytotoxicity testing of a heavy metal, sodium (meta) arsenite, was carried out in CMgT-1 cell line using two end point assays, *viz.* alamarBlue and Neutral Red (NR) assays. The toxicity expressed in terms of Inhibition Constant 50 (IC50), a value where 50% cell viability decreased, was found to be 6.00 and 10.57 µM, respectively. Similarly, toxicity testing was performed for another heavy metal, mercury chloride, in SREM-1 cell line where IC50 was estimated to be 411.0 and 321.9 µM using alamarBlue and NR assays, respectively. The IC50 value for $K_2Cr_2O_7$ in BBdF-1 cell line using alamarBlue assay was found to be 56.48 µM (Fig. 59).

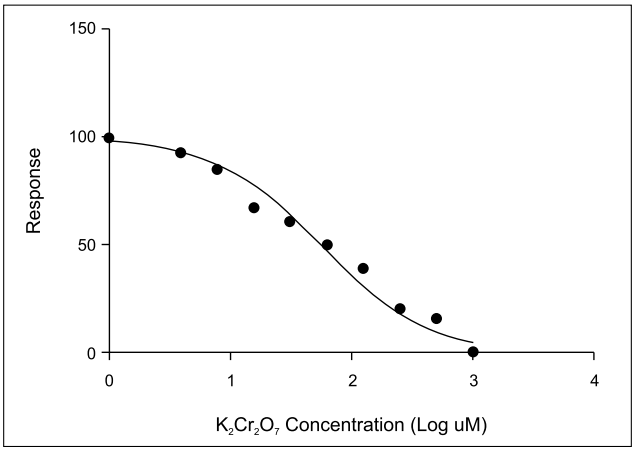


Fig. 59. Dose response curve of heavy metal in fish cell line

ICAR-NBFGR cell line repository is mandated to receive, maintain, and distribute cell lines to researchers. In this regard, general activities for maintenance of cell lines were carried out. Twenty five fish cell lines were revived, passaged and cryopreserved. COI barcode sequences were generated and submitted in NCBI portal for 13 cell lines. Mycoplasma testing was carried out for 9 cell lines that were found to be negative. Further, chromosome profiling was also undertaken and karyotypes of 14 cell lines were prepared. Eighteen fish cell lines were distributed to various researchers across the country, including institutions like ICAR-CIFE, Mumbai; College of Fisheries, Mangaluru; CUSAT, Kochi; MS Baroda University, Baroda; NITTE University, Mangaluru; DG Ruparel College, Mumbai etc. for R&D purposes.

Demand of cell lines and the research activities using cell line have considerably grown with increase of requests of knowhow in the field of cell culture by young researchers. A Short term training course on "Cell

Line: Development, Maintenance and Applications" with hands-on training and demonstration on 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.

Project: Livelihood improvement through integrated fish farming model using indigenous resource

Period: April, 2017- March, 2020

Personnel: Sharad Kumar Singh (PI), Lalit Kumar Tyagi, Akhilesh Kumar Yadav and Sanjay Kumar Singh

Funding Support: Institutional, ICAR-NBFGR

The project envisages that best aquaculture management practices in barren and low crop productive land of Uttar Pradesh can be developed through scientist-farmer participatory mode. Survey of new site for the project was undertaken in the district of Barabanki for selection of farmers (Shri Dal Chand, S/o Muneshwar Prasad and Shyam Lal, S/o Kallu, Gadhai, Kursi, Fatehpur, Barabanki). Soil sampling of the area was done in both the site in relation to pond-led-farming system. The soil pH was within the range of 7.5-8.2. The water quality from nearest sources was found suitable for aquaculture activities. Excavation/ development of fish pond could not done in case of earlier surveyed farm site in the village Lalaikheda, Mazara, Samesi Viilage, Mohanlalganj, Lucknow due to financial constraints.

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, 2018 - March, 2021

Personnel : Kuldeep K. Lal (PI), Ravindra Kumar, Vindhya Mohindra, Gaurav Rathore, Kripal Datt Joshi, Lalit Kumar Tyagi, T.T. Ajith Kumar, Sullip Kumar Majhi, Ajey Kumar Pathak and Rajesh Dayal

Funding Support: NFDB and DBT

Structural development mechanisms of the repository

The project aims to establish a National Germplasm Repository and Museum as an integrated aqautic genetic resource centre. During the reporting period, design of the interpretation centre at the repository was finalized. Design for cell line repository, microbial repository and, sperm and DNA repository were finalized and implemented. Equipment's such as Cryo-vessel (1000 l capacity) and LN_2 vapour storage system were installed for ensuring uninterrupted LN_2 supply for storing fish tissues, cell lines, DNA etc.

The fish specimens from different water bodies (marine, freshwater and brackish water) were procured and preserved to display at the repository. A facility for autoradiography for fish skeleton studies and a separate processing room was established. Further, a training and taxonomy reference study facility was also established.The online database on the fish fauna of India titled AqGRISI covering information on fish taxonomy, biology, genomics and diesases was finalized and launched.

Component-II: Diploid Germplasm Cryobanking for *Ex-situ* Conservation and Multiplication of Aquatic Resources.

Period: April, 2018 - March, 2021

Personnel: Sullip Kumar Majhi (PI), Aditya Kumar and L. Mog Chaudhury

Funding Support: Institutional, ICAR-NBFGR

The project aims to develop diploid cell bank as part of *ex-situ* conservation. For *Channa punctatus, Clarias magur*, *Heteropneustes fossilis* and *Mastacembelus armatus* caudal fin, explant method was followed to isolate the cells.

In vitro culture from caudal fin cells of *C. punctatus, C. magur*, *H. fossilis* and *M. armatus* were carried out (Fig. 60). In the case of *C. punctatus,* cell growth and radiation started from 2nd day and formed complete monolayer after day 25 of the culture. Furthermore, in the case of *C. magur*, cell growth and radiation started from 4th day and formed complete monolayer after day 23 of the culture. In the case of *H. fossilis*, cell growth and radiation started from 4th day and after attaining the monolayer cells were passaged twice and cryopreserved. However, in the case of *M. armatus,* cell growth and radiation started from 4th day and after

attaining the monolayer cells were passaged thrice, cryopreserved and stored in LN_2. The cryopreserved cells will be revived at certain time intervals to assess the viability. Under this project, *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala*, *Cyprinus carpio*, and *Carassius auratus*, caudal fin primary cells were also maintained in the repository. In another experiment, 10 specimens of *L. rohita* were treated with high dose of anaesthesia (2-phenoxyethanol) to euthanize, and preserved in ice for 8 h. Explant culture was carried out from caudal fin at 1 h interval for 8 h for cell growth and it was found that cells were growing even 8 h after death (Fig. 61).

Explant culture from caudal fin of *Channa punctatus*

Explant culture from caudal fin of *Clarias magur*

Explant culture from caudal fin of *Clarias magur* at 17 days

Explant culture from caudal fin of *Heteropneustes fossilis*

Cell culture from caudal fin of *Mastacembalus armatus*

Fig. 60. Explant culture of various species

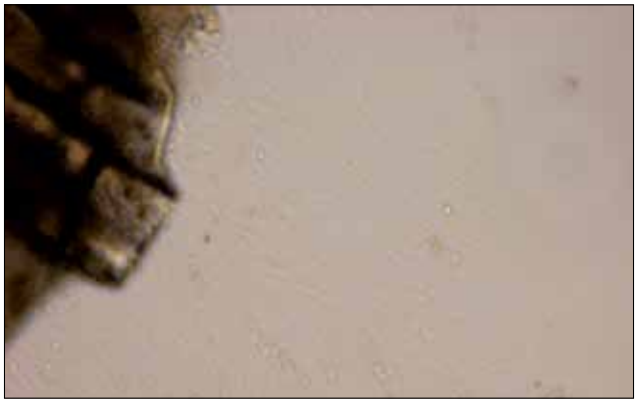


Fig. 61. Explant culture from caudal fin of *Labeo rohita* after 8 h of death

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), Lalit Kumar Tyagi and Charan Ravi

Funding Support: UNDP - Mangrove Foundation and Mangrove cell, Department of Forest, Govt. of Maharashtra

One of the means to conserve biodiversity and species is to involve local stakeholders in its management. The present project aims to set up a marine ornamental fish village in Maharashtra to promote livelihood options to mangrove dwellers and also sustain biodiversity conservation. Ten species of Clownfishes; *Amphiprion ocellaris, A. percula, A. frenatus, A. clarkii, A. ephippium, A. sebae, A. nigripes, A. akallopisos, A. perideraion* and *Premnas biaculeatus* were stocked in the hatchery. Successfully developed the broodstock/pair for seven species. Larval rearing and juvenile production was achieved for *A. percula, A. clarkii* and *A. ocellaris* and subsequent batches are being produced. Three beneficiary rearing units were established in Dive Kevani village of Thane district. Clownfish Juveniles, *A. percula* to the beneficiary units are ready to be supplied. Live feed culture facility was established and *Chlorella marina*, *Isochrysis* sp. and *Chaetoceros* sp. and rotifer, *Brachionus plicatilis* and *B. rotundiformis* are being maintained.

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 (PI), Santosh Kumar, Aditya Kumar, Ajay Kumar Singh and Rama Shankar Sah

Funding Support: NFDB

Development of infrastructure.

Basic facility for cryo-storage of carp milt on a large scale has been established. This includes Liquid Nitrogen Vapour Storage System, Dry shippers and 1000 l Liquid Nitrogen Storage Tank (Fig. 62).

Supply of cryopreserved IMC milt

ICAR-NBFGR supplied 1.5 litre of cryopreserved Indian major carp milt to 13 hatcheries across 4 states (Uttar Pradesh, Bihar, West Bengal and Odisha) and produced 37.2 lakh spawn (Fig. 63). The spawn will be raised as brooders for future breeding program, mainly to check the production of inbred seed. Collection, storage and supply of cryopreserved milt

Fig. 62. Liquid Nitrogen Vapour Storage System

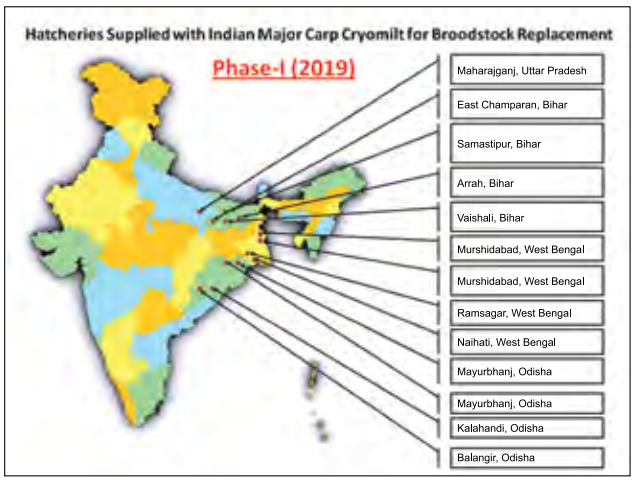


Fig. 63. Indian map depicting supply of cryopreserved IMC milt to various hatcheries

was undertaken where 5000-6000 vials prepared for three species (rohu 40%, catla 30%, mrigal 30%) approx. Diluted milt volume was 8-9 l. Investigated the possibility of up-scaling milt cryopreservation through various experiments. Data collection from the hatcheries supplied with cryopreserved IMC milt and comparative assessment with original farm stock is being undertaken.

Project: Development of biotechnological approach for production of *Clarias magur* (Hamilton, 1822) spermatozoa for aquaculture

Period: January, 2018 - December, 2020

Personnel: Sullip Kumar Majhi (PI) and Santosh Kumar

Funding Support: DBT

Application of assisted reproductive biotechnology appears to be a promising approach for generation of valuable genetic resources from fish species that have difficulty in releasing milt smoothly in captivity. This project, during the first year, examined the suitability of treatment with Busulfan, a cytotoxic agent, and warm water, known to cause germ cell degeneration, for depletion of endogenous germ cells in *P. hypophthalmus* intended to be used as surrogate father for *Clarias magur*.

Standardization of surgical interventions for partial harvest of spermatozoa cell

Sexually mature *C. magur* male were placed over a platform under anesthetic condition. A midline incision was made on the abdomen. Testicular lobes were carefully lifted from the coelomic cavity. A sterilized scissor was used to harvest spermatozoa from each testicular lobe. The viability of harvested cells was evaluated by trypan blue exclusion assay and quantified. The abdominal incision was stitched with surgical thread and resucated in clean water. A small quantity of the spermatozoa was used for artificial insemination trial and remaining was cryopreserved in the liquid nitrogen for posterity use.

Optimization of protocol for stem cell transplantation

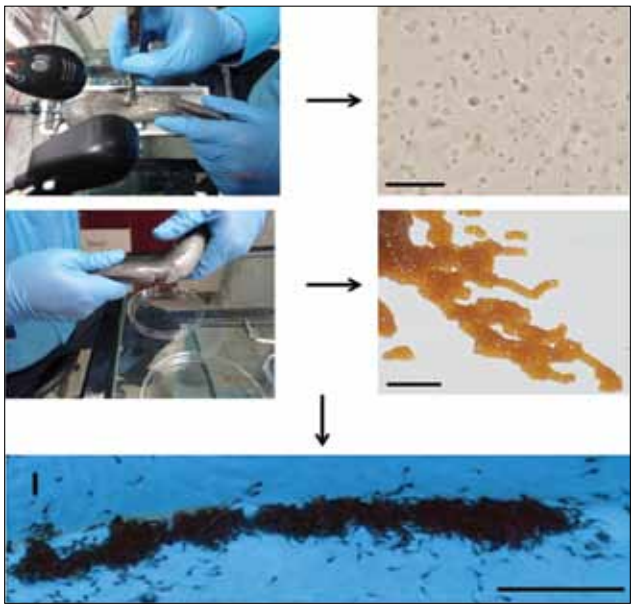
The spermatogonia cell was harvested from donor *C. magur* and labelled with PKH 26 Cell Linker. Spermatogonial cell were transplanted into recipient (*P. hypophthalmus*) gonads through non-surgical interventions. The transplantation efficiency was observed by distribution of trypan dye throughout the gonads. (Fig. 64).

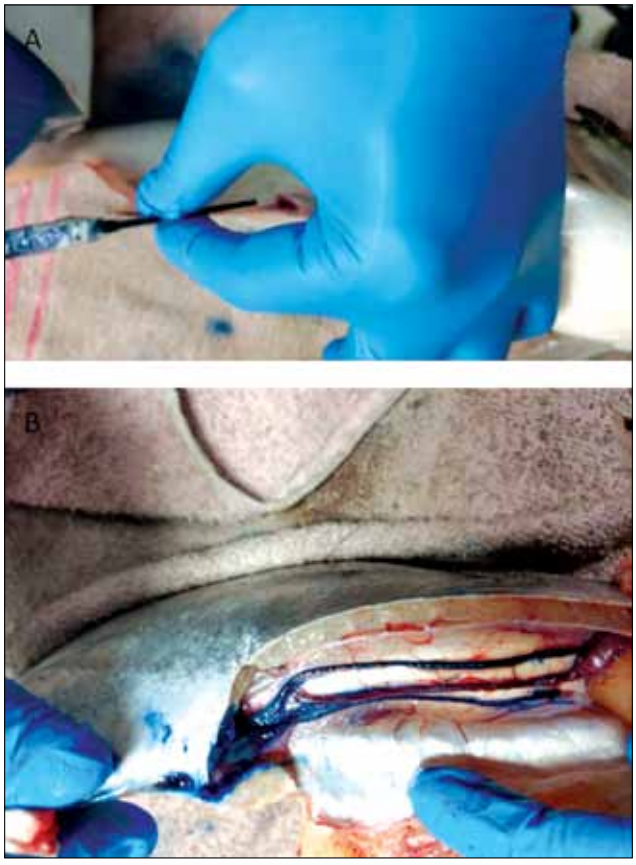
Isolation of spermatogonial stem cell

C. magur aged 3+ months were collected locally and acclimatized in cemented tanks for 1 month. The fish were sacrificed by anaesthetic overdose, the testes were excised and rinsed in phosphate-buffered saline. The gonadal tissue was finely minced and incubated in a dissociating solution containing 0.5% Trypsin, 5% Fetal Bovine Serum, and 1mM Ca2+ in PBS for 2 h at 22°C. The dispersed gonadal cells were sieved through a nylon screen (mesh size 50 µm) to eliminate non-dissociated cell clumps, suspended in a discontinuous Percoll gradient, and centrifuged at 200 g for 20 min at 20°C. The phase containing predominantly spermatogonia cell was harvested and the cells were rinsed and subjected to a cell viability test by Trypan blue (0.4% w/v) exclusion assay. The PKH 26 Cell Linker kit was used to label the cells. The cells were labeled with the dye at a concentration of 8 µl/ml for 10 min at room temperature. Spermatogonial cell were

transplanted into recipient (*P. hypophthalmus*) gonads through non-surgical interventions.

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. The spermatozoa cryopreserved this year will be evaluated and given to a few farmers for seed production and awareness.





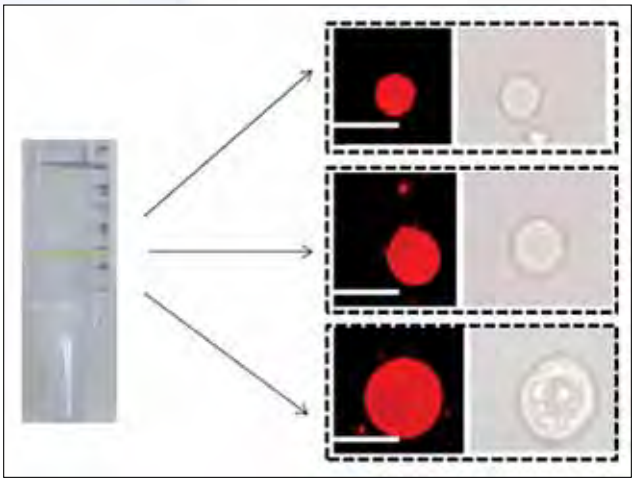


Fig. 64. Stem cell transplantation

Project: Network project on Ornamental fish breeding and culture (NPOFBC)

Period: November, 2018 - March, 2019

Personnel: V. S. Basheer (PI) and A. Kathirvelpandian

Funding Support: ICAR

Prioritised ornamental fish, *Dawkinsia rubrotinctus* were collected from Cauvery River, *Pethia setnai* from Goa and *Halduria fasciata* from Chalakkudy rivers were collected and transported to the Hatchery in Kochi and reared in fibre glass tank with artificial feed (Fig. 65). *D. rubrotinctus*, collected from Cauvery river and the F1 stocks of last year were taken for breeding. Fifty offspring from that initial spawning as well as six wild collected fish were used for breeding. Fishes were fed on commercial carp feed (Growell 2 mm pellets) supplemented with frozen blood worms and earthworms. Sexual dimorphism is not pronounced in this species, with males exhibiting brighter colours than females. A simple technique for spawning was tried, which does not involve the use of any hormones for breeding. Adult brood fishes in the ratio of 1:1 or 2M:1F were maintained in 200 l FRP tanks in groups of 6 to 8 fishes. A spawning tub with ceramic rings and nylon spawning media was placed in the tub for collection of spawn. Aeration was given continuously and feeding was done once in the morning. The fishes bred within 2-3 days in tub, and after a week, fry were siphoned out into rearing tanks. On an average, 70-100 fry were obtained from each trial. Temperature of water was in the range of 25-28°C, pH in the range of 6.5-7.5 and dissolved oxygen 3.5-5.0 ppm, Mortalities were observed due to ich infestation, and sudden changes in water quality parameters. Free swimming

spawn were fed with live feed green algae and later with Artemia nauplii, Vinegar eel, Grindal worm, Moina and Daphnia, as per availability of the culture. A total of 12 trials were conducted and nearly 1000 young ones were produced. We observed development of colour patterns in *D. rubrotinctus*, following successful spawning under captive conditions. Adult fish are characterised by the presence of three round blotches on the body; one under the dorsal fin, one on the caudal peduncle and one at the caudal fin base. Newly hatched fry are ~3 mm in length and translucent with a few scattered chromatophores. Free swimming fry at ~5 mm exhibit chromatophores at the origin of the dorsal fin and caudal fin base, as well as along the lateral line and ventral surface. At ~7 mm, chromatophores are observed on the caudal fin base, caudal peduncle and extending downwards from the origin of the dorsal fin to the swim bladder. At ~10 mm, the chromatophores form 3 distinct bands; one on caudal fin base, one on the caudal peduncle and one immediately under the dorsal fin. A fourth band can sometimes be faintly observed extending downwards from the occiput. At ~15 mm length, the chromatophores are organised into a pattern of vertical stripes resembling the pattern of *H. fasciata*. At ~30 mm, the juveniles look like miniature versions of the adult fish. Further studies are required for larval rearing, feeding and colour development.

H. fasciata, commonly known as the melon barb, endemic to the Western Ghats and is popular aquarium fish. Wild broodstock were collected from Chalakkudy river in Kerala and reared in fibre glass tanks. Artificial feed was given during the rearing period. The fish exhibits clear sexual dimorphism and males and females were conditioned separately for 2 weeks before being placed in spawning tanks at 1:1 ratio. Spawning was observed within 24-48 hours. Temperature of water was in the range of 24-27.5°C, pH in the range of 6.5-7.5 and dissolved oxygen 3.5-4.6 ppm, It was observed that the eggs of *H. fasciata* were very prone to fungus and fry are extremely susceptible to ich. Spawn were collected after one week from the spawning tank and reared with live feed, initially green algae and later with Artemia nauplii and Moina. A total of 6 trials were conducted and nearly 200 young ones were produced.

P. setnai is a small, colourful barb known from west flowing rivers in the central Western Ghats. Broodstock were collected from Goa in August, 2019 and transported to the hatchery in Kochi and reared in fibre glass tank. Heavy mortality of adult fish was observed during rearing. Two breeding trials were tried but could not observe proper breeding.

Live feeds are the fundamental need for larval rearing and fry production. Dependency on imported source for live feed will increase the production cost. Thus cultures of live feed are necessary to ensure sustainability. We evaluated culture techniques for various live feeds and their use in feeding newly hatched freshwater fish. Daphnia and Moina, were cultured in 100 l tank at a pH of 7.5-8 using four different types of feed; yeast, groundnut cake, banana peel and green water system. It was found that yeast at 1 mg/100 l culture volume provides maximum yield. Grindal worms were cultured on a bed made of layers of nylon pads and dog feed pellet. This yielded better results compared to the traditional method of coco-peat and soil mixture bed. Vinegar eel cultures were maintained in medium of equal parts water and beer with addition of a piece of organic fruit. While the best results were obtained with newly hatched Artemia nauplii, our study suggests that Moina, vinegar eels and micro worms can be used as an acceptable substitute at a greatly reduced cost. Vinegar eels were found to be the best starter food for the newly hatched larvae of small freshwater fishes. The highest growth rates and maximum survival were observed in fry that were fed a diet rich in Moina.

Dawkinsia rubrotinctus

Pethia setnai

Haludaria fasciata

Setting up of spawning tub

Young ones of *D. rubrotinctus* in group

Metamorphosis observed in *D. rubrotinctus*

Grindal worm culture

Vinegar eel culture

Fig. 65. Prioritized ornamental fishes and its breeding strategy

Project: Establishing germplasm resource centre 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: DBT

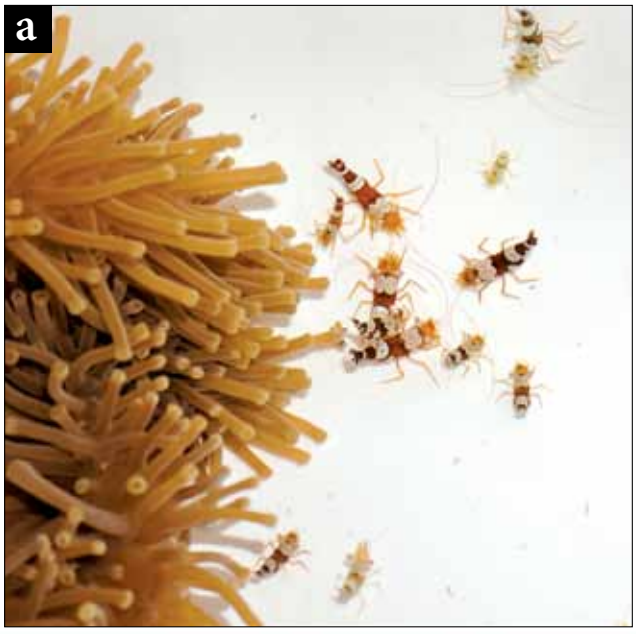
The project aims to concurrently conserve ornamental marine invertebrate germplasm and provide livelihood options to Lakshadweep people. Exploratory surveys were carried out in eight islands of Lakshadweep - Agatti, Kalpetti, Thinnakara, Bangaram, Parali I, Parali II, Kavaratti and Minicoy. 212 individual ornamental shrimps and 35 sea anemones were collected, besides crabs, nudibranchs and worms. The collected shrimps belong to 7 families, 11 genera and 15 species. They are *Alpheus lottini, Alpheus* sp., *Gnathophyllum americanum, Saron marmoratus, S. neglectus, Thor hainanensis, Ancylocaris brevicarpalis, Stenopus hispidus, Lysmata amboinensis, L. hochi,*

Fig. 66. *Urocaridella* arabianensis, species new to Science

Periclimenella agattii, Urocardidella sp. *Urocaridella arabianensis*, species new to Science from Lakshadweep was reported (Fig. 66).

Broodstock development was achieved for *T. hainanensis, A. brevicarpalis, S. hispidus, P. agattii, S. marmoratus, L. hochi, G. Americanum* and *Urocaridella* sp. Juveniles were successfully raised for *T. hainanensis* and *P. brevicarpalis* (Fig. 67), which is the first attempt nationally and globally. In addition, experimental success in juvenile production was achieved for *G. americanum, S. marmoratus, P. agattii* and *L. hochi* (Fig. 68).

Sexual and asexual propagation methods were experimented for Sea anemone, *H. magnifica*. Asexual propagation (dissection method) was attempted in 15 individuals of *H. magnifica* and within 5 months, complete development of individuals was observed. But, there was no progress in the animals maintained for sexual reproduction.



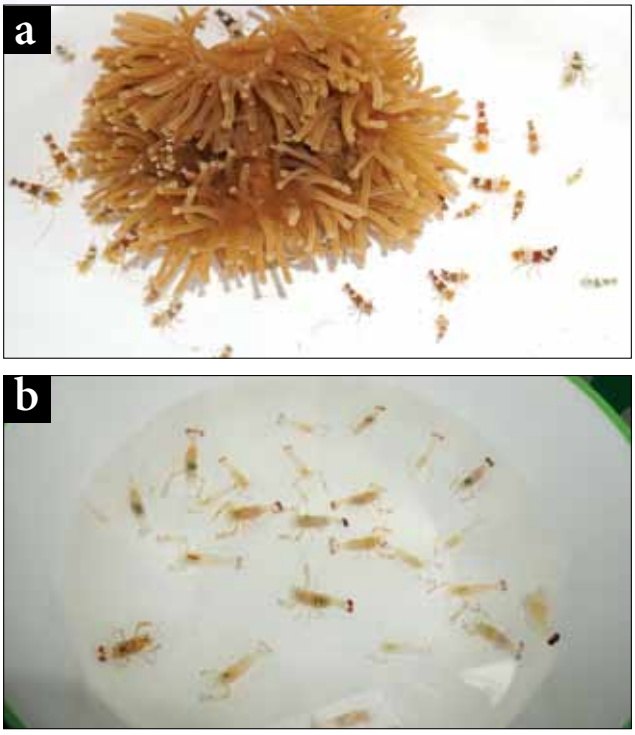


Fig. 67. Captive raised first attempt in India and International; a. *Thor hainanensis*, b. *Periclimenes brevicarpalis*

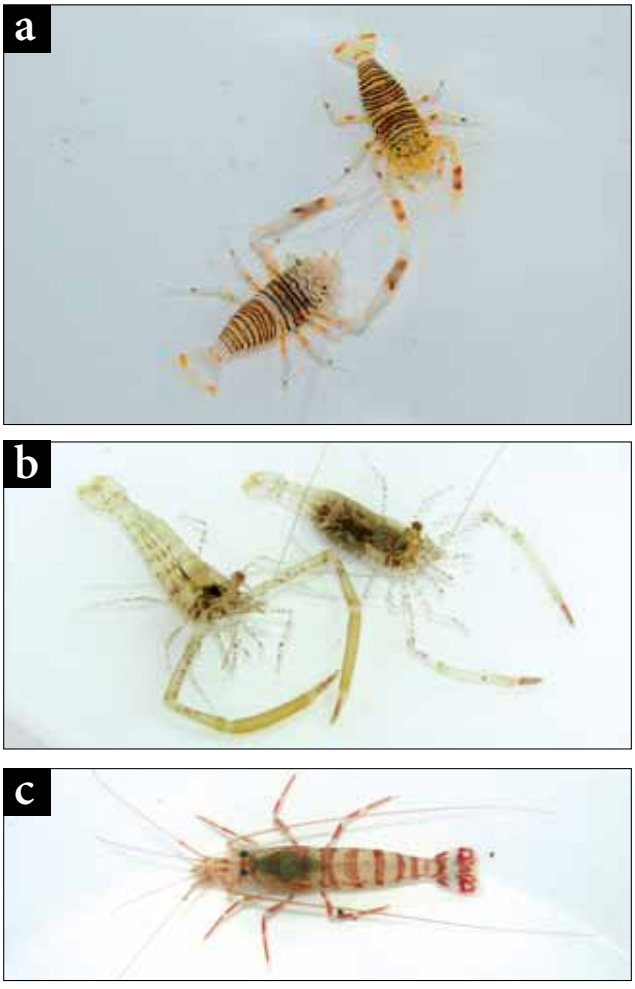


Fig. 68. Captive developed spawning pair of a. *Gnathophyllum americanum*, b. *Periclimenella agattii* and c. *Lysmata hochi*

Project title: Establishment of spermatogonial stem cell line (SSC) from *Sahyadria denisonii*.

Period: August, 2018 - March, 2020

Personnel: T. Raja Swaminathan (PI), Charan Ravi and Divya P.R.

Funding Support: ICAR Extramural Scheme

A total of ten numbers of trials of testis tissue explants of *Sahyadria denisonii* was carried out and radiation of cell reported from the explants, but monolayer could not be obtained. Experiments on primary culture of *S. denisonii* testicular cells using dissociation methods found that collgenase gives better results than trypsinization method. Microscopic observation of culture consists of mixed population of somatic cells and spermatogonial cells (various stages of spermatogenesis) including motile sperm. Primary culture of *S. denisonii* testicular cells using Ficoll gradient separation of spermatogonial cells was performed using germ cell line media formulated in the lab. Monolayer of testicular cells of *S. denisonii* was established and passaged for 5 times (Fig. 69). Monolayer of sertoli cells of the testis of *S. denisonii* was also established during the course of establishing SSC cells.

Spermatogonial clusters during differential plating culture

After culturing for 96 h, a great number of testicular cells, mostly including somatic cells, adhered to culture plates. We isolated floating cells, containing germ cells and transferred them into a new dish with 5% FBS. Under an inverted microscope, the SSCs were seen as round or oval in shape with a large nucleus and little cytoplasm after one week of culture. The isolated SSCs tended to aggregate and form small cell clusters and attached to remaining somatic cells. After 2 weeks of culture, SSCs began to form cell clusters. These clusters were transferred into laminin- coated plates containing the same media and 2% FBS. The medium was changed every 3–5 days. Under feeder-free conditions in laminin coated plates, extension of SSCs was observed for up to 6 weeks (Fig. 70).

Spermatogonial cell enrichment from testicular cells

The amount of SSCs in fish testis is very low and we tried to purify spermatogonial cells and enrich them from the primary culture of total testicular cells. Total testicular cells prepared from *S. denisonii* by enzymatic digestion were cultured in L-15 complete medium. Microscopic observations of primary testicular culture contained a mixed population of somatic cells and spermatogonial cells including motile sperm. First, a primary culture of enzymatically digested testicular cells was separated by gradient (Ficoll, HiMedia) that resulted in partly removing unwanted somatic cells and spermatids. Spermatogonia remained at the top as well as in the middle layers, whereas spermatids, spermatozoa, cell debris, etc. were pelleted down at the bottom of the tube. Using this procedure, we could not achieve a highly purified sample of spermatogonia as per our requirement. Second, these gradient-separated cells (top and middle layers) were subsequently subjected to Magnetic Activated Cell Sorting (MACS) using Thy1.2 (CD90.2) and GRF-1 antibody, which yielded about 3×10^4 spermatogonial cells. Microscopic observation confirmed that sorted cells were free from (decontaminated) spermatids, etc. The purified cells were cultured *in vitro* for 2 months in L-15 complete medium. The sorted cells proliferated, forming characteristic clumps/colonies and remained loosely attached to the culture dish. They could not be maintained in culture for more than 2 weeks.

Colonies formation of SSCs in co-culture

Approximately, after 4 days of culturing, spermatogonia cells formed colonies (Fig. 71). Several SSCs colonies were observed and developed in the co-culture group. Alkaline phosphatase reactivity was used for detection of SSCs in the colonies that appeared in co-culture group and also by gene expression using different primers for identifying the SSCs *viz.* Germ cell markers *viz. Oct4*, D*mrt*1 and *Vasa.* Sertoli cell markers *viz.* WT1, *Foxl*2 and *Sox*9a will be carried out.

In addition, we developed three finite cell lines, *Clarias dussumieri* fin (ClDuF) (Fig. 72), Pearlspot fin (PSF) and *Horabrachus brachysoma* fin (HBF) from caudal fin of three endemic fish species of the Western Ghats *viz. C. dussumieri, E. suratensis* and *H. brachysoma* respectively. These cell lines have been passaged up to 5 times in L-15 with 1% FBS. Karyotyping of all three cells indicated diploid chromosome in all three species. Species authentication of cells was performed by sequencing of the fragment of 16S rRNA and COI genes. All the 3 cell lines were submitted to National Fish cell line repository (NRFC), ICAR-NBFGR.

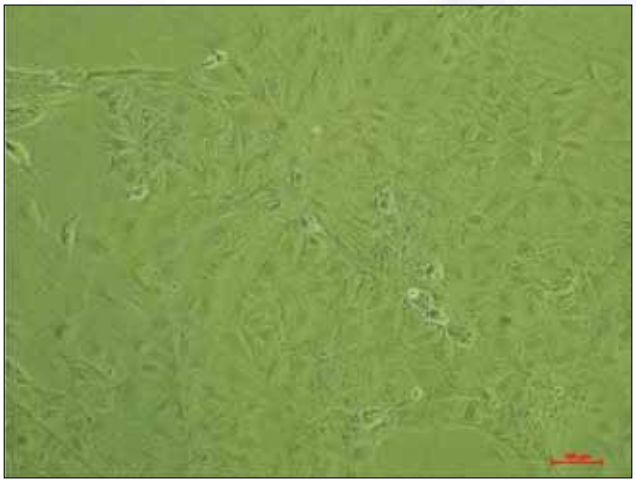


Fig. 69. Monolayer of testicular cells of *Sahyadria denisonii*

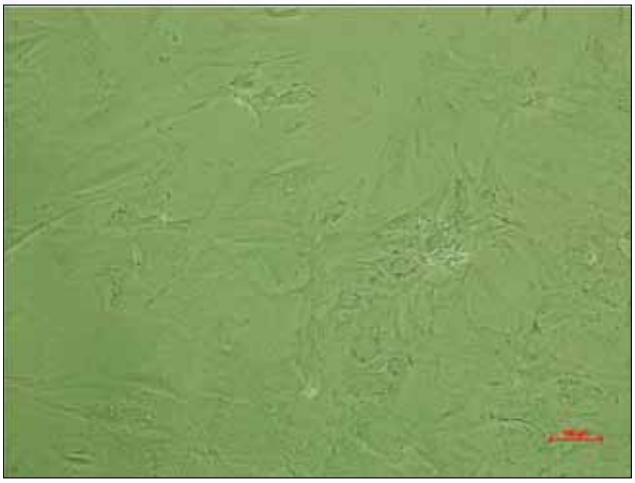


Fig. 70. Spermatogonial clusters of *Sahyadria denisonii* during differential plating culture

Fig. 71. Spermatogonia stem cells colonies developed from testis of *Sahyadria denisonii*

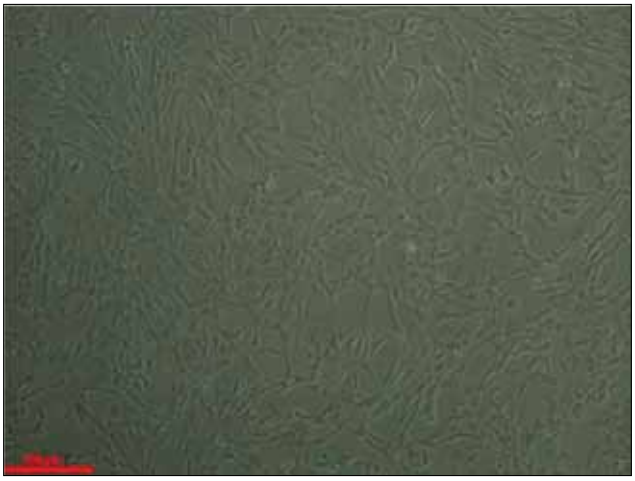


Fig. 72. *Clarias dussumieri* fin (ClDuF) cell line at 25th passage.

Program 5.5: Documentation of fish genetic resources of India

India, being a country with vast water resources offers rich diversity of aquatic fauna. Hence, documentation of the aquatic germplasms is key to gather background information and status of any specific genetic resources. This information is essential for sustainable exploitation of potential resources and formulation of targeted strategies to safe-guard depleted/vulnerable resources. Further, the documentation of aquatic resources will supplement 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. In this regard, ICAR-NBFGR is continuously undertaking various programmes to document the aquatic genetic resources of the country. The data thus documented through different programmes are ethically being presented in a web-interactive database named as Aquatic Genetic Resource Information System of India (AqGRISI). This single window platform enriched with information on genetics, genomics and diseases etc., which will give a holistic overview of the aquatic genetic resources of the country. ICAR-NBFGR is also the nodal centre for National Fish Museum and Repository recognised by National Biodiversity Authority under section 39 of Biological Diversity Act, 2002 of India; hence efforts are being made to enhance the visibility of the research on aquatic genetic resources through linking live germplasm and repositories along with the museum.

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

Celebration of World Intellectual Property Day

ICAR-NBFGR celebrated World Intellectual Property Day on April 26, 2019 to create awareness towards IP for fostering innovation and creativity among researchers. The theme of the celebration was IP, Creativity, Innovation and sports. Various events were organized including presentation on IPR for inculcating creativity, a studio session on creative brainstorming for fostering creativity, a scripted play for understanding plagiarism and copyright. An exhibition cum display on IP awareness for kids and visitors was conducted. Further conducted an outreach activity on creativity for rural women Self Help Group for co-creating bespoke sustainable unique products for office use and urban market, wherein around 70 researchers and students also participated (Fig. 73).

Development of women entrepreneurship

Three women researchers were mentored for creating entrepreneurial journey through the project, Knowledge Involvement in Research Advancement through Nurturing (KIRAN) funded by DST under Women Scientist Scheme at CSIR-CIMAP, Lucknow.

IP awareness and creativity inculcation

An endeavour was initiated to ignite young

Fig. 73. Glimpses of celebration of World Intellectual Property Day at ICAR-NBFGR on April 26, 2019. Clockwise: Inauguration of workshop; Jute bouquet cum planter created by Kalyani Village Women Incubation Centre; Exhibition at Ganga Aquarium for IP awareness for kids; Interactive studio session and outreach activities on creativity.

minds with ideas for creative learning, by trying, failing fast and redoing things and experimenting by utilising creativity for a solution. An interactive outreach awareness session was organized on the theme "Intellectual Property Rights and Creativity for Innovation" in a rural village at the outskirts of Raebareli at Poorva Madhyamic Vidhyalaya, Jhakrasi for 70 school kids of class 6 to 8 on October 25, 2019. An exercise based to understand different types of IP was organised. The objective of the programme was to raise awareness among kids to open up unseen possibilities for thinking differently in daily works. The outreach activity included basics of IPR, creativity and ideation exercise and redesigning everyday items. The programme also taught them to be future entrepreneurs by acting on ideas. They were taught how to prepare an aquarium and rear fish. They also filled a work book specially designed for rural kids to understand the nitty gritty of IPR. The kids were given biodegradable jute made pouches specially procured by Rural Women Self Help Group of Kalli Paschim. The ultimate aim of the workshop was to contribute in cultivating one Million kids as Neoteric Innovators. Dhanvantri diwas was also celebrated on October 25, 2019 at State Ayurvedic Dispensary, coordinated by Medical Officer Dr. Neelam Jayant and prizes were distributed to winners of creative slogan writing. The purpose was to connect science with rural kids at a level that creates curiosity. Scientists from ICAR-NBFGR gave demonstration on how to creatively build an aquarium from scratch.

Empowering Rural Village Self Help Groups (SHGs)

Women SHGs participated in an interaction session on "Co-creating Community Upliftment through design-based intervention for empowerment of women Self Help Groups" on September 26, 2019. An exhibition of handicrafts prepared by women using natural fibre jute-moonj and upcycled single use plastic products like flex made bags. The objective was to create new livelihood opportunities through enhancing sustainable productivity by up-cycling and re-cycling. An interaction session of Rural Women SHG conducted with Mrs. Deepmala Ghosh, DGM (FM) of Bankers Institute of Rural Development of NABARD for understanding aspects of micro-finance management, marketing and various schemes (eg. SHG-2) for creating rural agri-entrepreneurs helped rural women to understand financial management. A studio session and exhibition for brainstorming ideas for upcycled functional, non-decorative products from single use plastic for researchers was also organized for creative brainstorming for ideas of single use plastic.

Patent informatics in Proteomics

Patent information provides technological knowledge that has precedence over journal publications. Prior art search through patent literature was conducted in the field of proteomics for technological advancement (Fig. 74). A patent landscape for proteomics and LC-MS based Mass Spectroscopy showed trends in technological advancements that can help for competitive intelligence. Major databases namely, World Intellectual Property Organisation (WIPO), European Patent Office (EPO), and United States Patent and Trademark Office (USPTO), searched with International Patent Classification (IPC) Codes for curated analysis of patents associated in the field of instrumentation provided 3236, 204 and 3418 patents, respectively. The analysis showed trend in the areas of biomarker, instrumentation, food adulteration, mass quantification, plasma generator assembly, and peptide scoring, validation and identification algorithm for protein. Patent analysis was done of dominant players in the field of instrumentation and software for identification of peptide sequence and analysis of LC-MS data. The search strategy provides information on latest upgradation without incurring cost due to open patent documents, thus by being at par with a competitive edge through improvement in existing knowledge through upgraded patent filing. Intellectual Property Rights thus helps in boosting start-ups while the Indian start-up scenario provides a fertile platform for new ideas that need to be incubated for proof of concept for final validation,

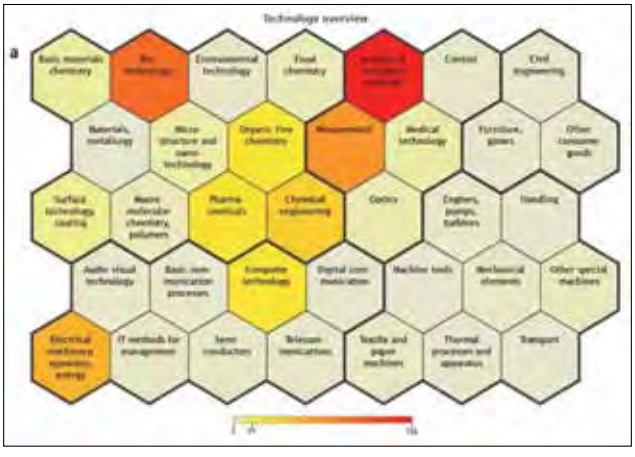


Fig. 74. Prior Art Search in the area of proteomics: The visualization of IPC codes grouped in 35 technology fields

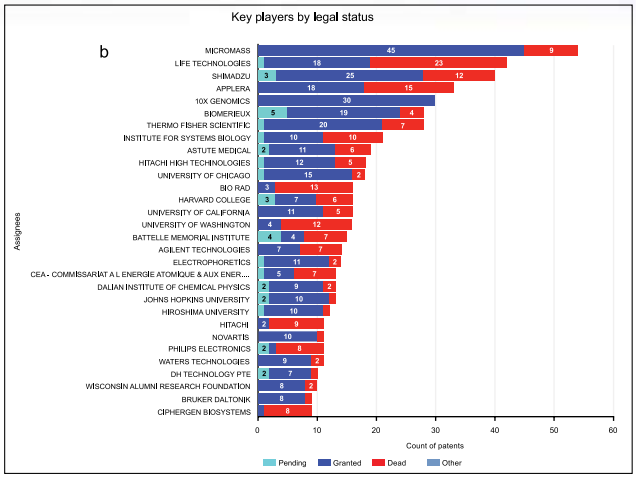


Fig. 75. Key players by legal status in the area of proteomics; applicants who have withdrawn from the sector due to abandonment, lapse and/or expiration of their patents and those who have patents granted still in force

resulting in university spin-offs, finally converging in a start-up. Proteomics being an emerging field with potential product development needs handholding and scouting of potential biomarkers that can be scaled for a spin-off through University and Industry research (Fig. 75).

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 (PI), T.T. Ajith Kumar, Mahender Singh, Poonam J. Singh, Rejani Chandran, Rajesh Dayal, Reeta Chaturvedi and Ravi Kumar

Funding Support: Institutional, ICAR-NBFGR

AqGRISI known as Aquatic Genetic Resources Information System of India is one of the web-based e-products generated as an output from the project entitled "Information-base on Fish Genetic Resources of India". This e-product in the line with different databases/information systems developed by ICAR-NBFGR and databases of external agencies of national and international importance available worldwide like FishBase, NCBI, WROMS, FAO, IUCN, ICAR-CMFRI, ICAR-CIFRI, Google Patents and MNHN etc. AqGRISI provides the ability for user to browse and view the information on various aspects of fish genetic resources native to Indian waters. The beta version of this system (Fig. 76) included with data and user management capabilities accessible at URL: http://mail.nbfgr.res.in/agrisi is an unique platform for accessing diverse information. Presently this information system covers 3138 native fish species belonging to 247 families and 47 orders. The system currently provides information on systematics, distribution, habitat, biology, type specimen, length-weight, disease, patent, fish nutrition, bibliography information on shellfish resources of India and fish accessions from different repositories of NBFGR like live germplasm, tissue, cell lines and museum. Besides providing the information oriented services, the system includes a beautiful photo gallery of fishes and an interactive GIS based point map displaying occurrence information of the Indian fish specimens recorded in the Global Biodiversity Information Facility as well as information documented in global museums or repositories. In addition to these, the system integrates in-house molecular resources like HRGFish (A database of hypoxia responsive gene 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) developed under the National Agricultural Bioinformatics Grid in ICAR project, which facilitates the user to view the information from these resources. During the development of this system, all necessary cares were taken to correctly digitize the data and display scientifically accurate information.

Fig. 76. Homepage of AqGRISI - Beta version

The final version of the aforesaid system under NET environment is in progress (Fig. 77). In the reporting period, biological information for 200 marine and 150 freshwater fishes has been updated. The information on food and feeding for 1589 fish species (Marine - 386, Freshwater - 847, Brackish water - 356) has been collected. A list of 403 fish species reported from high altitude waters has been compiled from old and new references and action has been initiated to update the information on these species.

Fig. 77. Homepage of AGRISI - Upgraded version

Program 5.6: Evaluation of fish genetic resources; exotics and health management

Trans-boundary movement of aquatic species and emerging aquatic animal diseases are the prime areas of concern in fisheries sector. Hence, addressing this important niche area is immensely important for minimizing the production loss in the culture systems and ecological risks to the open waters. In this direction, ICAR-NBFGR has been instrumental in implementing, National Surveillance Programme on Aquatic Animal Diseases in the country. Further, to contain the disease outbreak, the institute has several focussed research programmes on development of rapid diagnostic tools, therapeutic and prophylactic measures against major aquatic animal diseases. Antimicrobial resistance (AMR) is a global human health concern and a national program is being coordinated by the institute to assess the status of AMR in fisheries sector. With the advent of globalization, movement of aquatic animal resources across the countries has been intensified in last few decades for several reasons including species diversification, higher growth rate or resistance to specific disease. The introduction of these exotic fish species pose serious threats to the huge indigenous fish fauna, as these are being established in the Indian open waters. Hence, a holistic risk-benefit assessment is very important for the evaluation of exotics before introducing in the Indian waters. The institute is undertaking several research programmes to evaluate the risk-benefit assessment modelling of already introduced exotic fish species.

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)

Infection with *Aphanomyces invadans* is one of the important diseases affecting freshwater fishes. Importantly, Indian major carps (IMCs), the major cultured species in Indian subcontinent, are highly susceptible to this disease whereas, common carp is known to be resistant to the disease. However, very limited information is available regarding host-pathogen interaction. Therefore, to understand the mechanism of susceptibility and resistance, rohu and common carp were experimentally infected with *A. invadans* and RNA sequencing of head kidney was carried out. Analysis of RNA-seq data of susceptible rohu revealed 5608 differentially expressed genes (DEGs), out of which, 390 genes were involved in 21 immune pathways. The major affected immune pathways included antigen processing and presentation, leukocyte trans-endothelial migration, IL-17 signaling pathway, T-cell receptor signaling pathway, C-type lectin receptor signaling, platelet activation and toll-like receptor signaling pathway. In the affected pathways, a number of immune genes were found to be down-regulated, suggesting an immune evasion strategy of *A. invadans* in establishing the infection in the susceptible host (Fig. 78). On the other hand, a total of 5288 genes were differentially expressed in head kidney of common carp. Out of these, 731 genes were involved in immune pathways.

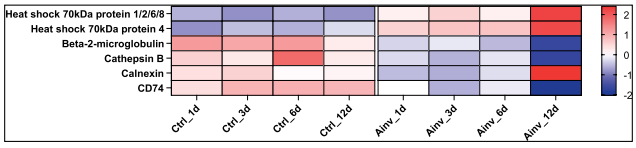


Fig. 78. Heatmap showing differentially-expressed genes in head kidney of rohu following infection with *Aphanomyces invadans*, mapping to antigen processing and presentation pathway; "Ctrl"-control and "Ainv" *A. invadans*-infected animals

The major affected pathways included antigen processing and presentation, NOD-like receptor signaling pathway, leukocyte trans-endothelial migration, chemokine signaling pathways among others. Importantly, majority of genes in antigen processing and presentation and NOD-like receptor signaling pathway were found to be up-regulated, suggesting that these would be playing an important role in resistance to *A. invadans* infection.

Project: National Surveillance Programme for Aquatic Animal Diseases (NSPAAD)

Period: February, 2013 - June, 2020

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

The National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) coordinated by ICAR-NBFGR is being implemented through 31 collaborating centres in 19 states and 3 union territories of the country. During this period, the first report of red sea bream iridovirus (RSIV) disease (an OIE-listed disease) in sea bass by College of Fisheries, Mangalore was validated at ICAR-NBFGR and ICAR-CIBA. Since this was the first report of the disease from the country, a report was compiled and submitted to Department of Fisheries (DoF), Ministry of Fisheries, Animal Husbandry and Dairying, Government of India. Subsequently, the disease was notified to World Organization for Animal Health. Four QAAD reports in the year 2019 were compiled on the basis of reports received from NSPAAD collaborating centres and submitted to DoF, Ministry of Fisheries, Animal Husbandry and Dairying.

During the reporting year, the positive controls for different pathogens were shared with the collaborating centres as per their requirement. Technical backstopping was provided to Department of Fisheries

regarding ban on import of frozen shrimp due to presence of WSSV and IHHNV. Similarly, inputs were provided to MPEDA regarding compartmentalization for disease free zones in shrimps.

An ICAR-NACA School on Aquatic Animal Epidemiology and Disease Surveillance was organised at ICAR-NBFGR under NSPAAD during March 1-6, 2019 for 12 researchers from 8 Institutes (Fig. 79). The school was led by Prof. K.L. Morgan, Emeritus Prof. of Epidemiology, University of Liverpool, Neston, UK. Besides, there were presentations by Prof. Iddya Karunasagar, International Food Safety Consultant, FAO, Rome and Dr. Eduardo Leano, Coordinator, Aquatic Animal Health Programme, NACA, Bangkok. ICAR-NBFGR also coordinated organization of training programmes for AquaOne Centres of NFDB by RGCA, Nagapattinam; FFSc, Kolkata and SIFT, Kakinada. One Quarantine Officer, AQCS (WR) was imparted training during June 24-28, 2019 regarding collection, preservation and dispatch of samples for screening of samples for aquatic animal pathogens and major diseases in finfish and shellfish. Further, a TAC meeting was organized at ICAR-NBFGR, Lucknow on December 19, 2019 and the committee members were apprised about major achievements of NSPAAD and proposal for 2nd phase of NSPAAD (Fig. 80).

Fig. 79. ICAR-NACA School on Aquatic Animal Epidemiology and Disease Surveillance

Fig. 80. TAC meeting for NSPAAD programme

Two new proposals i.e. 2nd Phase of NSPAAD for funding from DoF; Centre for Aquatic Animal Disease Informatics and Referral Diagnostics funding from NFDB on the basis of NSPAAD were prepared and submitted during this period. Moreover, lead presentation on "The India's National Surveillance Programme: a case study of systematic approach for controlling Aquatic Animal Diseases in Asia" and oral presentation on "The challenges of establishing and sustaining the health status of groundwater based inland saline shrimp farming system in Haryana, India" were made during Global Conference on AquaEpi II being held in Hua Hin, Thailand during November 4-6, 2019 (Fig. 81). During the Conference, ICAR-NBFGR won the bid to host AquaEpi III in New Delhi proposed to be held in November, 2022.

Fig. 81. Participation in AquaEpi II at Thailand

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

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

Under this sub-project, ICAR-NBFGR has the responsibility to carry out disease surveillance in Haryana and Uttar Pradesh. Pangas farms in the different districts of Uttar Pradesh were surveyed and sampling was carried out in a total of 33 farms in different districts i.e. Lucknow, Barabanki, Hardoi, Sultanpur, Jaunpur, Azamgarh, Siddharthnagar and Balrampur. The major bacterial pathogens associated with diseases in pangas included *Edwardsiella tarda* and motile aeromonad species, namely *Aeromonas hydrophila*, *A. caviae*, *A. veronii* and *A. sobria*. In

addition, *Saprolegnia parasitica* was identified as the causative agent of large-scale mortalities in pangas farms (n=11) in Azamgarh district of Uttar Pradesh (Fig. 82). Samples collected from shrimp farms of Haryana were screened for the presence of *Enterocytozoon hepatopenaei* (EHP), WSSV, HPV, IHHNV and MBV. The samples were positive for EHP infection and negative for remaining pathogens. Besides, a number of disease cases from the different districts of Uttar Pradesh were investigated and in most of the cases, co-infection of parasites, oomycete and bacteria was observed (Fig. 83).

Fig. 82. Mass mortality in pangas farm located in Azamgarh district of Uttar Pradesh

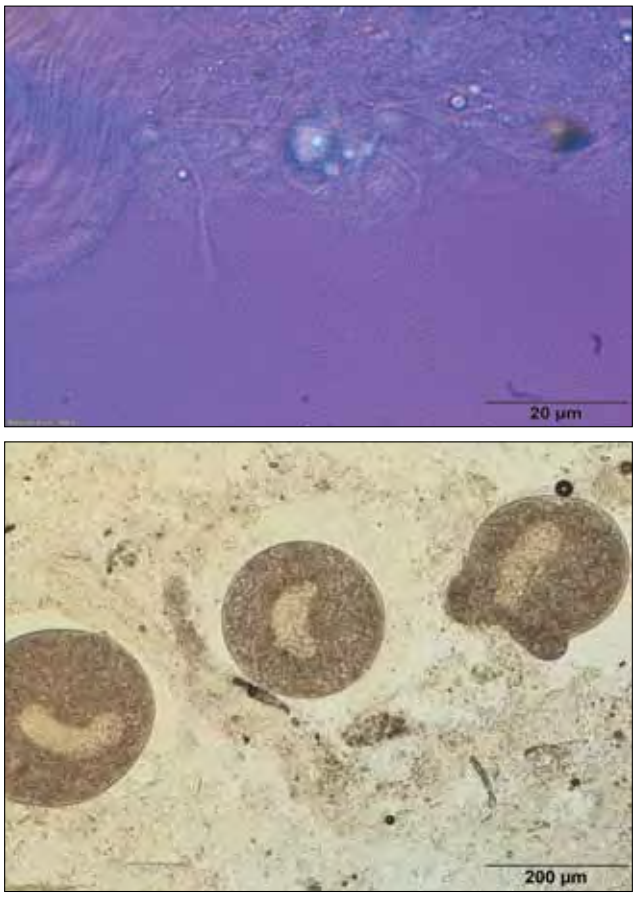


Fig. 83. Wet mount preparation from diseased fish tissues showing bacterial and parasitic infection

Sub-Project III: NSPAAD Sub-Project No - 09 Surveillance of ornamental fish diseases

Personnel: T. Raja Swaminathan (PI)

Ornamental fish industry, which holds tremendous potential as the livelihood support for small and marginal farmers is booming in different parts of the country. However, expansion of this sector leading to the emergence of new diseases and reporting of these diseases are pivotal for implementing management strategies and safe exports. In this regard, a total of 125 ornamental fish samples were collected from 5 districts of Kerala and 2 districts in Tamil Nadu for targeted active surveillance of Spring viraemia of carp and Koi herpes virus in ornamental fish and all samples found negative. A total of 78 goldfish samples were also tested for Cyprinid herpesvirus -2 (CyHV-2) and 24 samples found positive for CyHV-2. A total of 85 koi carp samples were also tested for Carp edema virus (CEV) and 28 samples found positive for CEV.

First detection of Infectious Spleen and Kidney Necrosis Virus (ISKNV)

During October - December 2019, very high mortality (>80-90%) were reported in intensive oscar, *Astronotus ocellatus* and giant gourami, *Osphronemus goramy* culture systems across Kerala. From a total of 210 fish samples representing these 2 species, ISKNV was detected in all samples. Affected fish showed darkening, erratic swimming and abdominal distension with associated ascites. Histopathological observations of affected tissues taken from moribund fish revealed hypertrophic cells, single-cell necrosis, and inflammatory infiltration of granulocytes, lymphocytes, and macrophages in liver, spleen, and kidney. Transmission electron microscopy revealed the presence of numerous polygonal viral particles (~150 nm in diameter) within the cytoplasm of enlarged cells. A PCR assay for the detection of megalocytivirus amplified 324 bp of major capsid protein (MCP) gene that was 100% identical to ISKNV. All positive cases did not show any clinical signs of ISKNV. Three restriction enzymes analyses showed that the fish were infected by identical strains of the same virus species within Megalocytivirus genus. Major capsid protein (MCP) genes of 10 ISKNV strains were sequenced and compared with 9 other reference nucleotide sequences acquired from GenBank. Sequence analysis of MCP gene showed that all strains detected in this study were closely related to the reference ISKNV

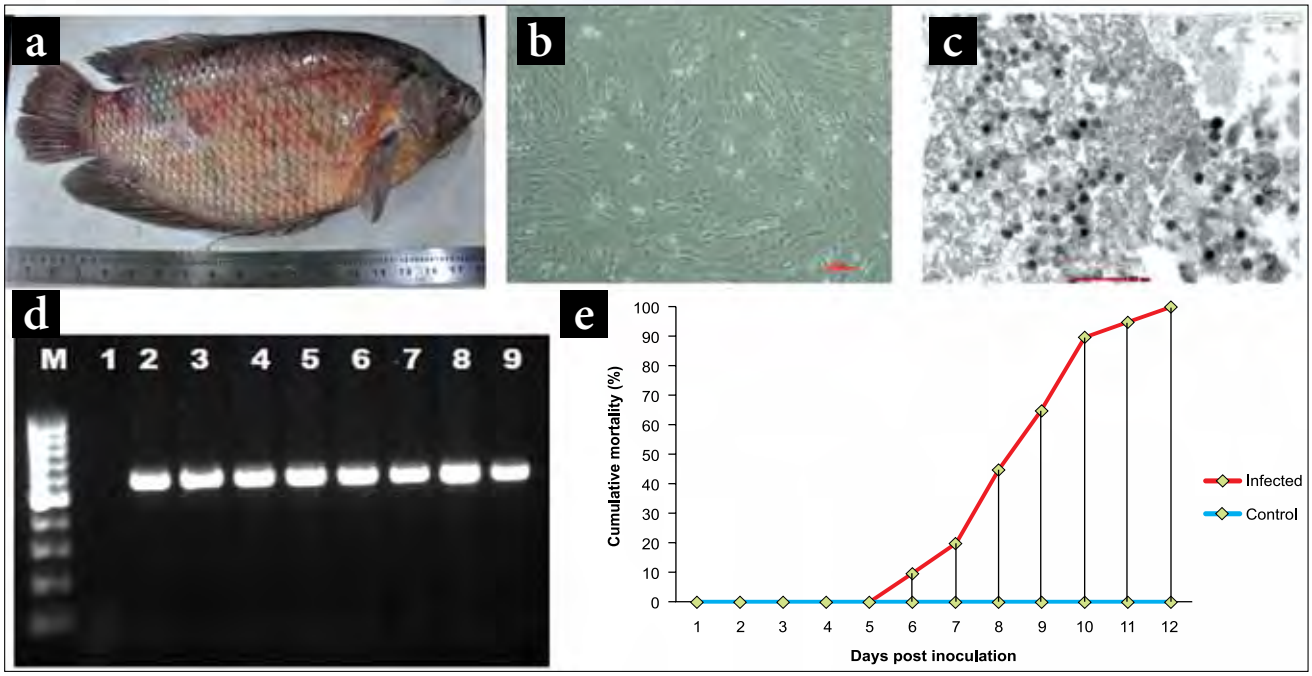


Fig. 84. Isolation and detection of ISKNV from a disease outbreak in Giant Gourami. A) Infected Giant Gourami B) Viral cytopathic effects in *Astronotus ocellatus* fin cell line ; C) Mature virus particles in the ultra-thin sections of liver in Transmission Electron Microscope; D) Amplification of 570 bp target band in ISKNV by molecular diagnosis of ISKNV using OIE PCR. M – 100bp Marker; 1 – Negative control; 2 – Naturally infected Fish tissue; 3 – Naturally infected Fish tissue; 4 – Naturally infected Fish tissue; 5 – Experimentally infected fish; 6 – Experimentally infected fish; 7 – AOF cell line; 8 – onlL cell line; 9 – PSF cell line; E) Cumulative mortality curve of the experimentally infected oscar fish (12-15 cm; 16-23 gm), using challenged with 106.8±0.26 TCID50/mL ISKNV (passage 3) propagated in AOF cells.

with nucleotide sequence identity that was ranging from 99.8% to 100%. PCR confirmation and DNA sequencing identified the virions in the tissues of the diseased fish as Infectious Spleen and Kidney Necrosis Virus (ISKNV). An experimental infection of naive oscar fish using supernatant from ISKNV infected AOF cell line developed from fin tissue of oscar caused 100% mortality. The fish started exhibiting clinical signs at 6-7 dpi, and these included skin discoloration, abdominal distension, protrusion of scales, exophthalmia, and pale liver, similar to those observed in naturally infected fish. The experimentally infected fish started dying at 10 dpi, with cumulative mortality reaching 100% by 12 dpi. However, no morbidity or mortality was observed in control group injected with supernatant from oscar cell line and ISKNV infection in the challenged fish was confirmed by the amplification of DNA polymerase gene, histopathology and transmission electron microscopy (Fig. 84).

Epizootic ulcerative syndrome among estuarine fishes of Kerala

Epizootic ulcerative syndrome (EUS), epizootics was evidenced among estuarine fishes of Kerala, India under post-flood conditions 3 decades after its primary outbreak. Six fish species (*Mugil cephalus, Platycephalus sp., Scatophagus argus, Arius sp., Planiliza macrolepis* and *Epinephelus malabaricus*) were found to be infected; forming the first confirmed natural case in *E. malabaricus* and *P. macrolepis*. The histological and molecular characterization revealed that the fishes were severely infected with *Aphanomyces invadans*. Phylogenetic analysis based on internal transcribed spacer region of the rRNA gene showed that the same clone of pathogen has spread across different continents regardless of fish species and ecotypes (fresh/estuarine environments).

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

Collection of fish samples from four districts of Uttar Pradesh

Fish samples were collected from Barabanki, Varanasi and Bareilly districts of Uttar Pradesh. A total of 97 farms were sampled and 97 fish samples were analysed for isolation of *E. coli, Aeromonas* spp., and *Staphylococcus* spp.

Isolation, identification and antimicrobial susceptibility of *Aeromonas* spp., *E. coli* and *Staphylococcus* spp.

During the course of study, a total of 272 bacterial isolates were analysed comprising of 82 isolates of *E. coli*, 95 isolates of *Staphylococcus* spp., and 95 isolates of *Aeromonas* spp. AMR testing was done by disc diffusion method following CLSI guidelines and data was analysed by WHONET software. A total of 82 isolates of *E. coli* were analyzed for AMR comprising 15 listed antibiotics. Out of these, highest resistance of 26.8% was seen against ampicillin and nalidixic acid, and 20.7% isolates were resistant to ceftriaxone and cefotaxime. A total of 7.3% of isolates were resistant to tetracycline (Fig. 85). Further, a total of 95 isolates of *Staphylococcus* spp. were analyzed for AMR comprising 9 listed antibiotics. Out of these, 47.4% isolates were resistant to penicillin, and 27.7% isolates were resistant to trimethoprim/ sulfamethoxazole. A total of 21.1% of isolates were resistant to erythromycin (Fig. 86). Moreover, a total of 95 isolates of *Aeromonas* were analyzed for AMR for 11 listed antibiotics. Out of these, 11.6% isolates were resistant to cefotaxime. A total of 6.6% of isolates were resistant to ceftazidime (Fig. 87).

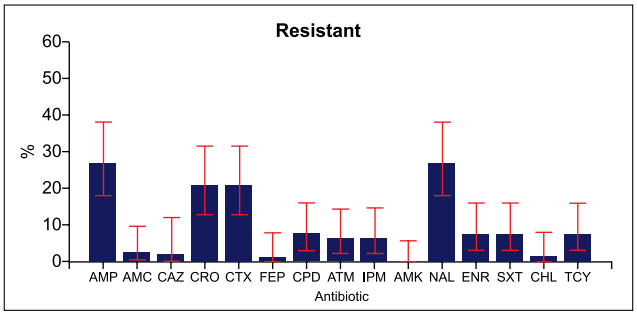


Fig. 85. Antibiotic resistance in *E. coli* isolated from freshwater fish of Uttar Pradesh

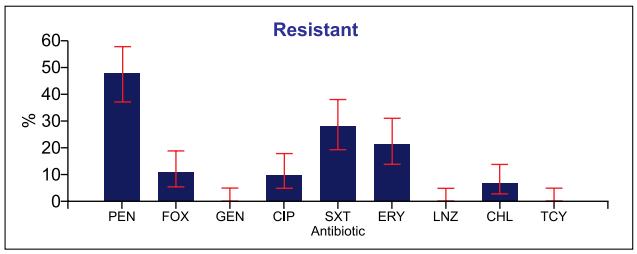


Fig. 86. Antibiotic resistance in *Staphylococcus* spp. isolated from freshwater fish of Uttar Pradesh

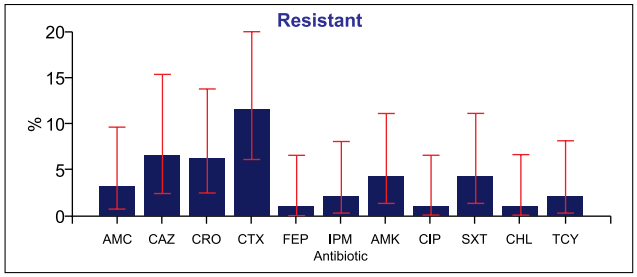


Fig. 87. Antibiotic resistance in *Aeromonas* spp. isolated from freshwater fish of Uttar Pradesh

Project:	**Risk and benefit assessment modelling for exotic species**
Period:	**April, 2017 - March, 2020**
Personnel:	**Kripal Datt Joshi (PI), V.S. Basheer, Aditya Kumar, Satyendra Mohan Srivastava and Vikash Sahu**
Funding Support:	**Institutional, ICAR-NBFGR**

Exploratory surveys were conducted in selected rivers, wetland and open-water resources in different parts of the country to assess water quality and occurrence, expansion, composition and biological attributes of alien fishes. The details of the studies conducted are as below:

River Ganga

Explorations were conducted in the river Ganga at Dalmau, Prayagraj and Kanpur, during the period to assess the occurrence and establishment of the alien fishes (Fig. 88). The river was observed to be under massive invasion of common carp (*Cyprinus carpio*) and Nile tilapia (*Oreochromis niloticus*). Besides these, no other alien fishes were observed from the river sites. Among the total fish catch from the river at Prayagraj, alien fishes form approximately 26-45% of the total catches. The size ranges of common carp from river Ganga at Prayagraj comprised 90 to 660 mm with corresponding weight of 10 to 4020 g, respectively and tilapia from 225 to 305 mm with corresponding weight of 250 to 540 g, respectively. Availability of all life stages in the catches evidence established populations of both the species. The deteriorated water quality parameters (Table 13) facilitate occurrence and establishment of alien fishes in the rivers (Fig. 89).

Fig. 88. Sampling in the river Ganga at Prayagraj

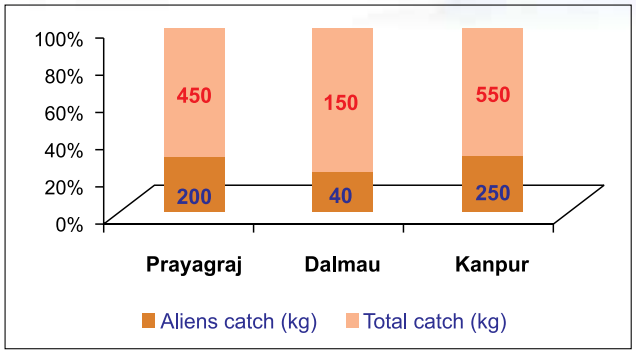


Fig. 89. Estimated catch (per day) of fishes in the river Ganga at three selected sites

Table 13. Key water quality parameters of the river Ganga at three selected sites

S.N.	Sampling sites	Water quality parameters				
		pH	Dissolved oxygen (mg)	Total dissolve solids (mg)	Conduc-tance (umhos/ cm)	Water temperature (°C)
1.	Prayagraj	8.8	5.0	156	311	33.7
2.	Dalmau	8.4	5.4	152.0	308	31.5
3.	Kanpur	7.8	4.35	105.0	300	28.46

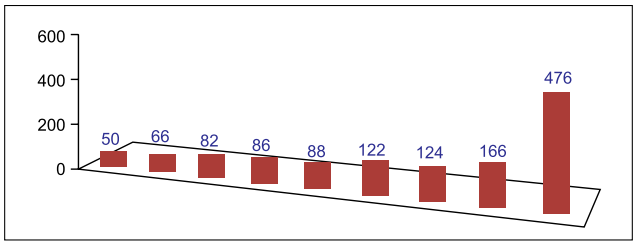


Fig. 90. Body weight (g) profile of the tilapia samples caught from river Tons

River Tons, a tributary which drains into river Ganga near Prayagraj was also observed to be infested with aliens namely, Nile tilapia and common carp. The river catch comprises 20-25% alien fishes, dominated by tilapia. The size range of tilapia ranged from 160 to 297 mm with corresponding weight of 66 to 476 g, respectively (Fig. 90). Availability of all size ranges of tilapia and common carp confirm established populations of both the species.

River Yamuna

The river Yamuna is an extreme example of anthropogenic activities and resultant degradation of river habitats, fishery and establishment of alien fishes. The river was surveyed at Agra, Etawah and Prayagraj sites during the period, to assess the alien diversity, composition and vital water quality parameters in the down and midstream stretches of the river. Among the aliens, *O. niloticus* was highly established in the river followed by *C. carpio*. The size range of tilapia from the catches at Prayagraj comprised body size range from 203 to 475 mm with corresponding weight of 160 to 1900 g, respectively (Fig. 91). The length of common carp from catches comprised 95 to 645 mm with corresponding weight of 12 to 5582 g, respectively. The estimated composition of alien fishes from the selected sites of river Yamuna was estimated at 35-70% of the total catch. Sizeable population of African magur (*Clarias gariepinus*) was also observed in the river at Agra and Etawah, which may pose serious threat to the native aquatic fauna of the river. Size range of African magur from the catches in the river comprised 172 to 630 mm with corresponding weight of 280 to 1620 g. The decadal evaluation reveal that there was marginal decrease in composition of common carp and increase in tilapia in the river Yamuna, in comparison to the year 2008 (Fig. 92). The key water quality parameters indicate impaired condition in the river (Table 14). Sampling of the river water and experimental fishing (Fig. 93) was conducted across the river Yamuna at Agra. Tilapia form sizeable composition in fish markets of Agra (Fig. 94).

Fig. 91. Tilapia, *Oreochromis nilotius* river Yamuna at Prayagraj

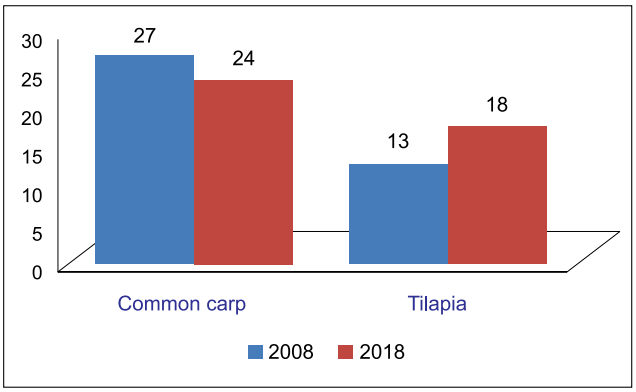


Fig. 92. Decadal changes in alien fish catch in the River Yamuna

Fig. 93. Expenimental fishing in the river Yamuna at Agra

Table 14. Key water quality parameters of river Yamuna

S.N.	Sampling sites	Water quality parameters				
		pH	Dissolved oxygen (mg)	Total dissolve solids (mg)	Conduc-tance (umhos/ cm)	Water temperature (°C)
1.	Prayagraj	9.0	8.26	417	835	32.6
2.	Etawah	8.3	6.18	439	877	29.22
3.	Agra	8.1	8.1	641	1283	29.62

Fig. 94. Tilapia for sale at Agra fish market

Assessment of gut content of African magur

Analysed gut contents of African magur, *Clarias gariepinus* caught from the river Yamuna near Agra, with the objective to assess its food material in the river habitat and assessment of gonadal maturity (Fig. 95). The percent composition of the gut reveals aquatic worms (46%), detritus (43%), insects (7%), and plant matter (4%) (Fig. 96).

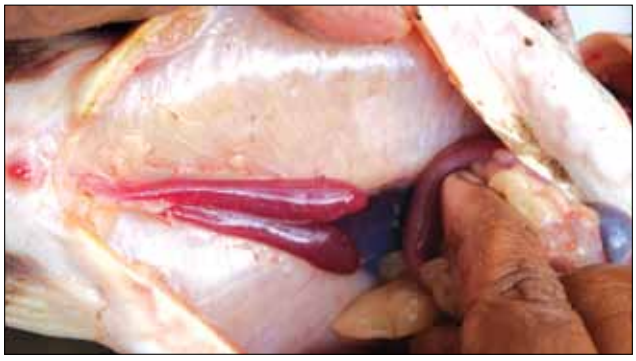


Fig. 95. Assessment of gonadal development of African magur

Fig. 96. Assessment of gut content in African magur

River Gomti

Exploratory survey on two sites of the river Gomti in Lucknow indicate considerable invasion of alien fishes, which form 10-20% of the total catches. Common carp (*C. carpio*) forms major share of the total catches, followed by Nile tilapia (*O. niloticus*). Stray samples of silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Hypophthalmichthys nobilis*) and grass carp *(Ctenopharyngodon idella*) were also caught. Few samples of African magur (*C. gariepinus*) were also available occasionally in the river. Even after impaired water condition, the river still holds good population of IMC, minor carps, catfishes and minnows.

Soor Sarovar Bird Sanctuary (Keetham Wetland), Agra

The Soor Sarovar wetland also known as Keetham jheel spread in an area of 797 ha, in which 225 ha comprise water spread area. The wetland is located on Yamuna basin. It is an artificial lake developed in the year 1942 after construction of a bundh across the river channel. The area was declared a bird sanctuary in the year 1991. The wetland is connected with a canal, which

Fig. 97. Limited experimental fishing in Soor Sarovar, Agra

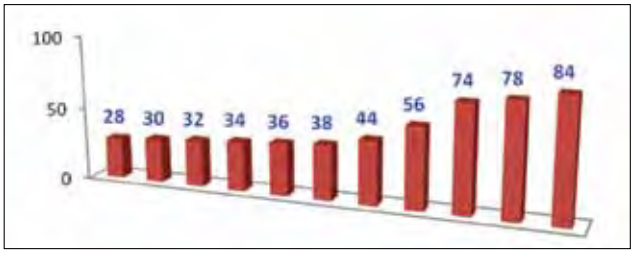


Fig. 98. Body weight (g) profile of the tilapia samples caught from the Soor Sarovar

receives water into the wetland. The overflow of water drains to river Yamuna. The wetland has maximum depth of about 7 m. The wetland is surrounded by dense forest canopy. The water column remains at minimum level during winters. Limited experimental fishing (Fig. 97) conducted in the wetland with due permission of the concern authorities reveal that the wetland holds rich fish diversity, mostly represents that of river Yamuna. Besides native species, luxurious population of alien fishes including Nile tilapia (Fig. 98) and common carp were also observed in the wetland. Availability of all-sized tilapia specimens clearly reflect about its established population.

The water quality parameters are almost similar to Yamuna water and pH ranged from 7.6-7.8, dissolved oxygen varied from 3.1-4.8 mg/l, TDS values were between 672 and 924 while conductance ranged from 1343 to 1850 µmhos/cm.

Fort moat of Lohagarh (Sujan Ganga Nahar), Bharatpur, Rajasthan

The Lohagarh Fort located in Bharatpur is famous for its sizeable moat known as Sujan Ganga Nahar (Fig. 99 & 100). The moat was the main source of portable water for the residents of the Bharatpur city long ago, which has now turned into a polluted drain. The moat encircling the huge fort is approximately 3 km in length, 15-50 m in width and 3-10 m in depth.

Fig. 99. Moat view of Lohagarh Fort, Bharatpur

Fig. 100. Water sampling in moat of Lohagarh Fort, Bharatpur

The moat water is highly impaired due to high organic load received through city drainages and run-off from the catchments. The quality of moat water indicates considerable decline in dissolved oxygen (4.7-5.28 mg/l) and accumulation of carbon dioxide (2.8-3.2 mg/l), pH ranged from 7.7-8.3, TDS values were extremely high and found between 2762 and 2948 mg/l while conductance ranged from 5710 to 5968 µmhos/cm. The moat is reportedly stocked with mixture of carp seed comprising Indian major carps and exotic carps. But due to degraded water quality parameters, the aliens in general and Nile tilapia in particular are flourishing in the moat water. Experimental fishing (50 casts with cast net) yielded almost 100% tilapia catch.

Periyar National Park and Wildlife Sanctuary, Kerala

Fish sampling in the Periyar lake indicate sizeable occurrence of alien fishes including African magur (*C. gariepinus*), common carp (*C. carpio*) and tilapia (*O. mossambicus*). African magur caught from the lake were in length range of 250-400 mm with corresponding weight of 500-1500 g, respectively.

Food items observed in the gut of fishes were plant material, broken rice, insects, fishes and some molluscs. Juveniles of *C. gariepinus* were also collected from nearby fields, confirming established population of the fish in the region.

Panamaram and Mananthvadi rivers

Exploratory survey and sampling of the rivers Panamaram and Mananthvadi, tributaries of Kabini in Karnataka and Kerala states were conducted for assessment of alien fishes (Fig. 101). Stray samples of *C. gariepinus* were caught from the rivers. Length of the *C. gariepinus* recorded between 300-400 mm with corresponding weight of 700-2000 g, respectively.

Fig. 101. Sampling in Panamaram River

Occurrence of *C. gariepinus* also observed from freshwater canals, tanks and temple ponds in the vicinity of Calicut city and also from Mankuzhi tank and associated canals as well as the drainage canals (Fig. 102). The pond attached to the Thiruvachira temple is safe shelter to a large population of *C. gariepinus*. Due to the absence of fishing, the pond is a safe haven for the invasive fish.

Fig. 102. Juvenile of African magur caught from the river

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 is one of the strategies to reduce disease-related losses due to infection with *Aphanomyces invadans*. During the reporting period, paraformaldehyde-killed zoospores alone and in conjunction with adjuvant Montanide™ ISA 763 AVG were used for immunization of rohu juveniles. After 28 days of immunization, the fish were given a booster dose. The fish from immunized and control group were challenged with zoospores of *A. invadans* to determine the relative percent survival (RPS), after 14 days of the booster dose. The results revealed 100% mortality in all the groups, suggesting that immunization with inactivated zoospores did not render protection in immunized rohu. Subsequently, to validate the findings of study carried out in preceding year, rohu were immunized with inactivated germinated zoospores in conjunction with adjuvant, and given a booster after 28 days of immunization. Challenge experiments after 14 days of booster immunization revealed 60% RPS in immunized group whereas, only 10% RPS was observed after 28 days of booster immunization. Hence, it can be inferred that the immunization with inactivated germinated zoospores of *A. invadans* appear to offer short-term protection against infection.

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 different concentrations of commonly used chemicals and antifungal drugs such as formalin, potassium permanganate ($KMnO_4$), hydrogen peroxide (H_2O_2), sodium thiosulphate ($Na_2S_2O_3$), amphotericin B and fluconazole against different stages (zoospores, germination of zoospores and growth of hyphae) of *Aphanomyces invadans* was studied under *in vitro* conditions. During the reporting period, a detailed investigation on the concentration-specific chemotherapeutic efficacy of these chemicals against different life-stages of *A. invadans* in terms of quantifiable inhibition was performed. Among the

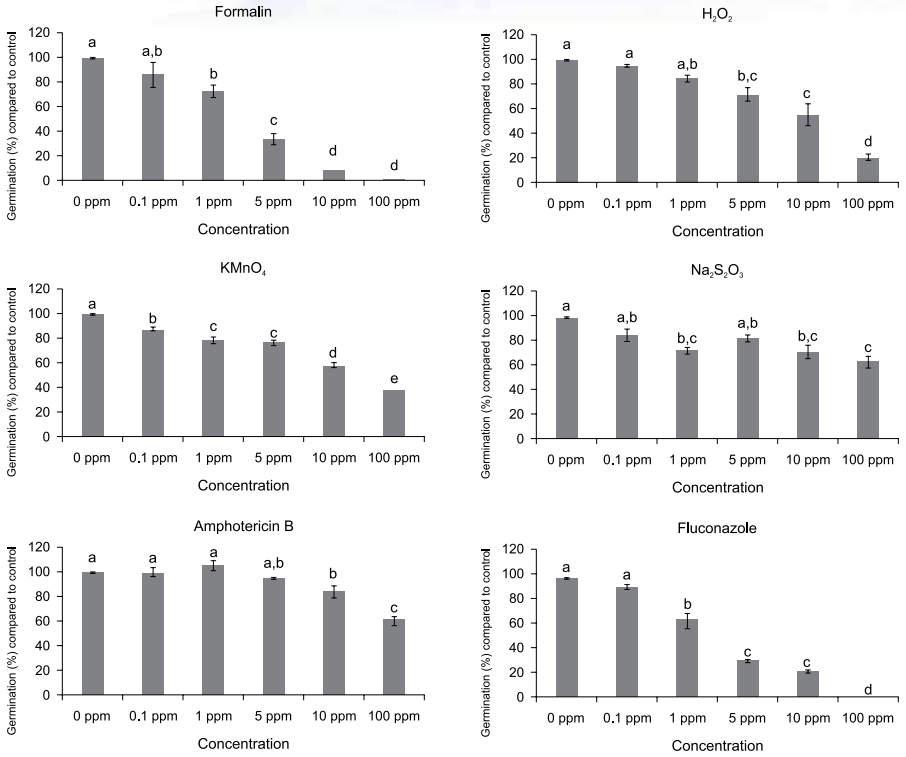


Fig. 103. Germination (%) of zoospores of *A. invadans* compared to control at 6 h post exposure with different concentrations of the chemicals. Different letters mentioned above bar indicate significant differences ($p \leq 0.05$) between different concentrations within a treatment group compared to the control

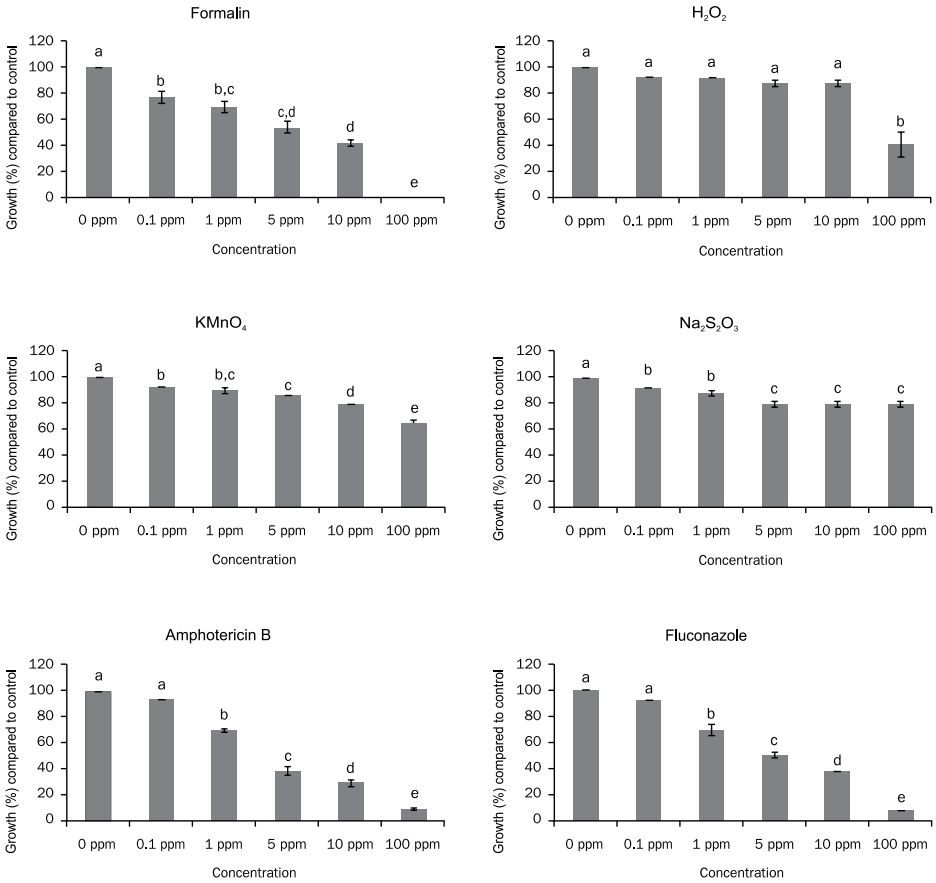


Fig. 104. Growth (%) of *A. invadans* hyphae compared to control in GPY agar containing different concentrations of the chemicals. Different letters mentioned above bar indicate significant differences ($p \leq 0.05$) between different concentrations within a treatment group compared to the control

disinfectants tested, formalin could potentially inhibit the sporulation at 10 ppm, and significant level of inhibition of the germination of zoospores and growth of hyphae was observed at this concentration (Fig. 103 & 104). The complete inhibition of spore germination and growth of hyphae could only be detected at the concentration of 100 ppm. On the other hand, H_2O_2 and $KMnO_4$ could inhibit germination of zoospores and growth of hyphae only up to certain extent even at 100 ppm. Importantly, $Na_2S_2O_3$ was found to be ineffective against *A. invadans* life stages. In addition, both the antifungal drugs i.e. amphotericin B and fluconazole completely inhibited zoospores production at 100 ppm. Complete inhibition of germination of zoospores with fluconazole was recorded only at 100 ppm, whereas, amphotericin B could not inhibit germination of zoospores even at highest tested concentration of 100 ppm. Neither of the above two drugs could completely inhibit growth of hyphae at 100 ppm (Fig. 103 & 104).

The six chemicals tested showed varying degree of effect on sporulation, germination of zoospores and growth of *A. invadans* hyphae. Out of the six chemicals, formalin and fluconazole showed considerably better effect. The concentration-specific effect of these chemicals would serve as a basis for their application in aquaculture systems and to specifically target the different life stages of *A. invadans*.

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: ICAR Education Division

Three new cell lines including Fantail goldfish gill (FtGG), Fantail goldfish liver (FtGL) and Fantail goldfish brain (FtGB) has been established and characterized from the gill, liver and brain tissue of *Carassius auratus* respectively for the isolation of CyHV-2 (Fig. 105). Cell lines were optimally grown at 28°C in Leibovitz-15 (L-15) medium supplemented with 10% fetal bovine serum (FBS). Karyotyping analysis indicated that the cell lines remained diploid, with a modal chromosomal count of 100. The revival rate of FtGG cell line was 82% after 6 months of cryopreservation whereas, it was 72% and 70% in FtGL and FtGB cells respectively. All the three cells showed similar cytopathic effect (CPE) between 3-5 days post-infection (dpi) with CyHV-2 and complete destruction of the monolayer was observed at 8 - 10 dpi (Fig. 106). The viral titers of CyHV-2 in FtGG, FtGL and FtGB reached $10^{7.09}$ $TCID_{50}$/ml, $10^{4.73}$ $TCID_{50}$/ml and $10^{6.89}$ $TCID_{50}$/ml, respectively. The results provide solid evidence that the FtGG cell line is highly permissive for the isolation and propagation of CyHV-2.

Confluent monolayer cultures containing about 5 x 10^7 FtGF cells were infected with CyHV-2 and incubated for 48 h at 28°C with L-15 medium containing 5% fetal bovine serum. The cultures were shaken to complete detachment of the cells from the flask and the cells separated from the medium by centrifuging at 200 g for 10 min. The infected cells (4 x 10^7 cells/ml) were resuspended in phosphate-buffered saline (pH 7.3) and disrupted to liberate the virus by repeated freezing and thawing or by ultrasonic treatment with a 500 W at 40 kcyc/sec. Large particles of cell debris were removed by centrifuging at 800 g for 5 min. The virus was sedimented from the crude suspension by centrifugation in an angle rotor (Beckman Model L Ultracentrifuge) at 35,000 g for 30 min and the supernatant fluid, containing most of the protein, discarded. The deposit was resuspended in a volume equal to the original volume of buffer + azide and centrifuged in the same way. This washed deposit was resuspended in one-tenth of the original volume of buffer + azide and is referred to as semi-purified virus. Lusteroid tubes (3 x 1 inch) were filled by layering successively from pipettes 6 ml each of 60, 50, 40 and 30% (w/v) sucrose in buffer + azide followed by 6 ml of semi-purified virus. The tubes were centrifuged at room temperature in the swinging bucket rotor at 39,000 g for 20 min. Purified virus formed an opalescent zone in the 50% (w/v) sucrose layer with zones of impurity above and below.

The purified virus in about 50% (w/v) sucrose was diluted with 2 volume of 0.004 M-McIlvaine buffer (pH 7.8) and centrifuged at 35,000 g for 60 min. The deposited virus was washed twice with buffer and three times with water using a volume equal to the original sucrose suspension and centrifuged at 35,000 g for 30 min for each wash. The final deposit of virus was suspended in water and stored at -80°C.

The LAMP primer sequences were designed using Primer Explorer V4 and the locations are indicated in Fig. 107a. Optimal amplification of LAMP product

Development of vaccines and diagnostic kit for the disease management of Goldfish Herpesviral Hematopoietic Necrosis Disease in India

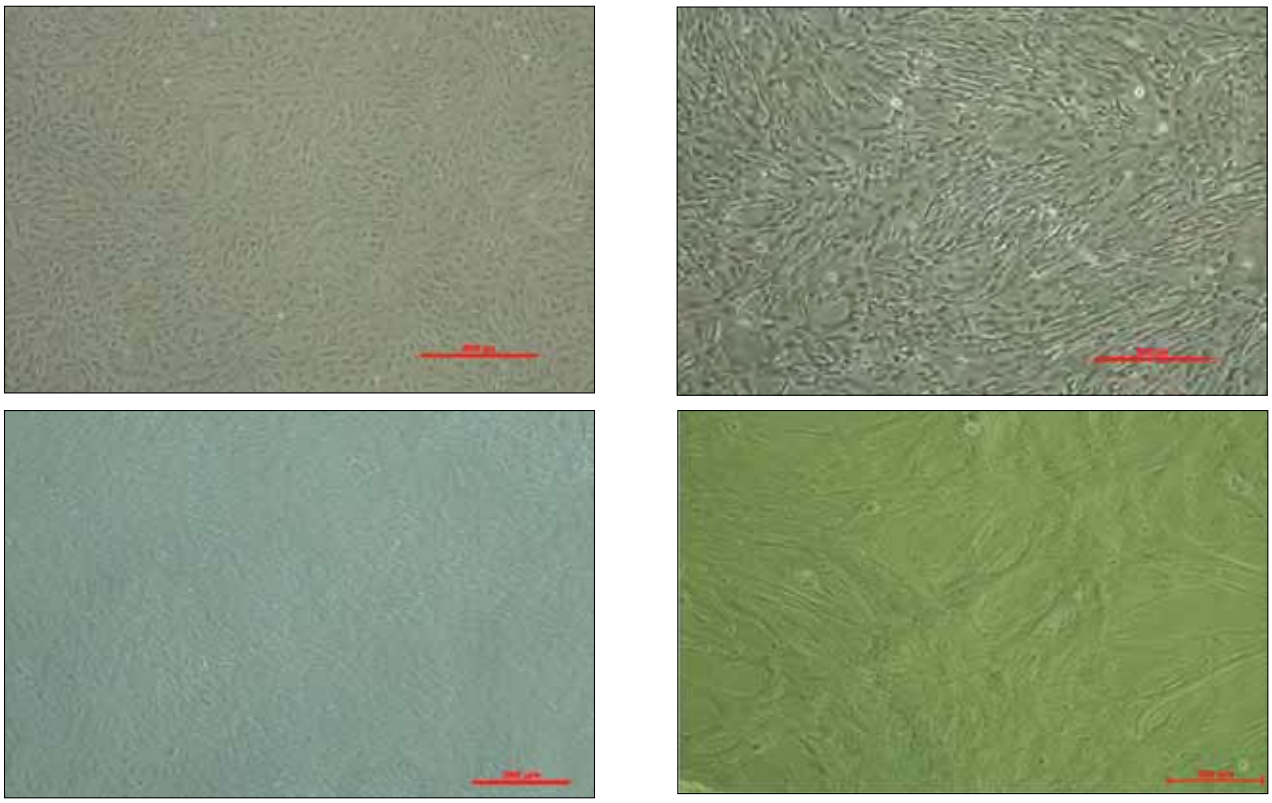


Fig. 105. Photomicrographs of cell lines developed from different tissues of Fantail Goldfish. (a) Fantail Goldfish Fin (FtGF cell line at 32 passage; (b) Fantail Goldfish Gill (FtGG) cell line at 28 passage; (a) Fantail Goldfish Liver (FtGG) cell line at 30 passage; (a) Fantail Goldfish brain (FtGB) cell line at 20 passage

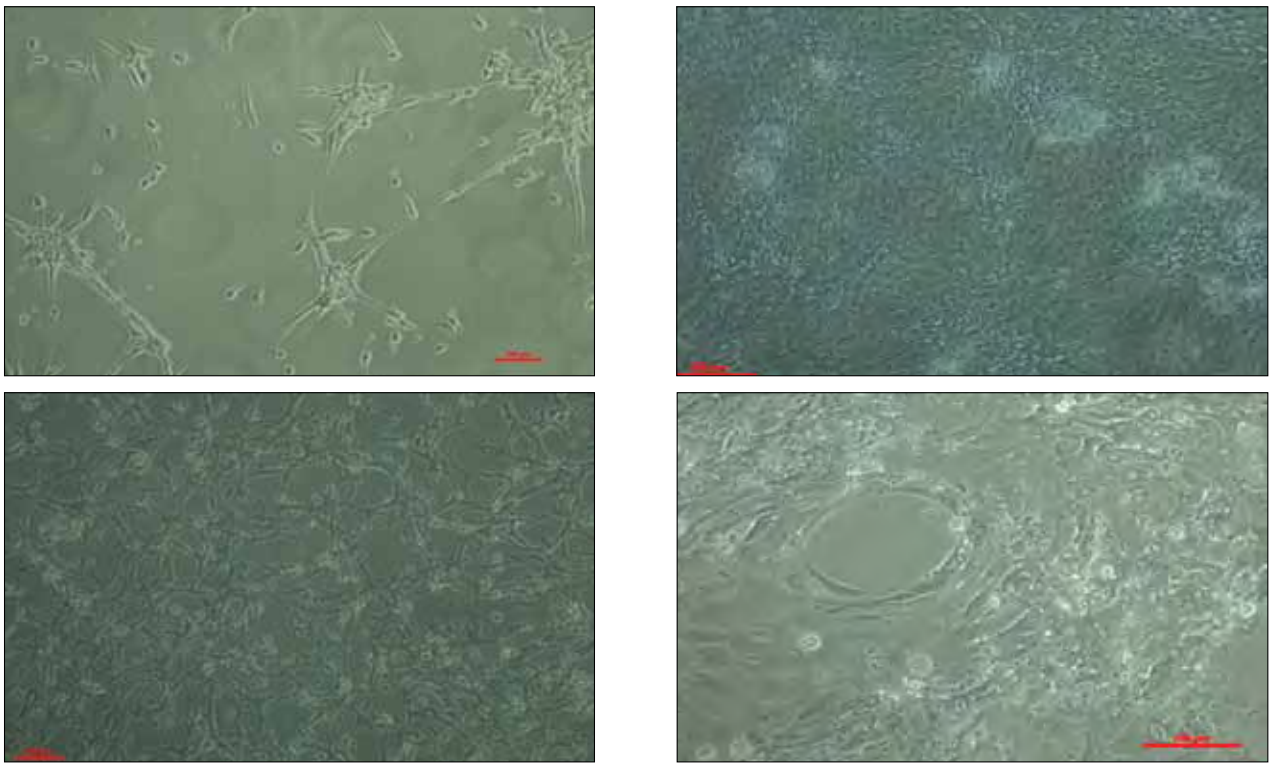


Fig. 106. Cytopathic effect (CPE) in cells following infection with CyHV-2. (a) FtGF cells infected with CyHV-2 at passage 15 at 2 dpi; (b) FtGG cells infected with CyHV-2 at passage 15 at 2 dpi; (c) FtGL cells infected with CyHV-2 at passage 15 at 4 dpi; (d) FtGB cells infected with CyHV-2 at passage 15 at 6 dpi.

Development of vaccines and diagnostic kit for the disease management of Goldfish Herpesviral Hematopoietic Necrosis Disease in India

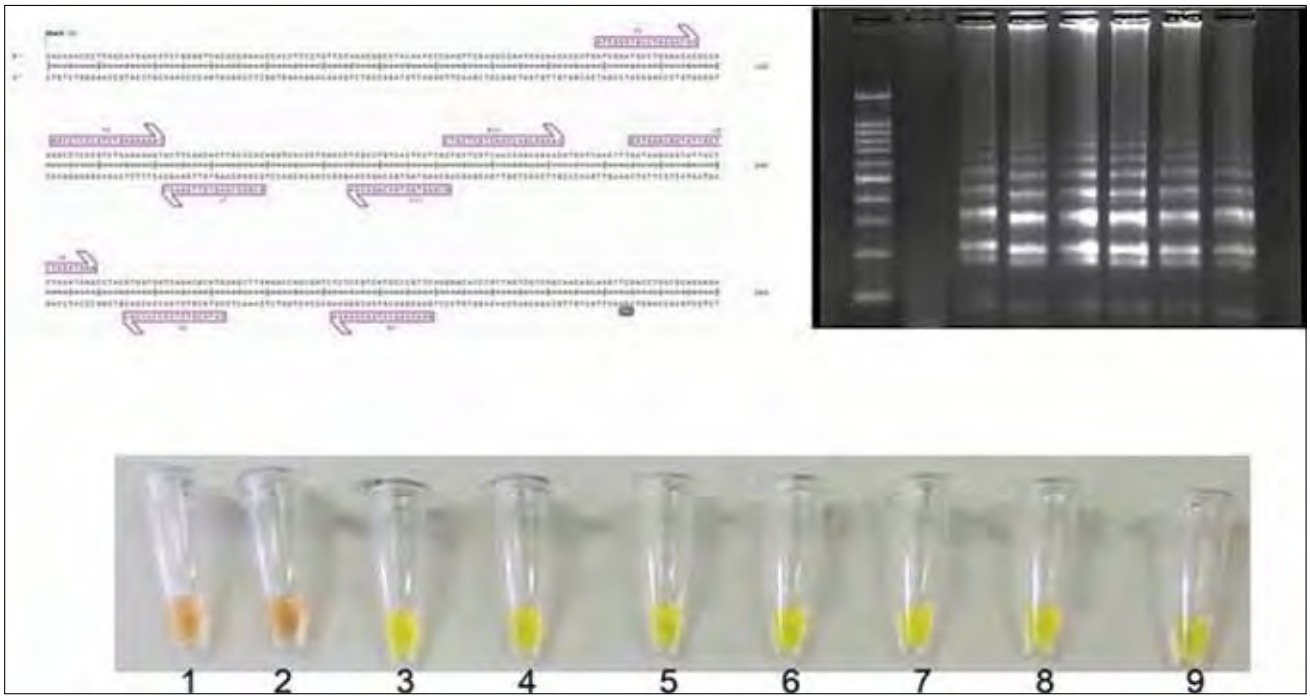


Fig. 107. Loop me diated isothermal amplification of CyHV-2. (a) Primer binding site of primer of LAMP reaction; (b) Agarose gel electrophoresis of LAMP product showing ladder like pattern; Lane 1-DNA 100 bp ladder; Lane 2- Known CyHV-2 negative; lane 3-5 ng/ul; Lane 4-2.5 ng/ul; Lane 5-1.25 ng/ul; Lane 6-0.625 ng/ul; Lane 7-0.3 ng/ul; Lane 8-0.15 ng/ul; (c) Sensitivity of newly designed LAMP primer in the detection of CyHV-2. Tube 1 and 2-Known CyHV-2 negative DNA; Tube 3-10 ng/ul; Tube 4-5 ng/ul; Tube 5-2.5 ng/ul; Tube 6-1.25 ng/ul; Tube7-0.625ng/ul; Tube 8-0.3 ng/ul and Tube 9-0.15 ng/ul

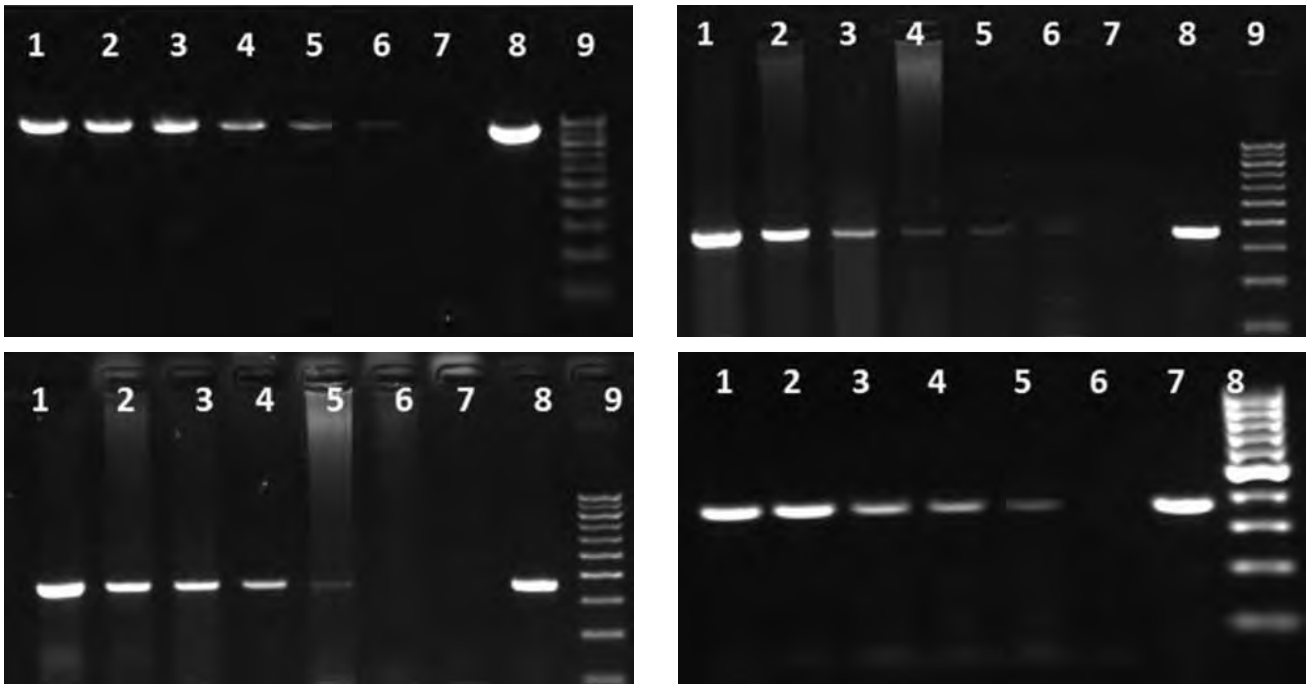


Fig. 108. Sensitivity of the different PCR primers in detecting CyHV-2. (a) Newly designed PCR primer to detect the partical fragment of major capsid protein (942 bp) of CyHV-2 DNA from infected goldfish; (b) PCR primer to detect the partial fragment of DNA polymerase gene (362 bp) of CyHV-2 DNA from infected goldfish; (c) Helicase gene PCr primer to detect the partial fragment of major capsid protein (366 bp) of CyHV-2 DNA from infeeted goldfish; (d) Helicase gene PCr primer to deteect the partial fragment of major capsid protein (357 bp) of CyHV-2 DNA from infected goldfish.

was achieved at 8 mM $MgCl_2$ concentration and at a temperature of 60°C for 1 hour. The LAMP reaction was capable of detecting 10 copy numbers of the MCP gene plasmid construct. The results of the LAMP assay were observed both by typical ladder-like pattern in gel electrophoresis (Fig. 107b) and also by naked eye for its fluorescent green colour production (Fig. 107c).

In our study, the newly designed primer set could amplify 942 bp partial sequence of the MCP gene of CyHV-2. The sequences of the MCP gene of CyHV-2 isolated from goldfish in this study were deposited in GenBank (accession numbers KU527546 and KU527547). A GenBank BLAST search on the sequence revealed 100% similarity with CyHV-2 isolate SYC1 strain (KM200722) and CyHV-2 isolate STJ1 strain (JQ815364). Newly designed PCR primer could amplify 100 copy numbers of the CyHV-2 MCP plasmid construct (Fig. 108a). Further, the PCR primers targeting 362 bp fragment of DNA polymerase gene could detect 100 copies of plasmid construct, whereas, PCR primers targeting 366 bp and 357 bp fragments of helicase gene could detect 1000 and 100 copy numbers of plasmid construct in our study (Fig. 108b, c & d). The newly designed MCP PCR and LAMP primers were found to be specific for CyHV-2, they did not amplify the nucleic acids of SVCV, CyHV-3, VNNV, *Aeromonas hydrophila, A. veronii, A. caviae, Edwardsiella tarda, Vibrio anguillarum, V. parahaemolyticus, V. harveyi* and *Proteus hauseri*.

A total of 25 goldfish, *C. auratus* weighing 20 g ± 0.52 g and rohu, *Labeo rohita* weighing 50 g ± 0.45 g each were housed in the glass aquarium in the wet laboratory, PMFGR Centre, ICAR-NBFGR. Prior to the experimental challenge study, five fish were randomly selected to undergo screening for iridovirus and CyHV-2, using a PCR analysis. To prepare for the viral challenge, fish were sedated using 3- aminobenzoic acid ethyl ester methanesulphonate (MS-222) at the dose rate of 150 mg/l of water for 15-20 min exposure. Fish in the control group were injected intraperitoneally with supernatant from normal fantail goldfish fin (FtGF) cells, while fish in the infected group were injected with supernatant from FtGF cells infected with CyHV-2 at a dose of 1 $\times 10^6$ $TCID_{50}$/fish. At the same time *L. rohita* Gill (LaRG) cell line was also infected. At 3 dpi, typical clinical signs were observed in challenged goldfish only but not from rohu. Virus was re-isolated in FtGF cells from gills, liver, kidney and spleen of experimentally infected goldfish and not from rohu. Of note, distinct CPE was observed in inoculated FtGF cells within 5 dpi, while FtGF cells inoculated with tissue homogenate from the control group and LaRG cell line did not show any CPE. Three fish each from the control group and the infected group were subjected to PCR analysis to confirm the presence of CyHV-2. All infected fish showed a positive PCR product on agarose gel. In challenged fish, mortality started at 4 dpi and lasted until 10 dpi with cumulative mortality of 86.67% for goldfish. The control fish and rohu did not show any clinical signs of infection or mortality.

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 (PI) and Anutosh Paria

Funding Support: DBT-Twinning

In the period, a total of 34 fish samples collected from fish markets and processed, bacteriophage was isolated against *Aeromonas hydrophila* bacterial strains *viz.* 4P1, 10G1, 10C and 7C. In the diffusion method, all phages had titers $>10^9$pfu/ml. Among the isolated phages, 10G1 and 7C retained its activity in terms of plaque size and clarity. Out of these two phages, 7C phage was found to have an efficient lytic activity, hence taken up for phenotypic and molecular characterization. Further, twenty five fish samples were processed for the isolation of bacteriophages against *Flavobacterium columnare* using standardized protocol. However, till now no bacteriophages against *F. columnare* could be isolated.

Characterization of *A. hydrophila* bacteriophage 7C

Phage 7C was purified by collecting a single, well separated plaque in SM buffer, then preparing its serial dilutions and finally mixing it with culture and pouring on TSA plates same as diffusion method; concentrated using PEG precipitation method and stored at 4°C for further characterization. Purified and concentrated bacteriophage 7C had a titre of 2.5×10^{13} pfu/ml. A working stock of 6×10^7 pfu/ml was made from concentrated phage stock. Bacterial count of 7C strain of *A. hydrophila* was calculated as 2×10^7cfu/ml at the mid-exponential phase culture (OD_{600} 0.2). All

the characterization experiments were conducted at a multiplicity of infection (MOI) of 1.

- **One Step growth experiment:** *A. hydrophila* 7C strain was grown to mid-exponential phase (OD_{600} 0.2- about 2×10^9cfu/ml) and infected with purified phage to give a MOI of 0.01. Phages were allowed to absorb for 10 minutes and after that pellet was suspended in SM buffer, diluted in nutrient broth and incubated at 37°C with shaking at 150 rpm. At selected time intervals, representative sample was taken, and phage titer was estimated by double layer agar method. Purified phage 7C showed a latent period of 15 min and a rise period of 165 min. Burst size of the phage was 364.8.
- **Time of Death (TOD)**: It's the time required by a bacteriophage to reduce the optical density (A_{600}) of a bacterial population, from 0.2 to 0.1. In order to calculate TOD, 7C mid-exponential phase culture was infected with purified phage to give a MOI of 0.01. Incubated at 37°C with shaking at 150 rpm and optical density (OD_{600}) was measured at different time intervals. TOD of the purified 7C phage was found to be 30 minutes.
- **Lysogenization frequency**: Exponential bacterial culture pellet of 7C was dissolved in SM buffer and infected with phage at MOI of 0.01. After incubation at 37°C, pellet was dissolved in SM buffer and centrifuged to eliminate non-adsorbed phages. The titre of infective centres was determined by diffusion method. Infected bacteria were also spread on TSA plates to detect the lysogens. Lysogenic frequency was calculated as the ratio of lysogens/infective centres. The phage 7C had a lysogenic frequency of 0.81%.
- **Influence of pH on phage viability**: Phage 7C was suspended in SM buffer, previously adjusted with 1M NaOH or 1M HCl, to yield a pH range of 3 to 11. After 60 mins of incubation at 37°C and serial dilution, each treated sample was tested against *A. hydrophila* 7C strain in a double layer agar assay to check the viability of phage. Phage viability was checked at pH 3, 5, 6, 7, 9, 10 and 11. Results showed that the isolated phage has a tolerance range between pH 6-10, but loses its viability at pH 3, 5 and 11. At pH 7, the phage showed a viability of 85.2%.
- **Effect of temperature on phage viability**: Phage were suspended in SM buffer and incubated at a temperature range of 4, 45, 55, 65 and 75°C for 1 hour. The surviving phages were serially diluted and then counted with the double layer agar method on 7C. The result showed that at 4°C bacteriophage had 100% viability, however, at higher temperature gradients i.e. 45, 55, 65 and 75°C, the phage lost its viability by 30, 75, 100 and 100%, respectively (Fig. 109).

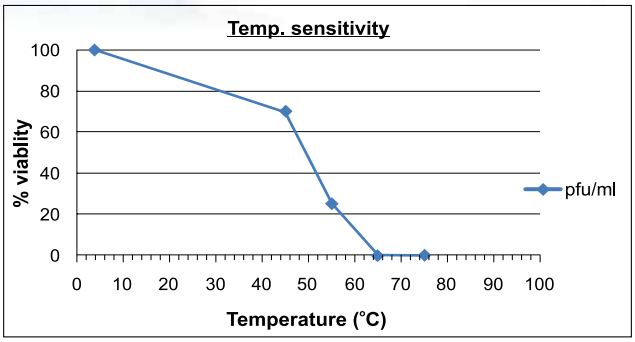


Fig. 109. Effect of temperature on viability of bacteriophage

- **Host range**: A good phage in terms of therapeutic potential is the one which is potent in its activity against a wide range of the host species and therefore, to isolate a phage that will act against various strains of *A. hydrophila*, finding the host range is imperative. All the four isolated phages were tested on lawns of five different strains of *A. hydrophila* by spotting method. However, no plaques were obtained on strain other than 7C of target bacteria indicating strain-specific host range of the isolated phage.

Project: Understanding molecular basis of host-pathogen-environment interaction of Tilapia Lake Virus Disease

Period: October, 2019 - October, 2022

Personnel: Pravata K. Pradhan (PI), Neeraj Sood, T. Raja Swaminathan and Anutosh Paria

Funding Support: NASF-ICAR, New Delhi

The recent emergence of Tilapia lake virus (TiLV) disease has resulted in significant mortalities and, therefore, posed a serious threat to tilapia farming all over the world. Considering the epidemic nature of the TiLV disease, understanding host-pathogen interaction in dynamic disease situation is crucial for identifying key factors involved in disease development process, thereby strategizing the management measures. The project initiated in this period will delineate different aspects of host-pathogen interactions in model organism.

During the period, tilapia samples, collected previously from Ernakulam, Kerala and positive for TiLV using RT- PCR, were processed for virus isolation and the virus was propagated in OnH cell line (developed in our laboratory) (Fig. 110). The cell culture supernatant containing the virus will be used further for *in-vivo* infection trials.

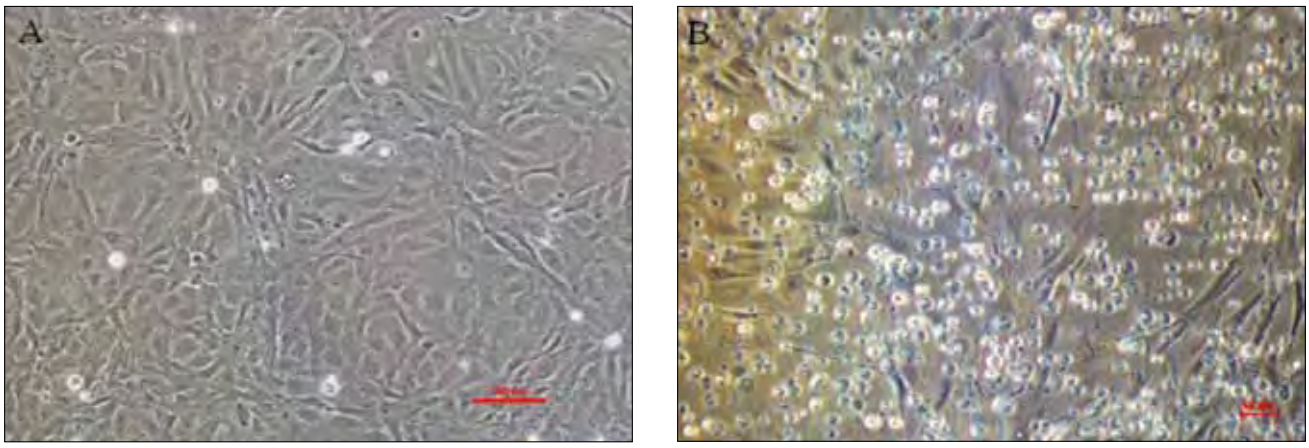


Fig. 110. Infection of OnH cell line with filtered tissue homogenate of tilapia, positive for TiLV in PCR (A) Control OnH cell line, (B) Cytopathic effects in OnH cells at 8 days post-inoculation

For establishing an experimental infection, a total of 50 tilapia were procured from a fish farm from Barabanki, Uttar Pradesh. From those fish, five fish were randomly selected and screened for TiLV. All the five fish were negative for TiLV in PCR. Thereafter, the supernatant from infected cell line as mentioned above, was used for experimental reproduction of TiLV disease. By 8 days, typical lesions including exophthalmia and abdominal distension were observed in the infected fish (Fig. 111a), and on post-mortem examination, ascetic fluid was observed in the abdominal cavity (Fig. 111b). The tissues have been stored in RNAlater for TiLV detection and also preserved in tissue culture medium for re-isolation of the virus.

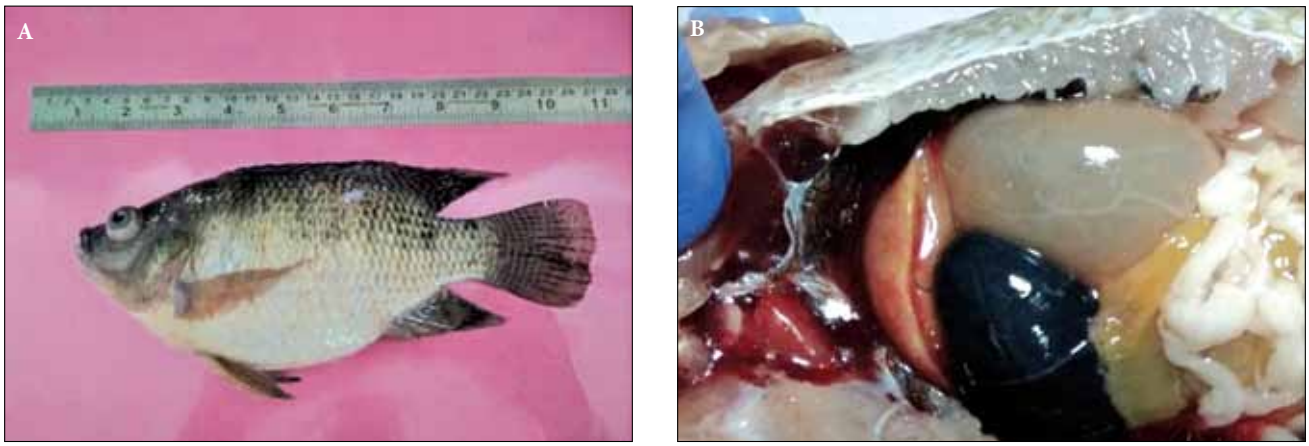


Fig. 111 a. Tilapia showing protrusion of eyes and distension of abdomen following experimental infection with TiLV; b. Accumulation of fluid in abdominal cavity of experimentally infected fish

WORKSHOPS / SYMPOSIA / MEETINGS ORGANIZED

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 through use of waste material and displayed the product made from clay, corn and scales of fishes. Dr. Kripal Datt Joshi, Principal 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: Dainik-4, Aaj, Dainik Jagaran, Nav Bharat Times, Sahara and The Pioneer.

Inauguration Productivity Day and National Productivity Week Celebration

Glimpses of National productivity week celebration

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 Brood stock and Seed of Certified Origin in Asian Aquaculture" from February 26-27, 2019. The programme was conducted with an aim of identifying 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.

Interactive session with the experts

Valedictory Program

Launch activities of the Regional Expert Consultation

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

Glimpses of the School

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 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 programme on Cell Line: Development, Maintenance and Applications

A short-term hands-on training programme on "Cell Line: Development, Maintenance and Applications" was conducted during August 20-29, 2019, at ICAR-NBFGR, Lucknow, covering various aspects of cell cultures, like cell line development, characterization, cryopreservation, maintenance, virus isolation, cytotoxicity testing etc. A total of 10 trainees from various organizations like ICAR-NIVEDI, Bengaluru; ICAR-NBFGR, Lucknow; BBAU, Lucknow and JNU, New Delhi participated in the program.

Participants of the training programme

Training programme on Karyotyping and Fish Cell Line Development

A short training programme on 'Karyotyping and Fish Cell Line Development' was conducted during October 19-22, 2019 at Department of Zoology,

Demonstration of chromosome preparation techniques

Gauhati University, Assam, with special focus on chromosome preparation from fish tissues, cell line development, characterization, and maintenance. This training program was attended by about 25 students and research scholars of Zoology Department, Gauhati University and nearby colleges.

Godavari river basin - Stakeholders meeting and awareness programme

A series of Godavari river basin - stakeholders meeting and awareness programmes were organized in some selected locations in the Godavari river basin in Karimnagar District in collaboration with Bioversity International, Professor Jayashankar Telangana State Agricultural University, Hyderabad and Telangana State Departments (agriculture/fisheries and others) during October 21-22, 2019. A meeting was organized with about 100 farmers at Dhanalaxmi Dhanya Vithana Raithu Paraspara Sahakara Parimitha Sangam Gangipalli (agricultural cooperative society), Gangipalli in collaboration with Bioversity International. All the farmers were aware about the ill effects of excessive usage of pesticides and other chemicals on crop, soil and human health. Irrational use of agro-chemical was the primary cause for the decreasing soil fertility. They were also sensitized about the indiscriminate usage of agro-chemicals, which will eventually affect the sustainability of agro-ecosystem in the landscape. Meeting with agro-chemical dealers and line department officials were also conducted at Krishi Bhavan, Karimnagar on October 21, 2019. A stakeholders meeting was conducted at Velgatoor, Cheggaon, Kukkalagudur and Rajaram village

Meeting with stakeholders on Godavari river aquatic diversity assessment

on October 22, 2019. A total of 60 stakeholders (fishermen and agriculture farmers) participated including officers from line department and scientists of ICAR-NBFGR & Bioversity International. The meeting was aimed at explorations and assessment of aquatic diversity in Godavari River.

Glimpse of the National Consultation on Genomics and Bioinformatics in Agriculture

National Consultation on Genomics and Bioinformatics in Agriculture: The way forward

The Indian Council of Agricultural Research, New Delhi and ICAR-National Bureau of Fish Genetic Resources (NBFGR), Lucknow jointly organized a one-day "National Consultation on Genomics and Bioinformatics in Agriculture: The Way Forward" at the National Agricultural Science Centre Complex, New Delhi on November 27, 2019. Dr. Trilochan Mohapatra, Secretary (DARE) & Director General (ICAR) highlighted the need to keep a track on the global developments and trends in the agriculture and aquaculture sciences. Dr. Mohapatra stressed to focus on the key genes having the potential for revolutionizing the gene improvement in the respective species. The Director General urged for preparing an effective road map for translating the outputs to the meaningful products.

Dr. Joykrushna Jena, Deputy Director General (Animal & Fisheries Science), ICAR, in his welcome address, underlined the major achievements made under ICAR-CRP Genomics Programme. Highlighting

the main purpose of the National Consultation, Dr. Jena accentuated that it aims to bring together the researchers across the different commodities (commercial crops, plants, fisheries, animals and microbes/pathogens) and identify the priority areas of research keeping in view the national importance. Dr. Jena also stated that the consultation will enable in making the road map for the effective implementation of this Consortium Research Platform on Genomics to get the meaningful and applicable outputs for the benefit of the country. Dr. A.K. Singh, Deputy Director General (Horticultural & Crop Sciences), ICAR; Dr. A.K. Singh, Deputy Director General (Agricultural Extension) ICAR; Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, Lucknow; Dr. Vindhya Mohindra, Head (Fisheries Conservation Division), ICAR-NBFGR) and Dr. Anil Rai, Head (Bioinformatics), ICAR-Indian Agricultural Statistics Research Institute, New Delhi were also present during the occasion.

National Conference on One Health & Ecosystem Services

ICAR-NBFGR, Lucknow, Uttar Pradesh and the Academy of Environmental Biology (AEB) organized a two-days Conference "One Health & Ecosystem Services (OHES-2019)" from November 29-30, 2019

Overview of the inaugural and valedictory sessions

at NBFGR, Lucknow in collaboration with Aquatic Biodiversity Conservation Society (ABCS). The conference was inaugurated by Prof. M.L.B. Bhatt, Vice-Chancellor, King George Medical University, Lucknow. The inaugural function was graced by a galaxy of senior experts including Dr. Habibar Rehman, Regional Representative, South-East Asia, International Livestock Research Institute, New Delhi; Dr. J.K. Jena, Deputy Director General (Fisheries and Animal Sciences), ICAR, New Delhi, Dr. Jaswant Singh, President, AEB, Lucknow, Dr. Krishna Gopal, Secretary, AEB and very senior experts of fishery, environment and academics.

Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, welcomed the dignitaries and emphasized the theme of the conference, need of discussion and actions on One Health, in his opening remarks. Over 250 delegates from various parts of the country, including planners, senior experts, university professors, scientists, researchers, students, representatives from government and non-governmental organization participated in the conference. The technical sessions of the conference were divided into 9 different thematic areas. The theme of the Conference-One Health was discussed in a number of invited lectures, lead lectures, poster presentations, expert discussions and addresses of the guests. The conference concluded on November 30, 2019 with the valedictory function chaired by Dr. B. Meenakumari, Former Chairperson, National Biodiversity Authority (NBA), Chennai. Participating experts and panelists identified following areas to fill knowledge gaps, future research, policy framework and governance:

1. Multiple anthropogenic activities are responsible for ecological imbalances in many ecosystems, which are further aggravated by the menace

of climate change, therefore there is a need to develop strong database to quantify each and every impacting factor affecting ecosystems.

2. Quantitative assessment of different ecosystem services is required for developing management practices to minimise environmental degradation and biodiversity loss.
3. Policy framework to support adoption of management practices are necessary for mainstreaming and maintaining ecosystem services.
4. Water availability is a major constraint in most of the regions, therefore water harvesting, re-use and re-cycling must be an integral part of any water related activities.
5. Environmental flow is highly desired to maintain downstream ecology, biodiversity and stakeholders' rights. Therefore, the methodologies employed for estimation of e-flows, must meet all environmental and socio-agricultural requirements of the stake holders.
6. Flow to rivers should be sustained and should also account into consideration, the need of sustaining the wetlands and the biodiversity therein.
7. The stock enhancement measures used for rivers, reservoirs and wetlands must be based on consideration of using native populations to avoid risk of losing natural genetic diversity, local evolutionary significance adaptability of the species.
8. Side pools, deep pools and connected wetlands are integral part of river ecosystems, which play vital role in maintenance of aquatic biota, therefore all steps must be taken to save the river habitats.
9. All possible measures need be initiated to control pollution and pollutants from land, air and aquatic ecosystems.
10. Impacts of climate changes on agriculture, horticulture, animals, fisheries and aquaculture need be mitigated through better, improved and climate resilient farming/culture practices.
11. Neurotransmitters are highly important for migratory fishes like hilsa, therefore there is need to study the composition and role of neurotransmitters in migratory fishes.
12. Certain climate resilient and hardy invasive alien species are threatening native species in different eco-climatic zones, therefore appropriate policy framework and management practices need be developed to control or eradicate invasive alien species.

Miscellaneous training programmes

- Dr. Neeraj Sood and Dr. T. Raja Swaminathan acted as mentors for imparting training to Ms. Monica Paolo Criollo Joaquin from Tumbes, Peru at ICAR-NBFGR, Lucknow for her Internship on 'Tilapia lake virus and Cell Line Development'.
- Dr. Neeraj Sood was involved in providing training to Mr. Arun Kumar Mishra, Quarantine Officer, AQCS (WR) on collection, preservation and transportation of finfish and shrimp samples during June, 2019.
- PMFGR, Kochi organized two-day hands-on training on the Production of value-added products using exotic catfish during January 14-15, 2019, in collaboration with ICAR-Central Institute of Fisheries Technology (ICAR-CIFT), Kochi, to tribal fishermen and women residing near Periyar lake, Kumali.
- Dr. Poonam J. Singh, Scientist mentored 3 women researchers for creating entrepreneurial journey through projects provided under Knowledge Involvement in Research Advancement through Nurturing (KIRAN) division of DST under Women Scientist Scheme at CSIR-CIMAP, Lucknow during December 5-7, 2019 at CSIR-CIMAP, Lucknow.
- Dr. Murali S., Scientist mentored 1 student from CUSAT, Kochi for 2 months dissertation programme during May to June, 2019.
- Dr. Murali S. and Dr. Anutosh Paria, Scientists mentored 6 students from Amity University, Lucknow for 1 month dissertation programme during June 1-30, 2019.
- Dr. Rejani Chandran, Scientist mentored 8 students from ICAR-CIFE, Mumbai for 7 days orientation programme during September, 2019.
- Dr. Anutosh Paria, Scientist mentored 1 student from Chandra Shekhar Azad University of Agriculture and Technology, Kanpur for 2 months training programme during July 1-September 1, 2 2019.

IMPORTANT DAYS AND 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 previous year. 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

International Women's Day celebration

ICAR-NBFGR, Lucknow celebrated International Women's Day 2019 on March 8, 2019. Dr. Vindhya Mohindra, Chairman, Women 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 organized on the occasion, which received great support from the staff, where 10 participants placed forth their view 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 of 2 members each participated.

Women of ICAR-NBFGR rejoicing on the occasion

World Intellectual Property Day

ICAR-NBFGR celebrated World Intellectual Property Day on April 26, 2019 to create awareness towards IP for fostering innovation and creativity among researchers. The theme of the celebration was IP, Creativity, Innovation and sports. Various events were organized including presentation on IPR for inculcating creativity, a studio session on creative brainstorming for fostering creativity, a scripted play for understanding plagiarism and copyright. An exhibition cum display on IP awareness for kids and visitors was conducted. Further conducted an outreach activity on creativity for rural women Self Help Group for co-creating bespoke sustainable unique products for office use and urban market, wherein around 70 researchers and students also participated.

Glimpses of celebration of World Intellectual Property Day at ICAR-NBFGR on April 26, 2019

Independence Day Celebration

The Institute celebrated the Independence Day on August 15, 2019 with full enthusiasm. Dr. Kuldeep K. Lal, Director hoisted the National flag in the presence of staff and their family 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 Celebration

Weekly Celebrations of 150th Birth Anniversary of "Father of Nation" Mahatma Gandhi

Commemoration of weekly celebration on 150th birth anniversary of Father of Nation, Mahatma Gandhi started with vibrant inauguration on September 26, 2019 under the chairmanship of Dr. Kuldeep K. Lal, Director, ICAR-NBFGR. Theme of the week long activities was "Mahatma Gandhi's Life". Dr. Lal stressed upon restricted use of single use plastics in day to day activities. He also informed that the waste management system established in the institute campus will be operational for lab waste disposal very soon. His deliberations on Mahatma Gandhi's life were highly relevant which covered aspects on judicious use of natural resources for sustainable development and longevity of human life in this planet. For tribal-women

from Malda, West Bengal, visiting ICAR-NBFGR, the message of Mahatma Gandhi to live in complete harmony with nature for healthy, balanced life and natural resource management was disseminated by the organizers. It was also narrated in the programme that how Mahatma Gandhi was educated from London but worked for the welfare of the depressed section of the society. Women participants also shared their views on clean, green campus and utilization of green energy by using solar panel. They also appreciated the aquarium, farm and museum facilities created by the institute. Various programmes were undertaken by all the divisions of the institute where a series of lectures on Mahatma Gandhi's life and ideologies were delivered.

A short video on "Mahatma Gandhi's Contribution to Humanity" was played for the benefit of staff members. Many expressed their views on Bapuji's role in structuring the society and his contribution to

Aerial view of rangoli event

women empowerment. Staff members highlighted the role of Gandhiji against dowry system, child marriage, women education and empowerment. Dr. Vindhya Mohindra, Chairperson, Women Cell spoke on the necessity and importance of Women's empowerment and Gandhiji's significant contribution to same. A Rangoli Competition on the topic "Bapuji" was also organized by Women's Cell of ICAR-NBFGR on October 1, 2019 in which six teams participated.

Vigilance Awareness Week

Vigilance Awareness Week-2019 was observed from October 28 to November 2, 2019. All the employees, students and research scholars took Integrity Pledge for Citizens & organizations in bilingual mode at ICAR-NBFGR Headquarters and its centres. Other than the staff, about 130 citizens also took vigilance awareness pledge. During the week, the institute also organized vigilance programme in the village Deoria, Chinhat, Lucknow where students and teachers of Junior and Basic Primary School, Deoria, Chinhat, Lucknow participated and took pledge. Mass media coverage was undertaken by All India Radio, Lucknow through its Hulchal and AIR FM Rainbow 110.7 programmes.

Vigilance Awareness Week celebration

Year-long-Program to commemorate the 70th Anniversary of Adoption of Constitution of India & awareness program on citizen's duty

A year-long celebration to commemorate the 70th Anniversary of Adoption of Constitution of India & awareness program on citizen's duty was conducted under various themes as given below:

S. No.	Themes/topics of activity	Date
1	Celebration of Constitution Day	26.11.2019
2	Meeting / Seminars / Gosthis on Fundamental Duties (Article 51-A of The Indian Constitution)	19.12.2019

World constitution day

On the eve of Constitution day, November 26, 2019, ICAR-NBFGR, Lucknow celebrated this great day with reading the preamble by Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, Lucknow. This was followed by lectures on awareness campaign on Fundamental Duty by Dr. Ravindra Kumar with pinpointing constitutional provisions under constitution whereas, Dr. Vindhya Mohindra expressed the requirement of fine coordination of fundamental rights and duties in public behavior for upgrading National patriotism. Dr. Gaurav Rathore expressed eco-friendly approach in conservation of natural resources and shared their views on community level approach for water conservation. PMFGR, Kochi, ICAR-NBFGR observed the Constitution day through reading preambles with all the staff. In a special lecture "Constitution Day Celebration in Statistical perspective" delivered by Dr. Achal Singh, highlighting the fact that role of number system (statistics) is important in deciding the future of government in constitutional environment. Finally, the importance of duty at Institute level highlighted by Director, ICAR-NBFGR and celebration ended

with vote of thanks by Sh. Amit Singh, Bisht, PRO & Co-Nodal, HRD Cell, ICAR-NBFGR.

Agriculture Education Day Celebration

Agriculture Education Day was celebrated on December 3, 2019 at ICAR-NBFGR, Lucknow. A total of 48 students from 8 schools of Lucknow participated: Four schools of CMS (Kanpur Road campus, Rajajipuram Campus-I, RDSO campus, Station road campus), Kendriya Vidyalaya AMC, Pioneer Montessori School, Eldeco-I, LPS, Vrindavan Yojana, DPS, Indiranagar. Students participated in three categories: (a) Drawing & Painting - Junior on theme, "Plastics and Environmental Health", (b) Drawing & painting - Senior on theme, "Empowered Women for Empowered Society" and (c) Essay Competition on theme, "Water is life line of Civilization".

A visit to Ganga Aquarium was also organised for participating school children. The students interacted with the Scientists and were addressed by Dr. B. Meenakumari, Former Chairperson, National Biodiversity Authority. She highlighted that food for all and diversified agriculture is the need of hour. Dr. S.D. Singh, Former ADG (Inland Fisheries), ICAR also interacted with the students regarding selection of agriculture as a profession. Dr. Kuldeep K. Lal, Director, ICAR-NBFGR spoke on Plastics & Environmental Health, Empowered women for Empowered Society and Water is life line of Civilization. Programme was coordinated by Dr. Achal Singh, Principal Scientist & HRD Nodal Officer, ICAR-NBFGR.

Glimpses of Agriculture Education Day celebration

Foundation Day of ICAR-NBFGR and Farm Innovation Day

ICAR-NBFGR celebrated Farm Innovators & Foundation Day during December 11-12, 2019. Ms. I. Rani Kumudini, IAS, Chief Executive ICAR-NBFGR (CE) of Hyderabad based National Fisheries Development Board (NFDB) was the chief guest during the celebration. Ms. Kumudini congratulated the awardees and said that the foundation day is important for remembering the long history of the organization, its infrastructure and contribution of staff. CE further added that the foundation day marks the achievement of the institute as well as the challenges to face in the coming days; and to retrospect ourselves where we are and where we have to go. She enumerated the role and responsibilities of the NFDB towards fish production and productivity. She appreciated the achievements of collaborative programs of ICAR-NBFGR with NFDB such as National Aquatic Animal Disease Surveillance Programme, Carp Sperm Cryobanking for Broodstock Improvement etc. Director of the institute, Dr. Kuldeep K. Lal said that this celebration-honouring initiative for school students, innovative farmers and staff will address some Sustainable Development Goals of FAO committed to transform world through capacity development programmes. On this occasion, institute also honoured staff for the performance in research, administration & management and upgradation of institute research works at national as well as international levels. It is expected that the celebration would encourage and prepare students, farmers and staff to act as awareness campaigner in the society. The winning students from different schools, who participated in drawing/painting and essay writing competitions during Agriculture Education Day on December 03, 2019 at the institute, were also awarded with prize and certificate during the program.

Foundation Day Celebration

List of Awardees

Certificate of Honour to Farmers

S. No.	Name and details	
1	Name Hatchery/farm Village District	Parvez Khan Dewa Fisheries Misripur Barabanki, Uttar Pradesh
2	Name Hatchery/farm Village District	Dharmendra Jahangirapur Kataundhi Sonebhadra,
3.	Name Hatchery/farm Village District	Rittwik Amir Raja hatchery Radhar Ghat, Behrampore Murshidabad, West Bengal
4.	Name Hatchery/farm Village District	Bablu Kumar Ghosh Aisharya Aquaculture Pvt. Ltd. Rajendrapur North 24 Pargana, West Bengal
5.	Name Hatchery/farm Village District, State	Dr. Sanjay Kumar Srivastava Medha Matsya Prajanan Kendra Barohia Maharajganj, Uttar Pradesh
6.	Name Hatchery/farm Village District	Yetendra Kumar Kashyap Kash Fisheries Bariyaria East Champaran, Bihar

S. No.	Name and details	
7.	Name Hatchery/farm Village District	Laxmi Narayan Panda Prafulla Integrated Fish & Seed Farming Bhairipali, Kalahandi, Odisha
8.	Name Hatchery/farm Village District	Akshaya Kumar Sahu Kailash Hatchery Astpura Mayurbhanj, Odisha
9.	Name Hatchery/farm Village District	Deb Sharan Ghosh Ghosh Rasbheluria Murshidabad, West Bengal
10.	Name Hatchery/farm Village District	Atanu Nandi Jamuna Fisheries Mouchura Bankura, West Bengal

S. No.	Name and details	
11.	Name Hatchery/farm Village District	Satyendra Kumar Madhvar Banasur Matsya Bhojpur Aara, Bihar
12.	Name Hatchery/farm Village District	Saroj Kumar Mishra S.S. Matsya Banda Dasaud Samstipur, Bihar
13.	Name Hatchery/farm Village District	Sayyad Zahid Ali Ali fish seed Loisingha Balangir, Odisha
14.	Name Hatchery/farm Village District	Dina Krushna Sahu Krishna Hatchery Bad Bisol Mayurbhanj, Odisha


Prizes given to School Children

Drawing and Painting Competition (Senior Group)	
1st Prize	Ms. Mansi Tripathi, Class - XI, C D.P.S. Indiranagar, Lucknow
2nd Prize	Ms. Preeti Nishad, Class - VII Pioneer Montessori Inter College, Eldeco-I, Lucknow
3rd Prize	Master Harshit Arora, Class - XI, C Kendriya Vidyalaya AMC, Lucknow
Drawing and Painting Competition (Junior Group)	
1st Prize	Ms. Sania Parveen, Class - VI, C Kendriya Vidyala AMC, Lucknow
2nd Prize	Ms. Srishti Rawat, Class - VI Excellia School, Lucknow
3rd Prize	Ms. Santushti Gautam, Class - VI, A Kendriya Vidyala AMC Cantt., Lucknow

Essay Writing Competition	
1st Prize	Master Aditya Shukla, Class - VIII Lucknow Public School, Vrindavan Yojna, Sector 4B, Lucknow
2nd Prize	Miss Ayushi Tiwari, Class - XI A.P.S. Academy, Lucknow
3rd Prize	Miss Shivani Verma, Class - XI Siddhant World School, Lucknow
Award for Best School going Children of employees	
Class XII	Master Saksham Sood, S/o Dr. Neeraj Sood
Class XII	Miss Moni Gautam, D/o Mr. Sanjeevan Lal









List of Office Awardees

S. No.	Category	Name of Awardees
1	Best Scientist of the Institute Certificate and Cash Award of Rs. 2500/-	Dr. Murali S., Scientist
2	Best Technical Staff of the Institute : Two Awards	Dr. Vikash Sahu, STA Mr. Sanjay Kumar Singh, STO Mr. Prem Chandra, STO Mr. Amit Singh Bisht, STO
3	Best Administrative Staff of the Institute : Two Awards Certificate and Cash Award of Rs. 2500/-	Mrs. Mamta Chakraborty, PS Mr. Santosh Kumar Singh, Sr. Clerk
4	Best Skilled Support Staff of the Institute Certificate and Cash Award of Rs. 2500/-	Mr. Dinesh Kumar, SSS Mr. Sanjay Kumar, SSS
5	Best Performer Award Certificate and Cash Award of Rs. 2500/-	Dr. S.M. Srivastava, CTO



Team Excellence Award

S. No.	Category	Name of Awardees
1	Draft genome assembly of *Tenualosa ilisha*, Hilsa shad, provides resource for osmoregulation studies	Dr. Vindhya Mohindra Dr. Rajeev K. Singh Ms. Tanushree Dangi Dr. Ratnesh K. Tripathi Mr. Rajesh Kumar
2	Germplasm Resource Center for Ornamental Invertebrates at Lakshadweep Islands	T.T. Ajith Kumar Dr. Charan Ravi Mr. A. Dhinakaran Ms. S. Bharathi Ms. Sheena Jose Mr. Manu Madhavan Mr. S. Akash Mr. M.C. Hassan
3	National Surveillance Programme for Aquatic Animal Diseases	Dr. Neeraj Sood Dr. P.K. Pradhan Dr. Gaurav Rathore Dr. Aditya Kumar Mr. Chandra Bhushan Kumar Dr. T. Raja Swaminathan Dr. V.S. Basheer Mr. Mahendra Kumar

S. No.	Category	Name of Awardees
		Mr. Ravindra Dr. M.K. Yadav Dr. D.K. Verma Mr. Uday Kumar Mr. Atul Krishna Dev Mr. Raj Kumar Ms. Aarthi Dharmaratnam Mr. Alok Chaurasia
4	AqGRISI-an online aquatic genetic resource information system for Indian fishes	Dr. Ajey Kumar Pathak Dr. Rajesh Dayal Dr. Poonam Jayant Singh Dr. Rejani Chandran Mrs. Reeta Chaturvedi Mr. Ravi Kumar Mr. Iliyas Rashid Mr. Rameshwar Pati



Kisan Diwas

Aquaculture Research and Training Unit, ICAR-NBFGR, Chinhat, Lucknow, Uttar Pradesh organized Kisan Diwas on December 23, 2019. More than 50 farmers, aquaculturists, civil society members, students, housewives and children attended the programme. Discussions on various aspects of swachhta initiatives undertaken by farmers/civil society officials were also held.

KIsan Diwas Activities

Important Meetings

Institute Management Committee Meeting

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

Institute IMC meeting in progress

Inauguration of AqGRISI

To promote the utility and services of Aquatic Genetic Resources Information System of India (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.

Launch of AqGRISI beta version

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, University, 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 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 (2018-19) was held in the S.A.H. Abidi Committee room of ICAR-NBFGR during April 29 to May 3, 2019. The Member Secretary, IRC, Dr. Rajeev K. Singh welcomed the Dr. Kuldeep K. Lal, scientists and technical staff from headquarters, Peninsular & Marine Fish Genetic Resources Centre (PMFGR), Aquaculture Research & Training Unit (ARTU), AO and AF&AO.

Annual IRC meeting in progress

The Mid-term Institute Research Committee (lRC) meeting (2019-20) was held on September 7, 2019. The meeting was called upon with specific agenda, discussions, needs and short-falls. The Chairman in his introductory address, urged the scientists to join their expertise in order to achieve bigger goals.

Annual Review Meeting of ICAR Consortium Research Platform on Genomics

The annual review workshop for ICAR Consortium Research Platform (CRP) on Genomics was held at ICAR-NBFGR, Lucknow on September 21, 2019 under the Chairmanship of Dr. J.K. Jena, Deputy Director General (Fisheries Science & Animal Science) and the Coordinator, CRP-Genomics. Dr. Kuldeep K. Lal, Director, ICAR-NBFGR welcomed Dr. J.K. Jena, and all PIs and Co-PIs of the programme. Addressing the meeting, Dr. Jena urged the scientists for meaningful and applicable research outputs from huge amount of data generated by respective institutes, under CRP-Genomics platform. He mentioned that the expectations from the CRP-Genomics programme have increased manifolds. He expressed satisfaction for developing in-house expertise for genome sequencing and bioinformatics analysis. He further told that the very objective of establishing the one platform for genomics of plants, animals, fish, insects, microbes and pathogens has been successful. He appreciated the impressive number of 34 publications, that have come out CRP-Genomics. Following the remarks, presentations were made by the PI/Co-PI from respective institutes. The presentations also included the work programme/proposals for next five years.

Participants of Annual Review Meeting of CRP-Genomics

9th Technical Advisory Committee Meeting for monitoring progress of NSPAAD

The 9th meeting of Technical Advisory Committee (TAC) constituted for monitoring and supervision of the National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) was held on December 19, 2019 at ICAR-NBFGR, Lucknow under the Chairmanship of Dr. J. Balaji, Joint Secretary, (Department of Fisheries). The meeting was attended by Dr. J.K. Jena, Coordinator, NSPAAD and Deputy Director General (Fisheries Sciences); Dr. Kuldeep K. Lal, Co-coordinator, NSPAAD and Director, ICAR-NBFGR; Dr. Parimal Roy, Director, ICAR-NIVEDI; Prof. (Mrs.) Indrani Karunasagar, Director (R&D), Nitte University; Dr. Manas Kumar Sinha, Senior Executive (Tech), NFDB; Dr. Gaurav Rathore, Principal Scientist and Head, FHME; Dr. Neeraj Sood,

TAC meeting in progress

Consortium Principal Investigator; Dr. P.K. Pradhan, Principal Scientist and Mr. Chandra Bhushan Kumar, Scientist.

At the outset, Dr. Lal explained briefly about the success, lessons learnt and capacity building achieved by 1st phase of NSPAAD and proposed plan for the second phase. Dr. Jena briefed about the genesis and salient achievements, and emphasized on the need of institutionalization of the programme. Prof. Karunasagar stressed on the importance of the programme in the context of international confidence on country's aquatic animal health status. The Chairman in his opening remarks emphasized that the purpose of his visit is to do comprehensive review of the ongoing NSPAAD and planning for the second phase. Dr. Sood made a detailed presentation about the progress and significant achievements and, plan of action for the implementation of the second phase. After the presentation and thorough discussion, the following action points emerged; constitution of a committee by Department of Fisheries for evaluation of first phase of NSPAAD; organization of a National level consultative workshop involving all States Fisheries Departments, NSPAAD partners and National and International aquatic animal health experts for finalizing the 2nd phase; and more frequent review of NSPAAD progress. The Chairman expressed satisfaction with the progress made under NSPAAD.

EXTENSION ACTIVITIES

Training Programmes on Clownfish Aquaculture

The ICAR-NBFGR has 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 kind in the country.

A 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. 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. The beneficiaries were trained on 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.

Hands on training about testing of water quality parameters

Another training programme on Clownfish Aquaculture was organized at the ICAR-NBFGR hatchery facility at Airoli, Mumbai during November 14-16, 2019 for 30 beneficiaries of Raigad district of Maharashtra.

Trainees with resource persons of the training on Clownfish aquaculture

Practical session during training on Clownfish aquaculture

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

A total of 11 training programmes on fish milt cryopreservation for genetic up-gradation of broodstock were organized between March to December, 2019. A series of lectures and practical demonstration were arranged during the programme. Total 372 hatchery operators from various states like West Bengal, Uttar Pradesh, Odisha, Bihar, Jharkhand, Chattisgarh, Assam, Tripura, Madhya Pradesh etc. were trained on fish milt cryopreservation to produce genetically diversified progeny.

Inauguration of training

Demonstration on milt collection

Demonstration on cryopreservation

Group photograph of the training program

Biodiversity awareness program

A two-days awareness program on Marine Biodiversity in the Coastal Region of Gulf of Mannar with special focus on fish genetic resources was organized by PMFGR Centre, Kochi of ICAR-NBFGR in collaboration with Central Marine Living Resources and Ecology (CMLRE), and Madurai Kamaraj University, Ramanathapuram, during June 17-18, 2019.

NFDB sponsored Training of Trainers Programme for State Officials

Two residential training programmes of 5 days duration under NFDB sponsorship for the all India state officials, entrepreneurs and progressive fish farmers were conducted on ToT for Re-Circulatory Aquaculture System (RAS). A total of 50 participants attended the training as detailed below:

S. No	Area of training	Duration of training	No. of Trainees
1	ToT on Re-Circulatory Aquaculture System (RAS)	January 21-25, 2019	25
2	ToT on Re-Circulatory Aquaculture System (RAS)	September 17-21, 2019	25

ToT activities at ARTU, Chinhat, Lucknow

NFDB sponsored Skill Development Programme for Farmers

Four residential training programme of 3 days duration for 153 farmers from different parts of India under NFDB sponsorship were conducted on Skill Development Programme (SDP) on Re-Circulatory Aquaculture System (RAS) with following details:

S. No	Skill area of training	Duration of training	No. of Trainees
1	SDP on Re-Circulatory Aquaculture System (RAS)	January 15-17, 2019	48
2	SDP on Re-Circulatory Aquaculture System (RAS)	August 27-29, 2019	35
3	SDP on Re-Circulatory Aquaculture System (RAS)	September 4-6, 2019	35
4	SDP on Re-Circulatory Aquaculture System (RAS)	December 26-28, 2019	35

SDP 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 October 15-19, 2019 for the U.P. state beneficiaries of SAME (ATMA) Rehmankheda, Lucknow. A total of 30 beneficiaries attended the training program.

U.P. State beneficiary training activities

Skill Development Training under Rashtriya Krishi Vikas Yojana (RKVY)

Two skill development programmes for freshwater aquaculture farmer under RKVY in collaboration with ICAR-ATARI, Kanpur and Agricultural Skill Council of India (ASCI) were conducted, where a total of 40 farmers were benefited. Among the farmers, 36 got certificate from Ministry of Agriculture & Farmer Welfare (Government of India).

Activities under RKVY sponsored training programme

S. No.	Skill area of training	Duration of training	No. of Trainees
1	RKVY sponsored skill development training on freshwater aquaculture	February 25 - March 23, 2019	20
2	RKVY sponsored skill development training on freshwater aquaculture	March 1-27, 2019	20

Mera Gaon Mera Gaurav Programme

A number of activities were suggested for taking up fish farming to the farmers of different villages with special reference to schedule caste (SC) community. Details are tabulated below:

S. No.	Name	Address	Land Area	Scope Aquaculture led System
1.	Smt. Rooprani	Village Saranva, Post-Kumranva, Lucknow	0.5 ha	Integrated Farming System (IFS)
2.	Shri Ram Baksh	Bahuta, Barabanki, Uttar Pradesh-227301	0.246 ha 0.430 ha 0.212 ha	Seed Production through establishment of FRP Hatchery
3	Smt. Rajwati Verma	Shahpur, Majhganwa village, Lucknow	0.9 ha Water depth-1.5-2.0 meter	Intensive Aquaculture with Indian Major Carp (IMC) and stocking of grass and common carp. Renovation, repairing & height raising of dykes during summer month for avoiding agricultural water runoff in the pond.
4	Shri Brij Kishore	Shahpur, Majhganwa village, Lucknow	0.26 ha & 0.8 ha (Nursery pond)	Pangas cultivation Renovation, repairing and height raising of dykes during summer month.

Activities under Mera Gaon Mera Gaurav Programme

Activities under Tribal Sub-Plan (TSP)

Under the Tribal Sub Plan scheme of the Government of India, the Institute has undertaken a variety of extension programmes and activities for the socio-economic development of tribal people in various areas of the country. These activities are aimed at facilitating tribal development through fisheries-based enterprises by providing scientific inputs and are co-ordinated by a team of scientists and technical officers. During the year under report, one training

Glimpse of training

programme on Fish Culture and Breeding were organized for tribal farmers of Baksa district, Assam in collaboration with Aquaculture & Biodiversity Center, Dept. of Zoology, Gauhati University, Guwahati in which total 30 tribal farmers were trained.

Technological and Infrastructure Support for Tribal farmers of Assam

Two programmes on Technological and Infrastructure Support for selected tribal farmers for taking up/strengthening fisheries based enterprises towards enhancing their livelihoods were continued and strengthened in Assam in collaboration with Dept. of Zoology, Gauhati University, Guwahati and Haflong Govt. College, Haflong, Assam. Ten tribal beneficiaries were selected in Dimali, Salbari and Batakuchi villages, Kamrup (Rural) district; five new tribal beneficiaries were selected in Majdia, Kahibari and Kallipar villages of Baksa district and four tribal beneficiaries were selected in Naben and Longmailai villages of Halflong district. They were provided technological guidance and infrastructure support in the form of pond renovation, supply of inputs such as fish seed, supplementary fish feed, a vermi-compost unit, a poultry shed made with indigenous material and poultry birds of indigenous breed of NE region. Regular monitoring and technical support is provided by the collaborating partner to the selected tribal farmers.

Infrastructure support activities for tribal farmers

Awareness programme on Livelihood Opportunities and Fish Seed Production in Uttar Pradesh

Two awareness programmes on Livelihood Opportunities for Tribal Farmers in Fisheries based Enterprises and Fish Seed Production and Hatchery Management, were organized at Myorpur and Kataundhi in Sonebhadra district during March 23-24, 2019, after the implementation of various interventions in the district, to further popularize the opportunities and benefits of taking up these enterprises. A total of

184 tribal farmers and women participated in these programmes. ICAR-NBFGR team explained about the initiatives taken by the Institute in the region to promote tribal development through establishment of fish seed production enterprise and how they can take benefit of it. Tribal farmers also shared their experiences on these aspects. Various other opportunities to enhance their livelihoods in fisheries activities, were explained to the participating tribal farmers. Extension literature prepared by the Institute in Hindi, and fishing nets were also distributed to the tribal farmers.

Glimpses of the awareness programme

Fish seed production

Quality fish seed production is one of the important activities of the institute for societal benefit and livelihood support of the fish farmers of the region. The institute has been supplying quality IMC seeds to fish farmers, hatchery owners and state fisheries departments of Uttar Pradesh. The institute has developed farm cum hatchery facilities at two sites - one at its main campus and another one at ARTU Chinhat, Lucknow. Brooders at the institute farm have been replenished regularly with the Gangetic IMC stocks. During the reported period, institute produced 923 lakh seed in the form of spawn, fry and fingerlings of Indian major carps, minor and exotic carps.

Farmer advisory services

Technical Guidance

Free consultancies were extended to the needy farmers visiting institute and also through application of ICT tools. Technical knowhow is being regularly extended to the aqua farmers/college students approaching the institute in the discipline of fish culture, fish disease, freshwater prawn culture, seed production of carps and catfishes. Exposure visit were also conducted for the needy.

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:

Date	Telecast/Broadcast Organization	Topic	Telecast/Broadcast Date
January 10, 2019	Lucknow Doordarshan	Live phone in programme	DD Lucknow on January 10, 2019
March 1, 2019	Lucknow Doordarshan	Matsya Palan me Samayaik Karya	Krishi Darshan programme on March 6, 2019
March 19, 2019	All India Radio (Akashvani), Lucknow	Matsya Palan se Dugani Aay	Vigyan evam Kisan Programme on March 25, 2019
April 18, 2019	Lucknow Doordarshan	Live phone in programme on Matsya Palan Kaise Karey	DD Lucknow on April 18, 2019
June 28, 2019.	All India Radio (Akashwani), Prayagraj	Greeshm kal men Matsya Palan Talabon kee Dekhbhal	AIR programme on June 28, 2019
July 3, 2019	All India Radio (Akashvani), Lucknow	Samekit Matsya Palan Se Doguni Amdani	Vigyan evam Kisan Programme on July 8, 2019
July 15, 2019	Lucknow Doordarshan	Matsya Palan me Samayaik Karya	Krishi Darshan programme on July 26, 2019
September 24, 2019	Lucknow Doordarshan	Jalkrishi Adharit Samgra Krishi	Krishi Darshan programme on October 9, 2019
November 14, 2019	Lucknow Doordarshan	Live phone in programme Matsya Palan Kaise Karey	DD Lucknow on November 14, 2019

AWARDS AND RECOGNITIONS

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.

ICAR-NBFGR hindi magazine, Matsyalok (7th issue) received 1st prize from Nagar Rajbhasha Karyanvayan Samiti, Lucknow for the year 2019.

Dr. Kripal Datt Joshi, Principal Scientist received fellowship of the Academy of Environmental Biology (AEB), Lucknow in the 39th Annual Conference of AEB - One Health & Ecosystem Services (OHES-2019) organized at ICAR-NBFGR, Lucknow during November 29-30, 2019.

ICAR-NBFGR team consisting of G. Kantharajan, Govinda Krishnan, Sunayana Sharma, Rejani Chandran, Rajeev K. Singh, Vindhya Mohindra, L.K. Tyagi, Achal Singh, N.K. Krishna Kumar and Kuldeep K. Lal was awarded the best poster in the 39th Annual Conference of AEB - One Health & Ecosystem Services (OHES-2019) organized at ICAR-NBFGR, Lucknow during November 29-30, 2019

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

- Dr. B.S. Chauhan Medal from Zoological Society of India on January 15, 2019.
- Excellent Researcher Award from Combined Society for Educational Research and Development, India on February 1, 2019.
- Best Scientist Award from Society for Science and Nature (SFSN) and Asian Biological Research Foundation (ABRF) on October 20, 2019.
- Er. V.S. Chauhan Award from the Academy of Environmental Biology, India on November 29, 2019.

Shri Satyandra Mohan Srivastava, Chief Technical Officer was conferred with the following awards:

- Life-member of the Society for Sciences and Nature (SFSN), Lucknow on September 15, 2019.
- Best Faculty Award 2019 in the International Conference on Recent Trends in Science, Technology Agriculture and Management organized by Society for Sciences and Nature (SFSN), Lucknow during October 20-21, 2019.

Shri Amit Singh Bisht, Senior Technical Officer, ICAR-NBFGR, was conferred with Special Honour for Fisheries Extension Award by Central Calcutta Science & Culture Organisation for Youth, Kolkata on August 31, 2019 in Kolkata.

Dr. Kripal Datt Joshi receiving fellowship award of AEB

Shri Amit Singh Bisht receiving Award

RESEARCH PROJECTS

Institutional Projects

S. No	Project Title	Personnel	Period
	Molecular Biology & Biotechnology Division		
1.	Stress tolerance response in cultivable freshwater fish species	Satish Kumar Srivastava (PI), Ravindra Kumar and Poonam Jayant Singh	April, 2017 - March, 2020
2.	Systematic review and evolutionary study of Indian Clupeiform fishes	Mahender Singh (PI), T.T. Ajith Kumar, Murali S., Teena Jayakumar T.K. and Akhilesh Kumar Mishra	April, 2017 - March, 2020
3.	Digital repository of transcriptome and proteome knowledge on Indian aquatic genetic resources.	Ravindra Kumar (PI), Poonam Jayant Singh, Trivesh S. Mayekar, Murali S.	May, 2019 – March, 2022
	Fish Conservation Division		
4.	Outreach activity on fish genetic stocks, Phase II NBFGR HQ Component PMFGR Center Component	Kuldeep K. Lal (Project Coordinator), Rajeev Kumar Singh (Co-coordinator and Lead Centre PI) Vindhya Mohindra, Sangeeta Mandal, Rejani Chandran, Achal Singh, Amar Pal, R.S. Sah and Rajesh Kumar Divya P.R. (PI), V.S. Basheer, A.K. Pandian and Charan Ravi	April, 2014 - March, 2020
5.	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
6.	Exploration for fish diversity assessment and traditional ecological knowledge in lower Mahanadi basin	Lalit Kumar Tyagi (PI), Sangeeta Mandal, Trivesh S. Mayekar, Rejani Chandran, Amit Singh Bisht and Sanjay Kumar Singh	April, 2016 - March, 2020
7.	Fish diversity pattern of fish communities from Luni river basin, Rajasthan, India	Ajey Kumar Pathak (PI) Rajesh Dayal, Ravi Kumar and Kantharajan G.	April, 2018 - March, 2021
8.	Exploration and assessment of fish diversity of mid-Himalayan tributaries and wetlands of Ganga river system	Kripal Datt Joshi (PI), Ajey Kumar Pathak, Santosh Kumar, Rajesh Dayal, Ajay Kumar Singh and Ravi Kumar	April, 2017 - March, 2020
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 **Component II:** Diploid germplasm cryobanking for ex situ conservation and multiplication of Aquatic Genetic Resources	Kuldeep K. Lal (Coordinator and PI) Ravindra Kumar, Vindhya Mohindra, Gaurav Rathore, Kripal Datt Joshi, Lalit Kumar Tyagi, T.T. Ajith Kumar, Sullip Kumar Majhi, Ajey Kumar Pathak and Rajesh Dayal Aditya Kumar (PI) and Mog Chaudhury	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 modelling for exotic species	Kripa Datt Joshi (PI), V.S. Basheer, Aditya Kumar, Satyendra Mohan Srivastava and Vikash Sahu	April, 2017 - March, 2020
12.	Network project on assessment of antimicrobial resistance in fisheries and aquaculture	Gaurav Rathore (PI), Chandra Bhushan Kumar, Anutosh Paria, Chinmayee Muduli, Satyendra Mohan Srivastava and Vikash Sahu	April, 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 Sub project-2: Survey and Collection of fishes from Marine Islands (Andaman & Lakshadweep)	 V.S. Basheer (PI) and Charan Ravi T.T. Ajith Kumar (PI), A. Kathirvelpandian and Teena Jayakumar T.K.	 April, 2016 - March, 2020 April, 2016 - March, 2020
	Aquaculture Research and Training Unit		
14.	Livelihood improvement through integrated farming models using indigenous resources.	Sharad Kumar Singh (PI), Lalit Kumar Tyagi and Akhilesh Kumar Yadav	April, 2017 - March, 2020

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 Jayant 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, Ajey Kumar 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)	Joykrushna Jena (Coordinator), Vindhya Mohindra (PI), Rajeev Kumar Singh, Basdeo Kushwaha and Labrechai Mog Chowdhury	ICAR- CRP	April, 2015 - March, 2020
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), T.T. Ajith Kumar, V.S. Basheer, Sullip Kumar Majhi, Santosh Kumar, Aditya Kumar, Ajay Kumar Singh 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*	Pravata Kumar Pradhan (PI), Neeraj Sood and Chandra Bhushan Kumar	ICAR-CRP	October, 2017 - March, 2020

S. No.	Project Title	Personnel	Scheme	Period
6.	All India network project on fish health	Pravata Kumar Pradhan (PI), Gaurav Rathore, Neeraj Sood and Anutosh Paria	ICAR	April, 2017 - March, 2020

External-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 virology, toxicology and gene expression studies	Basdeo Kushwaha (PI), Ravindra Kumar, Murali S. and Akhilesh Kumar Mishra	DBT, Govt. of India	May, 2017 - May, 2020
2.	Development of biotechnological approach for production of *Clarias magur* (Hamilton, 1822) spermatozoa for aquaculture	Sullip Kumar Majhi (PI) and Santosh Kumar	DBT, Govt. of India	January, 2018 - December, 2020
3.	National surveillance programme for aquatic animal diseases	Joykrushna Jena (Coordinator), Kuldeep K. Lal (Co-coordinator), Neeraj Sood (PI), Pravata Kumar Pradhan, T. Raja Swaminathan and Gaurav Rathore	NFDB	February, 2013 – June, 2020
	Sub project I: Surveillance of freshwater fish and shellfish diseases in Uttar Pradesh and Haryana	Pravata Kumar Pradhan (PI), Neeraj Sood, Chandra Bhushan Kumar and Gaurav Rathore		February, 2013 – June, 2020
	Sub project II: Surveillance programme for aquatic animal diseases of ornamental fishes in the states Kerala and Tamil Nadu	T. Raja Swaminathan (PI)		April, 2013 - June, 2020
4.	Poverty alleviation through prevention and future control of the two major socio-economically/important diseases in Asian aquaculture	Neeraj Sood (PI), Pravata Kumar Pradhan and Vindhya Mohindra	DBT-BBSRC	May, 2016 - November, 2019
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	May, 2018- May, 2021
6.	Understanding molecular basis of host-pathogen-environment interaction of Tilapia Lake Virus Disease	Pravata Kumar Pradhan (PI), Neeraj Sood, T. Raja Swaminathan and Anutosh Paria	NASF	October, 2019 – October, 2022

S. No	Project Title	Personnel	Scheme	Period
7.	Exploring our wetlands: Establishing DNA barcodes for finfishes and shellfishes of Ramsar sites in Kerala	Divya P.R. (PI)	KSCSTE	January, 2016 - December, 2019
8.	Development of vaccines and diagnostic kit for the management of goldfish herpesviral hematopoietic necrosis disease in India	T. Raja Swaminathan (PI)	ICAR National Fellowship	April, 2017 - March, 2022
9.	Quantifying agrobiodiversity and ecosystem services in Godavari river basin landscape	Kuldeep K. Lal (Coordinator), Rajeev Kumar Singh (PI), Lalit Kumar Tyagi, Achal Singh, Rejani Chandran and Kantharajan G.	Bioversity International	January, 2018 - July, 2019
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. Ajith Kumar (PI), Charan Ravi and Lalit Kumar Tyagi	UNDP -Mangrove Cell, Maharashtra	April 2017 -March, 2021
11.	Establishing Germplasm Resource Centre for marine ornamental invertebrates: Hormonising bioversity conservation and promoting livelihood to the islanders of the Lakshadweep	Kuldeep K. Lal (Coordinator), T.T. Ajith Kumar, Charan Ravi and Jaffer Hisham (Fisheries officer Administration of Lakshadweep)	DBT	July, 2018 – June, 2021
12.	Establishment of spermatogonial stem cell line (SSC) from *Etroplus suratensis*	T. Raja Swaminathan (PI), Charan Ravi and Divya P.R.	ICAR Extra Mural	August, 2018 – March, 2020
13.	Understanding genomic mechanism of thermal tolerance using golden mahsheer, *Tor putiptora* as model	Vindhya Mohindra (PI), Labrechai Mog Chowdhury and Trivesh S. 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 (PI), Aditya Kumar and Labrechai Mog Chaudhury	NASF	August, 2018 - July, 2021
15.	Indian Major Carp milt cryobank for improving genetic exchange between farms and commercial level quality seed production.	Sullip Kumar Majhi (PI), Santosh Kumar, Aditya Kumar, Ajay Kumar Singh and Rama Sankar Sah	NFDB	December, 2018 – November, 2020
16.	Population genomics and mapping signatures of natural selection in Asian Seabass in India	Rajeev Kumar Singh (PI), Sangeeta Mandal, Rejani Chandran and Labrechai Mog Chowdhary	DBT	April, 2019 - April, 2022

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 Kumar 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 Kumar 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. (NPDF), T. Raja Swaminathan (Supervisor)	SERB-DST	April, 2018 – April, 2020

PUBLICATIONS

Research Papers

International

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2. Ahmad, I., T. Leya, N. Saharan, B. Rani, G. Rathore, A.H. Gora, I. Bhat and A.K. Verma, 2019. Carbon sources affect water quality and haemato-biochemical responses of *Labeo rohita* in zero-water exchange biofloc system. *Aquaculture Research*, 50(10): 2879-2887.
3. Alam, A., N.K. Chadha, S.K. Chakraborty, K.D. Joshi, T. Kumar, S.C.S. Das, S.D. Roy, A.F. Rizvi and J. Kumar, 2019. Studies on the growth and mortality of invasive *Oreochromis niloticus* (Linnaeus, 1758) in sub-tropical river Yamuna, part of Gangetic River system, India. *Aquatic Ecosystem Health & Management,* 22: 473-480.
4. Anand, A., G. Kantharajan, P. Krishnan, K.A. Hakeem, K.S. Santosh, C.S. Rao, K.K. Lal, S.B. Choudhury, C. Manjulatha and D.E. Babu, 2019. Mapping the potential areas for enclosure fish culture in tropical reservoirs: geo-spatial solutions for sustainable aquaculture expansion. *Spatial Information Research*, 27(6): 733-747.
5. Arya, P., P.K. Pradhan, A. Paria, R. Sharma, D.K. Verma, Ravindra, G. Rathore and N. Sood, 2019. Ontogeny and tissue-specific expression of immune-relevant genes in *Catla catla* (Hamilton). *Gene Expression Patterns*, 34: 119071.
6. 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.
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8. Bhaskar R. and V. Mohindra, 2019. Phylogenetic relationships among Indian freshwater turtles (family Trionychidae and Geoemydidae) with special reference to *Lissemys punctata*, inferred from mitochondrial cytochrome b gene sequences. *Meta Gene,* 22: 100610.
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10. Das, S.C.S., K.D. Joshi, S.K. Chakraborty, D. Panda and A.K. Jaiswar, 2019. Length-weight relationship and condition factor of *Cyprinus carpio* Linnaeus, 1758 from the river Ganga, Allahabad, India. *Journal of Entomology and Zoological Studies*, 7(3): 1420-1424.
11. 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.*
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13. Doyle, R.W., K.K. Lal and C. Virapat, 2019. Domestication and genetic improvement: balancing improved production against increased disease risks from inbreeding. *Revue Scientifique et Technique (International Office of Epizootics)*, 38(2): 615-628.
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18. अजेय कुमार पाठक, इलियास राशिद एवं रवि कुमार, 2019. नीली क्रांति एवं जलकृषि विकास, *In:* मत्स्यलोक (सप्तम अंक), रा.म.आ.स. ब्यूरो, लखनऊ. pp. 57-58.
19. अचल सिंह, विन्ध्या मोहिन्द्रा, अमित सिंह बिष्ट, अभिषेक राना एवं कुलदीप कुमार लाल, 2019. 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. Kushwaha, B., Murali S. and Ravindra Kumar, 2019. Training manual for training program on Cell Line: Development, Maintenance and Applications. ICAR-NBFGR, Lucknow, 85 p.
8. Singh, S.K. and K.K. Lal, 2019. Re-Circulatory Aquaculture System (RAS) training manual: ICAR-NBFGR, Lucknow, 86 p.
9. Ajith Kumar, T T., Teena Jayakumar T.K. and K.K. Lal, 2019. Clownfish Aquaculture training manual. ICAR-National Bureau of Fish Genetic Resources, Lucknow, p. 127.
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Technical document

1. Lal, K.K., R.W. Doyle, V. Mohindra, R.K. Singh, J.K. Jena and C. Virapat, 2019. 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.

Booklet

1. Nakhwa, M.J, T.T. Ajith Kumar, Teena Jayakumar T.K. and K.K. Lal, 2019. Clownfish Prajanan Sangopan and Plan *(Marathi*). ICAR-NBFGR, Lucknow, 73 p.
2. Kathirvelpandian, A., G. Kantharajan, T.T. Ajith Kumar, K.K. Lal, 2019. Conservation and management of genetic resources in Gulf of Mannar through fisheries based Alternative Livelihood Opportunities (*Tamil*). ICAR-NBFGR, Lucknow, 45 p.

PARTICIPATION IN SEMINAR / SYMPOSIA / WORKSHOP / TRAINING / MEETINGS

Abroad

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

- Attended an interview as per invitation of the search committee 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.
- Regional workshop on Underutilized Fish and Marine Genetic Resources (FMGR) and their Amelioration held at National Aquatic Resources Research and Development Agency (NARA), Colombo, Sri Lanka during July 10-12, 2019 and presented the country status report on the underutilized aquatic genetic resources.
- Regional consultative meeting on Biodiversity Mainstreaming across Agricultural Sectors for Asia and the Pacific (Regional Consultative Meeting) held at the Royal Orchid Sheraton Hotel, Bangkok, Thailand during July 17-19, 2019.
- Third session of the COFI Advisory Working Group on Aquatic Genetic Resources and Technologies held from August 20-21, 2019, Rome, Italy. Appointed as a member of COFI Advisory Working Group on Aquatic Genetic Resources and Technologies (AWG).
- Regional consultative workshop on "Strengthening Governance of Aquaculture for Sustainable Development in Asia and Related Country Review Studies" and "Demographic Changes in Fishing Communities in Asia" co-organized by NACA and FAORAP held at Bangkok, Thailand during November 5-7, 2019.
- Visit to APAARI, for discussion on proposed program by APAARI during 2020 on Ex situ conservation on November 8, 2019.

Dr. Vindhya Mohindra, Principal Scientist and Head participated in the following activities:

- UK closing meeting of the Global Research Partnership in Aquaculture Project 'Poverty alleviation through prevention and future control of the two major socioeconomically-important diseases in Asian Aquaculture' held from July 29 to August 2, 2019 at Ocean and Earth Science, National Oceanography Centre, Southampton Waterfront Campus, Southampton, UK.

Dr. Gaurav Rathore, Principal Scientist and Head participated in the following activities:

- Hands-on training on "Standardized and Harmonized Surveillance Methods for Antimicrobial Resistance in Food Animals in South Asia" from May 27 to June 1, 2019 at Chulalongkorn University, Bangkok, Thailand.

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

- 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.
- Invited as an opponent for disputation of Ph.D. dissertation of Mr. Suarabh Dubey, Norwegian University of Life Sciences, Oslo during August 22-24, 2019.
- Lead presentation on "The India's National Surveillance Program: a case study of systematic approach for controlling aquatic animal diseases in Asia", chaired a session (November 5, 2019) and Panelist in the session "Current Status and Future Challenges to Aquaic Animal Health and Epidemiology" (November 6, 2019) during Global Conference on AquaEpi II held in Hua Hin, Thailand during November 4-6, 2019.

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

- International conference 12th Asian Fisheries and Aquaculture Forum (12AFAF), organised by Asian Fisheries Forum at Iloilo City, Philippines during April 8-12, 2019.

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

- 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.

- Oral presentation on "The challenges of establishing and sustaining the health status of groundwater based inland saline shrimp farming system in Haryana, India" during Global Conference on AquaEpi II held in Hua Hin, Thailand during November 4-6, 2019.

In India

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

- NFDB meeting for setting up Fish Farmers Interaction Centre and Referral Centre of Aquatic Animal Disease Diagnostics and Informatics on January 22, 2019 at NFDB, Hyderabad.
- Directors Conference held from January 31 to February 2, 2019 at NASC Complex, New Delhi.
- ICAR-NACA Regional Expert Consultation on Genetically Responsible Aquaculture held at ICAR-NBFGR, Lucknow during February 26-27, 2019.
- Workshop on Developing Agrobiodiversity Index and Assessing Ecosystem Services organized by ICAR in collaboration with Bioversity International during April 15-16, 2019 at New Delhi.
- Brain storming session on Sustainability of Livestock and Fishery Production Systems in India: Issues and Indicators on April 20, 2019 at ICAR-NDRI, Karnal.
- Academic Council meeting & XIV Convocation of ICAR-CIFE, Mumbai during April 21-22, 2109.
- EFC meeting during May 27-29, 2019 at Fishery Science Division, ICAR, New Delhi.
- Inauguration of ICAR-NBFGR facility of Fish Breeding at Airoli, Mumbai on June 5, 2019.
- Foundation day (58th) of ICAR-CIFE, Mumbai on June 6, 2019 as Chief Guest.
- Awareness programme on Marine Biodiversity Conservation (special focus, fish genetic resources) and utility of aquaculture as alternative livelihood option for the fishers in the Gulf of Mannar region at the Dept. of Marine Sciences at Puthumadam, Ramnad during June 17-18, 2019 organized by ICAR-NBFGR.
- Asian Pacific Aquaculture 2019 held at Chennai during June 19-21, 2019 organized by Tamil Nadu Dr. J. Jayalalithaa Fisheries University and World Aquaculture Society-Asian Pacific Chapter.
- 135th Meeting of MPEDA held at Kolkata on June 21, 2019.
- Meeting convened by Hon'ble Minister, Ministry of Fisheries, Animal Husbandry and Dairying, Sri Giriraj Singh along with other Ministers, Dr. Sanjiv Balian and Sri Pratap Chandra Sarangi on June 25, 2019 at New Delhi.
- Stakeholder's consultation meeting on Biodiversity Beyond National Jurisdiction (BBNJ), organized by the Centre for Marine Living Resources and Ecology (CMLRE) during July 1-2, 2019.
- Meeting with Mr. Nilesh Cabral, Hon'ble Minister for Environment and Forest, Goa on July 1, 2019.
- Viva-Voce Examination Committee meeting of ICAR-CIFE, Mumbai as Chairman on July 29, 2019.
- Meeting with Chief Executive, NFDB, Hyderabad on July 30, 2019.
- PMSTIAC-Mission National Biodiversity meeting convened under the Chairmanship of Principal Scientific Adviser to Government of India on August 5, 2019 at Prithvi Bhawan, New Delhi.
- Review meeting of activities of Bureaux under ICAR Chaired by Secretary, DARE & DG, ICAR, to review the work, rationalize the activities and define road map at NASC Complex, New Delhi on August 28, 2019.
- 136th Authority Meeting of MPEDA on August 29, 2019.
- Chaired the session in Aqua Aquaria India 2019 on August 30, 2019 at Hitex Exhibition Center, Hyderabad (MPEDA).
- Technical Monitoring Committee Meeting (2nd) for establishing NBC of *L. vannamei* project of MPEDA-RGCA at Chennai on September 24, 2019 under the Chairmanship of Hon'ble Chairman, MPEDA.
- Meeting at MPEDA, HQ for NBC & SAC at Kochi on October 15, 2019.
- SAC meeting of RGCA and visit to facilities at Kochi on October 16, 2019.
- Meeting with Vice-Chancellor, HAU, Hisar on collaboration and MoU on November 14, 2019.

- National consultation on Genomics and Bioinformatics in Agriculture: The Way Forward held at NASC, New Delhi on November 27, 2019.
- Meeting with Vice-Chancellor, HNB Garhwal University, Srinagar on collaboration and MoU during December 5-6, 2019.

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

- 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.
- 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.
- ICAR-NACA Regional Expert Consultation on Genetically Responsible Aquaculture held at ICAR-NBFGR, Lucknow during February 26-27, 2019.
- Awareness programme on Marine Biodiversity Conservation (special focus, fish genetic resources) and utility of aquaculture as alternative livelihood option for the fishers in the Gulf of Mannar region at the Dept. of Marine Sciences at Puthumadam, Ramnad during June 17-18, 2019 organized by ICAR-NBFGR.
- Consultation meet with ministries/departments, organizations and experts on Digital Sequence Information on July 30, 2019 at Teesta Hall, MoEFCC, New Delhi.
- Review meeting of network project on Agricultural Bioinformatics and Computational Biology on August 7, 2019 at CABin Division, ICAR-IASRI, New Delhi.
- Expert Member of the interview committee for the post of Young Professional II on October 14, 2019 at ICAR-CIRG, Makhdoom, Mathura.
- Review meeting of network project on Agricultural Bioinformatics and Computational Biology during November 1-2, 2019 at CABin Division, ICAR-IASRI, New Delhi.
- National consultation on Genomics and Bioinformatics in Agriculture: The Way Forward held at NASC, New Delhi on November 27, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

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

- BRAQCON 2019 at ICAR-CIBA, Chennai during January 22-25, 2019 and delivered an Invited Lecture.
- Annual Review Meeting (5th) of all the ongoing projects under NASF for the theme area, Abiotic and Biotic Stresses, and Quality Traits in Animals and Fisheries held at New Delhi on February 15, 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.
- ICAR-NACA Regional Expert Consultation on Genetically Responsible Aquaculture held at ICAR-NBFGR, Lucknow during February 26-27, 2019.
- Delivered a lecture on "Next generation Sequencing and Applications" at School of Biotechnology, Gauhati University on March 26, 2019.
- Awareness programme on Marine Biodiversity Conservation (special focus, fish genetic resources) and utility of aquaculture as alternative livelihood option for the fishers in the Gulf of Mannar region at the Dept. of Marine Sciences at Puthumadam, Ramnad during June 17-18, 2019 organized by ICAR-NBFGR.
- Asian Pacific Aquaculture 2019 held at Chennai during June 19-21, 2019 organized by Tamil Nadu Dr. J. Jayalalithaa Fisheries University and World Aquaculture Society-Asian Pacific Chapter.
- DST sponsored 2-week training program on Science Administration and Research Management at Administrative Staff College of India (ASCI), Hyderabad during July 1-12, 2019.
- Institute Management Committee meeting of ICAR-CIBA, Chennai on July 19, 2019 as member.
- Technical monitoring committee meeting for Establishment of NBC of *L. vannamei* project on September 5, 2019 at MPEDA, Kochi.

- National consultation (3rd) on the National Mission on Biodiversity and Human well-being held at the Brahmaputra Meeting Hall, Ministry of Environment, Forest and Climate Change, Indira Paryavaran Bhawan, New Delhi on October 16, 2019.
- Monitoring committee meeting of the Maharashtra Gene Bank Project funded by Rajiv Gandhi Science and Technology Commission, Government of Maharashtra on November 8, 2019 at IISER, Pune as Special Invitee.
- National consultation on Genomics and Bioinformatics in Agriculture: The Way Forward held at NASC, New Delhi on November 27, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow and delivered a talk on "Genomic resources and population structure in Hilsa shad, *Tenualosa ilisha*".
- Review meeting for NICRA project on December 17-18, 2019 at NASC, New Delhi.

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

- ICAR-NACA Regional Expert Consultation on Genetically Responsible Aquaculture held at ICAR-NBFGR, Lucknow during February 26-27, 2019.
- ICAR-USAID-FAO Workshop on "Operationalization of Animal Health Component of National Action Plan on AMR" at Kolkata during April 25-27, 2019.
- Viva-voce of a M.F.Sc. student at GBPUA&T University, Pantnagar as external examiner on July 6, 2019.
- ICAR foundation day and Director's meet on July 16-17, 2019 at New Delhi.
- Meeting organized by Joint Secretary, Ministry of Fisheries, Government of India at Krishi Bhawan, New Delhi on September 5, 2019 for discussion on disease free zones in fish/shrimp farms.
- National seminar on Antimicrobial Resistance (AMR) in Indian Fisheries: Measures of Mitigation, November 7-8, 2019, ICAR-CIFT, Kochi and delivered a talk on "Network Programme on AMR in aquaculture and Fisheries under INFAAR".
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow and delivered an invited talk on "Antimicrobial resistance (AMR) in aquaculture and fisheries".
- Meeting with Vice-Chancellor, HNB Garhwal University, Srinagar on collaboration and MoU during December 5, 2019 and delivered a talk on "AMR surveillance in aquaculture and fisheries".
- Review meeting of DBT-Twinning project titled "Biocontrol of *Aeromonas hydrophila* and *Flavobacterium columnare* infection in *Labeo rohita* through phage therapy and paraprobiotics" at NER-BPMC, New Delhi on December 18, 2019.

Dr. Kripal Datt Joshi, Principal Scientist participated in following activities:

- National committee meeting (24th) on Introduction of Exotic Aquatic Species into Indian Waters at Krishi Bhawan, New Delhi on April 4, 2019.
- Meeting at WWF-India, New Delhi with Mr. Suresh Babu, Director and Dr. Nitin Kaushal, Associate Director, WWF-India, New Delhi on April 4, 2019.
- Review meeting of National Academy of Sciences (NASI), Prayagraj on Schedule Tribe Sub-plan held at NIPGR, New Delhi on April 26, 2019.
- Regional research conference organized by ICFRE, Prayagraj at Hotel Renaissance, Gomti Nagar, Lucknow on June 3, 2019.
- World Environment Day celebration and 23rd Dr. C.R. Krishnamurti Memorial Oration organized by CSIR-IITR, Lucknow on June 6, 2019 at CSIR-IITR, Lucknow.
- Oral preliminary examination of a Ph.D. student of Govind Ballabh Pant University of Agriculture & Technology, Pantnagar on June 12, 2019 as External Expert.
- Nagar Rajbhashsa Karyanvan Samiti Meeting at ICAR-IISR, Lucknow and received Rajbhasha Award conferred to ICAR-NBFGR on behalf of the Director on June 25, 2019.
- Review meeting of Schedule Tribe Sub-plan of National Academy of Sciences (NASI) Prayagraj on June 28, 2019 at NASI, Prayagraj as Expert Member.
- Radio talk on " *Greeshm kal men Matsya Palan Talabon kee Dekhbhal*" at Akashwani Kendra,

Prayagraj on June 28, 2019.

- Management Development Programme (MDP) on Priority Setting, Monitoring and Evaluation (PME) of Agricultural Research Projects at ICAR-NAARM, Hyderabad during July 18-23, 2019.
- National symposium on Coldwater Fisheries Development in India: Innovative Approaches and Exhibition held at ICAR-DCFR, Bhimtal during September 24-25, 2019 and delivered invited lecture
- National Level Steering Committee meeting to oversee and monitor the tilapia seed and grow out production, held at Krishi Bhawan, New Delhi on August 23, 2019 and October 4, 2019.
- Ganga River Dolphin workshop organized by National Mission on Clean Ganga (NMCG), Ministry of Water Resources, River Development and Ganga Rejuvenation, New Delhi at WWF-India on October 5, 2019.
- Organizing Secretary of conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

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

- 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.
- Invited lecture on "Cytogenetic and genotoxicity assessment tools in fishes" on October 19, 2019 and demonstrated chromosome preparation technique to the students in Department of Zoology, Gauhati University during October 19-22, 2019.
- Invited lecture on "Advanced cytogenetic techniques and its application in fisheries/ zoology" to participants of refresher course in life science at UGC-Human Resource Development Centre at Gauhati University on October 22, 2019.
- National consultation on Genomics and Bioinformatics in Agriculture: The Way Forward held at NASC, New Delhi on November 27, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

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

- Experts meet on Uniform Policy on Fish Disease Diagnosis and Quarantine organized by National Academy of Agricultural Sciences on January 29, 2019.
- ICAR-NACA Regional Expert Consultation on Genetically Responsible Aquaculture held at ICAR-NBFGR, Lucknow during February 26-27, 2019.
- Expert committee meeting of National Agricultural Science Fund on May 10, 2019 at NASC Complex, New Delhi.
- Interaction meeting with officials from NFDB during July 8-9, 2019 at ICAR-NBFGR.
- Meetings of Expert Committee on drafting 'Aquatic Animal Disease and Health Management Bill 2019' on July 17, July 25 and August 1, 2019 in Krishi Bhawan, New Delhi.
- Annual review meeting of DBT-BBSRC project at ICAR-NBFGR, Lucknow on November 20, 2019.
- Presentation on "Need of Disease Surveillance and Health Management in Aquaculture" during World Fisheries Day 2019 in A.P. Shinde Hall, NASC Complex, New Delhi on November 21, 2019.
- Presentation on "National Surveillance Programme for Aquatic Animal Diseases and Centre for Aquatic Animal Disease Informatics and Referral Diagnostics" during meeting with Chief Executive, National Fisheries Development Board, Hyderabad at ICAR-NBFGR, Lucknow on December 11, 2019.
- Presentation on major achievements during National Surveillance Programme for Aquatic Animal Diseases and proposal for 2nd Phase of NSPAAD during TAC meeting held at ICAR-NBFGR, Lucknow on December 19, 2019.

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

- Meeting at Kerala State Biodiversity Board on Biodiversity related issues in Kerala on January 5, 2019.
- Lecture on "Exotic fishes: Prospectus and problems" in an International training programme

conducted by ICAR-CMFRI and African Asian Rural Development Organisation (AARDO) at ICAR-CMFRI on January 17, 2019.

- 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.
- Meeting at Kerala State Biodiversity Board for developing and planning Biodiversity guidelines in Kerala on March 1, 2019 as a subject expert member.
- Asian Pacific Aquaculture 2019 held at Chennai during June 19-21, 2019 organized by Tamil Nadu Dr. J. Jayalalithaa Fisheries University and World Aquaculture Society-Asian Pacific Chapter.
- Senior level training programme on Science, Technology and Innovation Policy at National Institute of Advanced Studies, IISc campus, Bengaluru during August 19-30, 2019.
- Lecture on "Exotic fishes in Indian Aquaculture" in workshop-cum training programme on Fisheries and Aquaculture, at ICAR-CMFRI, Kochi, sponsored by African Asian Rural Development Organization (AARDO), Ministry of Rural Development, Government of India on October 9, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

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

- 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.
- ICAR-NACA Regional Expert Consultation on Genetically Responsible Aquaculture held at ICAR-NBFGR, Lucknow during February 26-27, 2019.
- Expert committee meeting of National Agricultural Science Fund on May 10, 2019 at NASC Complex, New Delhi and presented project proposal, "Understanding molecular basis of host-pathogen-environment interaction of Tilapia Lake Virus Disease".
- Viva-voce examination of a Ph.D. scholar, Department of Aquaculture, GADVASU, Ludhiana on May 11, 2019 as external examiner.
- Technical Advisory Committee meeting for evaluation and monitoring of National Surveillance Programme for Aquatic Animal Diseases on December 19, 2019 at ICAR-NBFGR, Lucknow.
- Annual review meeting of DBT-BBSRC project at ICAR-NBFGR, Lucknow on November 20, 2019.
- Meeting with Chief Executive, National Fisheries Development Board, Hyderabad for reviewing the progress of National Surveillance Programme for Aquatic Animal Diseases and proposal for Centre for Aquatic Animal Disease Informatics and Referral Diagnostics during at ICAR-NBFGR, Lucknow on December 11, 2019.

Dr. Sharad Kumar Singh, Principal Scientist attended the following activities:

- ToT meeting organized at NFDB, Hyderabad on April 24, 2019.
- Examiner for M.Sc. Fish special practical examination 2019 at Deen Dayal Upadhaya University, Gorakhpur on May 6, 2019.
- Invited lectures on different aspects of Fish Culture at KVK, ICAR-IVRI, Izatnagar, Bareilly on July 30, 2019.
- Technical Advisory and Scientist-Farmer Aquaculture Interface meeting at Banda University of Agriculture and Technology (BUAT), Banda, U.P. on August 31, 2019 and delivered lecture on "Aquaculture led Farming System".
- Invited lecture on "Fisheries and Aquaculture" organized by Uttar Pradesh Matsya Jivi Sahkari Ltd., Gomti Nagar, Lucknow on November 27, 2019.

Dr. Lalit Kumar Tyagi, Principal Scientist participated in following activities:

- Meeting of the Steering Committee on Biotechnology Based Programme for Societal Development, Department of Biotechnology, Government of India held during February 7-8, 2019 at DBT, New Delhi.

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.
- Workshop on "Developing ABD index and Assessment of Ecosystem services" organized by Bioversity International during April 15-16, 2019 at NASC complex, New Delhi.
- Chairman of the Interview board for selection of Young Professional-I at ICAR-CISH, Lucknow on April 27, 2019.
- Seminar on Priorities and Strategies to Boost Farmer's Income organized by UPCAR, ICAR-IISR, & UP Academy of Agriculture Sciences on June 14, 2019 at Lucknow.
- Chief Guest in Award Ceremony at Science Exhibition organized by NGO -RGVKAS, Ballia, U.P. held at Adarsh Inter College, Fatehpur, U.P. on August 31, 2019.
- Judge for evaluation of "Working Model on Recent Technologies" at SR Group of Institution, Bakshi-Ka-Talab, Lucknow on September 16, 2019.
- Joint Secretary of conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow and delivered lead lecture on "Flexible modelling on Fish-Climate Time Series for understanding the role of climate variables in total fish production under climate change scenario of India".

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

- International workshop on Targeted Proteomics at ICAR-NDRI, Karnal on November 28, 2019.
- International workshop on Quantitative Proteomics at ICAR-NDRI, Karnal on November 29, 2019.
- International workshop on Proteogenomics at ICAR-NDRI, Karnal from November 30 to December 1, 2019.
- International conference on Proteomics for System Integrated Biomics, One health and Food Safety at ICAR-NDRI, Karnal during December 2-4, 2019.

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

- National workshop on recent trends in taxonomy held at Zoological Survey of India (ZSI), Jodhpur, Rajasthan during January 10-11, 2019.
- ICAR-NACA Regional Expert Consultation on Genetically Responsible Aquaculture held at ICAR-NBFGR, Lucknow during February 26-27, 2019.
- Review meeting on CRP-Agrobiodiversity held at the ICAR-NBPGR on May 13, 2019 and presented the progress of the ongoing project of ICAR-NBFGR, Lucknow.
- Steering committee meeting of All India Co-ordinated Project on Capacity Building in Taxonomy (AICOPTAX) held at the Zoological Survey of India (ZSI) Regional centre, Solan during May 15-16, 2019.
- Asian Pacific Aquaculture 2019 held at Chennai during June 19-21, 2019 organized by Tamil Nadu Dr. J. Jayalalithaa Fisheries University and World Aquaculture Society-Asian Pacific Chapter.
- Stakeholders consultation-cum brainstorming meeting on Biodiversity Beyond National Jurisdiction (BBNJ) held at CMLRE, Kochi during July 1-2, 2019.
- Research Advisory Committee (RAC) meeting of CMLRE, Kochi on July 8, 2019 as Co-opted member/Special Invitee.
- International conference on integrated coastal zone management: Lessons Learned and Relevance for India held at the National Centre for Sustainable Coastal Management (NCSCM), Chennai during July 9-11, 2019.
- International consultation on Achieving Sustainable Development Goals and Strengthening Science of Climate Resilience at M. S. Swaminathan Research Foundation, Chennai during August 7-9, 2019.
- International conference and aquarium show, Aqua Aquaria-2019 held at Hyderabad, organized by MPEDA from August 30 to September 1, 2019.
- Board of studies meeting for the M.Sc., interdisciplinary programme of Chettinad Academy of Research and Education, Chennai on September 17, 2019.
- Thematic consultation on biodiversity, agriculture and nutritional security as a part of the national mission on biodiversity and human well-being, organized by ATREE held at Bengaluru on October 29, 2019.

- Screening committee meeting of All India Co-ordinated project on Capacity Building in Taxonomy (AICOPTAX) held at Ministry of Environment, Forest and Climate Change, New Delhi on November 7, 2019.
- Sub-committee meeting to review and update the guidelines for import of ornamental fishes held at the office of the Fisheries Development Commissioner, Ministry of Agriculture and Farmers Welfare, New Delhi on November 8, 2019.
- Invited talk in the international conference on recent advances in marine biodiversity and conservation held at Alagappa University, Tamil Nadu on December 13, 2019.
- Signed a MoU with the Fish for all centre of the M.S. Swaminathan Research Foundation, Poompukar, Tamil Nadu on December 26, 2019 on behalf of the Director, ICAR-NBFGR.

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

- 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.
- Invited lecture on "Cryopreservation of fish milt" during workshop on Tools and Techniques in Life Sciences held at DDU Gorakhpur University, Gorakhpur (U.P.) from March 25-26, 2019.
- International conference on Recent Trends in Science, Technology, Agriculture and Management held at FDDI Fursatganj, Amethi, U.P., India during October 20-21, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

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

- ICAR-NACA Regional Expert Consultation on Genetically Responsible Aquaculture held at ICAR-NBFGR, Lucknow during February 26-27, 2019.
- Workshop on "Developing ABD index and Assessment of Ecosystem services" organized by Bioversity International during April 15-16, 2019 at NASC complex, New Delhi.
- Asian Pacific Aquaculture 2019 held at Chennai during June 19-21, 2019 organized by Tamil Nadu Dr. J. Jayalalithaa Fisheries University and World Aquaculture Society-Asian Pacific Chapter.
- Seminar series on GeoVision organized by ESRI India and National Informatics Centre, New Delhi on July 26, 2019 at Hyatt Regency, Lucknow.
- National consultation on Genomics and Bioinformatics in Agriculture: The Way Forward held at NASC, New Delhi on November 27, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

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

- Invited lecture in the National Seminar on Impact of Microbes on Food and Health (IMFH-2019) organized by Virunagar Hindu Nadar's Senthikumara Nadar College, Virudhunagar, Tamil Nadu on August 29, 2019.
- National seminar on Antimicrobial Resistance (AMR) in Indian Fisheries: Measures of Mitigation, November 7-8, 2019, ICAR-CIFT, Kochi.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

Dr. Ajey Kumar Pathak, Senior Scientist participated:

In 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:

- International conference BRAQCON organized by ICAR-CIBA at Chennai, India during January 22-25, 2019.
- Asian Pacific Aquaculture 2019 held at Chennai during June 19-21, 2019 organized by Tamil Nadu Dr. J. Jayalalithaa Fisheries University and World Aquaculture Society-Asian Pacific Chapter.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019

organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

- International conference, MARICON 2019 on Frontiers in Marine Science Challenges and Prospects organized by CUSAT, Kochi during December 16-20, 2019 held at CUSAT Marine Campus, Kochi.

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

- International conference on Design for Societal Development at National Institute of Design at Gandhinagar Campus from February 14-15, 2019.
- Programme implementation committee meeting at CIFT, ZTMC Kochi on March 27, 2019 as member.
- Invited lecture on "When Patents and Biopiracy Intercalate with Traditional Medicinal Knowledge and Genetic Resources: Issues in Governance and Sovereignty" during National Seminar on Intellectual Property Rights at Central Research Institute of Unani Medicine, Lucknow July 10, 2019.
- International conference on Proteomics for System Integrated Biomics, One health and Food Safety at ICAR-NDRI, Karnal on December 2-4, 2019.

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

- International conference BRAQCON organised by ICAR-CIBA at Chennai during January 22-25, 2019.
- Invited lecture on "Values of Biodiversity and its Conservation" during National Awareness Conference organized by the Department of Advanced Zoology and Biotechnology, Dr. Ambedkar Government Arts College, Vyasarpadi, Chennai on March 8, 2019.

Dr. Sangeeta Mandal, Scientist participated in following activities:

- 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.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

Dr. Rejani Chandran, Scientist participated in following activities:

- 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.
- Workshop on "Developing ABD index and Assessment of Ecosystem services" organized by Bioversity International during April 15-16, 2019 at NASC complex, New Delhi.
- Seminar series on GeoVision organized by ESRI India and National Informatics Centre, New Delhi on July 26, 2019 at Hyatt Regency, Lucknow.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

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.
- Seminar on Priorities and strategies to boost Farmer's Income organized by UPCAR, ICAR-IISR, & UP Academy of Agriculture Sciences on June 14, 2019 at Lucknow.
- Hindi workshop on अंतर्स्थलीय मात्स्यिकीः संरक्षण, संवर्धन एवं जीविकोपार्जन held at ICAR-CIFRI, Barrackpore on September 13, 2019.
- Meeting of Scientific Advisory committee, KVK Sitapur held at KVK Amberpur, Sitapur, U.P. on October 15, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

- International conference-cum-exhibition Smart Aqua India 2019 organized by Smart Agripost at New Digha, West Bengal during December 13-15, 2019.

Dr. Aditya Kumar, Scientist participated in following activities:

- Scientific advisory committee meetings (14th) of ICAR-IISR Krishi Vigyan Kendra, Lucknow on June 25, 2019 at IISR, Lucknow.
- Site selection committee member for the establishment of additional KVK in Prayagraj, U.P. on October 10, 2019.
- Site selection committee member for the establishment of additional KVK in Shrawasti, U.P. on October 11, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

Dr. Charan Ravi Scientist participated in following activities:

- 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.
- Asian Pacific Aquaculture 2019 held at Chennai during June 19-21, 2019 organized by Tamil Nadu Dr. J. Jayalalithaa Fisheries University and World Aquaculture Society-Asian Pacific Chapter.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

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

- 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 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.
- National workshop on Bioinformatics in Agriculture held at ICAR-NAARM, Hyderabad during July 26-27, 2019.
- Invited lecture on "Application of fish cell lines" on October 19, 2019 and demonstrated fish cell line development techniques to the students in Department of Zoology, Gauhati University during October 19-22, 2019.
- 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-IASRI, New Delhi during November 1-3, 2019.
- National consultation on Genomics and Bioinformatics in Agriculture: The Way Forward held at NASC, New Delhi on November 27, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

Shri Trivesh Suresh Mayekar, Scientist attended the Conference on One Health & Ecosystem Services

- (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

Dr. Anutosh Paria, Scientist attended the following activities:

- BRAQCON 2019 at ICAR-CIBA, Chennai during January 22-25, 2019.
- ICAR-NACA school on Aquatic Animal Epidemiology and Disease Surveillance held at ICAR-NBFGR, Lucknow during March 1-6, 2019.
- Asian Pacific Aquaculture 2019 held at Chennai during June 19-21, 2019 organized by Tamil Nadu Dr. J. Jayalalithaa Fisheries University and World Aquaculture Society-Asian Pacific Chapter.
- Training on Bacterial Identification & Antibiotic Susceptibility Testing for Veterinary Microbiologists organized by ICMR-PGIMER, Chandigarh during September 5-7, 2019.

- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.
- International conference-cum-exhibition Smart Aqua India 2019 organized by Smart Agripost at New Digha, West Bengal during December 13-15, 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.
- Asian Pacific Aquaculture 2019 held at Chennai during June 19-21, 2019 organized by Tamil Nadu Dr. J. Jayalalithaa Fisheries University and World Aquaculture Society-Asian Pacific Chapter.
- Training on Bacterial Identification & Antibiotic Susceptibility Testing for Veterinary Microbiologists organized by ICMR-PGIMER, Chandigarh during September 5-7, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

Mrs. Teena Jayakumar T.K. participated in conference on One Health & Ecosystem Services

- (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

Ms. Chinmayee Muduli, Scientist participated in Conference on One Health & Ecosystem Services

- (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

Shri Kantharajan G., Scientist participated in following activities:

- Training programme on Geospatial Technologies and Applications at ISRO-National Remote Sensing Centre, Hyderabad from October 12, 2018 to February 1, 2019.
- Workshop on "Developing ABD index and Assessment of Ecosystem services" organized by Bioversity International during April 15-16, 2019 at NASC complex, New Delhi.
- Seminar series on GeoVision organized by ESRI India and National Informatics Centre, New Delhi on July 26, 2019 at Hyatt Regency, Lucknow.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.
- Invited guest lecture series on Biodiversity and Pollution for UG and PG students (FRM) at College of Fisheries (CAU), Lembucherra, Tripura during December 23-27, 2019.

Technical Personnel

- Dr. Rajesh Dayal, Chief Technical Officer participated and delivered a 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. Satyendra Mohan Srivastava, Chief Technical Officer participated in following activities:

- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

Dr. A.K. Yadav, Chief Technical Officer participated in following activities:

- Bundeli Krishi Chaupal organized by BUAT, Banda, U.P at Jakhani village on June 19, 2019.
- Fish culture training for farmers at KVK, ICAR-IVRI, Bareilly on July 30, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

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

- International conference BRAQCON organized by ICAR-CIBA at Chennai during January 22-25, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

Smt. Reeta Chaturvedi, Assistant Chief Technical Officer participated in following activities:

- Training programme on Cyber-crime and Ethical Hacking at CDAC, Bangalore from July 29 to August 2, 2019.
- Training on e-office organized at ICAR-NBFGR during October 25-26, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

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

- Participated in the training programme on Koha for Library staff of ICAR organized by ICAR-NAARM, Hyderabad during February 21-26, 2019.
- भाकृअप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर में भाकृअप में राजभाषा हिन्दी के बदलते आयाम विषय पर दिनांक 30–31 अगस्त, 2019 तक आयोजित दो दिवसीय हिन्दी कार्यशाला में भाग लिया।
- Workshop on ICAR ERP FMS held at ICAR-IASRI, New Delhi on October 15, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

Dr. Akhilesh Kumar Mishra

- Training programme on Fish Milt Cryopreservation for Genetic Upgradation of Brooders at ICAR-NBFGR, Lucknow from March 27-30, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

Dr. Ranjana Srivastava, Senior Technical Officer participated in Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

Mr. Ravi Kumar, Senior Technical Officer participated in following activities:

- Training on e-office organized at ICAR-NBFGR during October 25-26, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

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

- 14th Agricultural Science congress on the theme "Innovations for Agricultural Transformation" at New Delhi from February 20-23, 2019.
- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

Shri Satya Veer Chaudhary, Senior Technical Officer participated in following activities:

- Training programme on Koha for Library staff of ICAR organized by ICAR-NAARM, Hyderabad during February 21-26, 2019.
- National Conference of Agriculture Librarians and Users Community (NCALUC-2019) on Role of Agriculture Libraries in the Networked Digital Environment organized by Navsari Agricultural University, Navsari, Gujarat during September 25-27, 2019.
- J-Gate@ CeRA Regional Training Program-2019 organized by ICAR-DKMA, NASC, New Delhi and Informatics Publishing Ltd., Bengaluru during November 15-16, 2019.
- National training programme for library professionals of SAUs, CUs, DUs, and ICAR Institutes on Implementation of KOHA and Creation of User-Friendly Interface-OPAC organized by National Knowledge Management Centre for Agriculture Education and Research at ICAR-IVRI, Izatnagar on October 23, 2019.
- 8th International Library and Information Professionals Summit (I-LIPS2019) on Empowering Libraries with Emerging Technologies for Common

Sustainable Future organized by Babasaheb Bhimrao Ambedkar University, Lucknow during November 22-24, 2019.

- Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

Shri Sanjay Kumar Singh, Senior Technical Officer participated in Conference on One Health & Ecosystem Services (OHES-2019) during November 29-30, 2019 organized by ICAR-NBFGR and Academy of Environmental Biology (AEB) at NBFGR, Lucknow.

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

- Training program on Antimicrobial resistance, surveillance, hands on workshop of AMR Project, jointly organized by ICMR & ICAR at CMC Hospital, Vellore, Tamil Nadu, during September 9-11, 2019.
- National symposium on Coldwater Fisheries Development in India: Innovative Approaches and Exhibition held at ICAR-DCFR, Bhimtal during September 24-25, 2019.

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 & Accounts Officer and Shri Tej Singh Seepal, Assistant Administrative Officer participated in workshop on ICAR ERP FMS held at ICAR-IASRI, New Delhi on October 15, 2019.

श्री राम सकल चौरसिया, वैयक्तिक सहायक ने भाकृअप–केन्द्रीय शुष्क बागवानी संस्थान, बीकानेर में भाकृअप में राजभाषा हिन्दी के बदलते आयाम विषय पर दिनांक 30–31 अगस्त, 2019 तक आयोजित दो दिवसीय हिन्दी कार्यशाला में भाग लिया।

Shri Ravi Bhadra, Assistant Finance & Accounts Officer; Shri Tej Singh Seepal, Assistant Administrative Officer; Smt. Mamta Chakraborty, Private Secretary; Shri Ram Sakal Chaurasia, Personal Assistant; Shri Sandeep, Junior Stenographer; Smt. Kaneez Fatima, Assistant; Shri Swapan Debnath, Assistant; Shri S.N. Srivastava, Assistant; Shri P.K. Awasthi, Assistant; Shri Sajivan Lal, Assistant; Shri Shreelal Prasad, Senior Clerk; Shri Vinay Kumar Srivastava, Senior Clerk; Shri Santosh Kumar Singh, Shri Ram Baran, Senior Clerk; Shri P.C. Verma, Junior Clerk; Shri Rajan Kumar Malhotra, Junior Clerk and Shri Vikrant Gupta, Junior Clerk attended training on e-office organized at ICAR-NBFGR during October 25-26, 2019.

SPORTS

ICAR-NBFGR promotes well-being and sportsmanship. A total of 34 staff members including 3 females from ICAR-NBFGR, Lucknow participated in the ICAR North Zone Sports Tournament held at ICAR-Indian Institute of Pulses Research (IIPR), Kanpur during December 12-14, 2019. About 800 participants from various institutes took part in the tournament.

The team members of ICAR-NBFGR actively participated in several events under the *Chef-de-Mission,* Mr. Chandra Bhushan Kumar. The institute bagged 4 medals (3 gold and 1 bronze). The winners of gold medals were Mr. Tej Singh Seepal and Mrs. Kaneez Fatima in Carrom event, and Mrs. Mamta Chakraborty in Chess, and the winner of bronze medal was Mr. Chandra Bhushan Kumar in Javelin throw.

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 headquarters, 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 7587 books, 15 e-books and 3348 bound volumes of journals and other reference materials. In addition to these, 32 journals were received on gratis/exchange basis.

Library Automation

The Library is operating in fully automated environment. The various activities of library have been computerized using KOHA: Open Source Library System, Version 18.05.05.000 with technical support from CSIR-National Institute of Science Communication and Information Resources (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 is made available for the library users.

Information and Reference Services

The Library rendered information and reference services to its users including locating materials, using the Online Public Access Catalogue (OPAC) 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 was provided through J-Gate Plus platform. The users of the library extensively used the Consortium for e-Resources in Agriculture (CeRA) to access 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 facilitated questionnaires on Bureau's infrastructure and other facilities. The unit also provided active reprography services, comb binding, spiral binding, and lamination facilities.

Exchange Services

The Library continued exchange relationship and resource sharing with leading national and international research institutes and development organizations. To keep abreast of the activities of the Bureau, the library sent the ICAR-NBFGR Annual Report 2018-2019 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

Relieving

	Scientist	Date of relieving
1.	Shri Trivesh Suresh Mayekar, Scientist relieved from ICAR-NBFGR, Lucknow to join at ICAR-CCARI, Goa	07.12.2019
	Administration	
1.	Shri Navin Kumar, Assistant Administrative Officer relieved from ICAR-NBFGR, Lucknow to join at ICAR-NBAIM, Mau, Uttar Pradesh as Administrative Officer	30.08.2019

Resignation

	Scientist	Date of resignation
1.	Dr. A Kathirvelpandian, Scientist, resigned to join the post of Associate professor, TNJFU, Tamil Nadu	10.07.2019
	Administration	
1.	Shri Darvesh Kumar, Administrative Officer, resigned to join the post of Dy. SP, Uttar Pradesh Police Department	07.09.2019

Promotions

	Technical	Promotion w.e.f.
1.	Dr. Rajesh Dayal, Chief Technical Officer (T-9) granted advance increment	03.02.2017
2.	Dr. S.M. Srivastava, Chief Technical Officer (T-9) granted advance increment	06.02.2017
3.	Shri Subhash Chandra, Sr. Technical Officer (T-6) Level-10 promoted to Assistant Chief Technical Officer (T -7/8) Level-11	18.09.2017
4.	Shri B.K. Rao, Technical Assistant (T-II-3) promoted to Sr. Technical Assistant (T-4) and to Technical Officer (T-5)	22.12.2004
5.	Shri Babu Ram, ACTO (T-7/8) Level-11 promoted to Chief Technical Officer (T-9) Level-12	24.02.2018
6.	Shri Surendra Pratap Singh, ACTO (T-7/8) Level-11 promoted to Chief Technical Officer (T-9) Level-12	24.02.2018
7.	Shri Prem Chandra, Sr. Technical Officer promoted to Asstt. Chief Technical Officer (T-7/8) Level-11	06.01.2016.
	Administration	**Promotion w.e.f.**
1	Shri P.K. Awasthi, Assistant promoted to Assistant Administrative Officer	20.12.2019

MACP

	Administration	Promotion w.e.f.
1.	Shri Ravi Bhadra, AF&AO granted 1st Financial up-gradation (Level-8)	06.11.2018
	Skilled Support Staff	
2.	Shri Ashok Kumar, Skilled Support Staff granted 1st Financial up-gradation (Level-2)	30.07.2019

Retirement

1.	Dr. A.K. Pandey, Principal Scientist	31.01.2019

Demise

1.	Shri Prahalad Kumar, Skilled Support Staff	23.04.2019

Staff Position

	Research Management/ Director	Scientist	Administrative	Technical	SSS
Sanctioned	01	41	21	38	20
In position	01	32	18	29	19

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 Pryagraj, 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

23rd RAC meeting of the Institute was held on March 18-19, 2019. The composition of the 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

QUINQUENNIAL REVIEW TEAM MEETING

The Indian Council of Agricultural Research (ICAR) constituted the Quinquennial Review Team (QRT) *vide* its letter No. F.No. Fy/7-5/2018-IAVI dated 26.11.2018, to assess the contributions made by ICAR-NBFGR and also to evaluate the progress, constraints, potential strategies and plans, both in scientific research and management of the programmes undertaken during the 5-year period from April, 2013 to March, 2018.

The composition of QRT is as under:		
1.	**Dr. (Mrs.) B. Meenakumari** Former Chairperson, National Biodiversity Authority Thevara, Kochi-682013, Kerala	Chairperson
2.	**Dr. Syed Ajmal Khan** Honorary Professor Annamalai University Faculty of Marine Science, CASMB Parangipettai-608502, Tamil Nadu	Member
3.	**Dr. N. Saravanane** Scientist F, Centre for Marine Living Resources & Ecology, Ministry of Earth Sciences Government of India Kochi, Kerala	Member
4.	**Dr. S.D. Singh** Former ADG (Inland Fisheries) Gomti Nagar, Lucknow	Member

The composition of QRT is as under:		
5.	**Dr. K. Sivakumar** Head & Scientist Department of Endangered Species Management Wildlife Institute of India Dehradun-248001, Uttarakhand	Member
6.	**Dr. Sridhar Sivasubbu** Principal Scientist CSIR- Institute of Genomics & Integrative Biology (IGIB) Sukhdev Vihar, Mathura Road, New Delhi-110025	Member
7.	**Dr. S.C. Mukherjee** Former Joint Director, CIFE Bhubaneswar-751007, Odisha	Member
8.	**Dr. (Mrs.) Vindhya Mohindra** Principal Scientist & HoD ICAR-NBFGR, Lucknow	Member Secretary

DISTINGUISHED VISITORS

The following distinguished guests visited ICAR-National Bureau of Fish Genetic Resources, Lucknow during the period:

- Dr. B. Meenakumari, Former Chairperson, National Biodiversity Authority, Chennai and Former Deputy Director General (Fisheries), Indian Council of Agricultural Research, New Delhi
- Shri J. Balaji, IAS, Joint Secretary, Department of Fisheries. Govt. of India, New Delhi.
- Ms. I. Rani Kumudini, IAS, Chief Executive, National Fisheries Development Board, Hyderabad, Telangana
- Prof. M.L.B. Bhatt, Vice-Chancellor, King George Medical University, Lucknow, Uttar Pradesh
- Dr. Habibar Rehman, Regional Representative, South-East Asia, International Livestock Research Institute, New Delhi
- Dr. J.K. Jena, Deputy Director General (Fisheries and Animal Sciences), Indian Council of Agricultural Research, New Delhi
- Prof. Brij Gopal, Former Professor, Jawahar Lal Nehru University, New Delhi
- Prof. T. Balasubramanian, Vice-Chancellor, Chettinad Academy of Research and Education, Tamil Nadu
- Dr. Neelam Ramaiah, Tokyo University India Office, New Delhi
- Dr. Ramaiah Nagappa, Former Scientist, National Institute of Oceanography, Goa
- Dr. Krishna Gopal, Former Scientist CSIR-Indian Institute of Toxicological Research Lucknow, Uttar Pradesh
- Prof. Jaswant Singh, President Academy of Environmental Biology, Lucknow, Uttar Pradesh
- Dr. Dilip Kumar, Former Director & VC, ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra
- Dr. W.S. Lakra, Former Director & VC, ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra
- Dr. George John, Former Advisor, Department of Biotechnology, New Delhi and Former VC, BAU, Ranchi, Jharkhand
- Dr. M. Sinha, Former Director, ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, West Bengal
- Dr. Madhumita Biswas, Advisor, Ministry of Environment, Forests and Climate Change, Govt. of India, New Delhi.
- Prof. P.C. Joshi, Former Principal, Maharaja Bijlee Pasi Government P.G. College, Lucknow, Uttar Pradesh
- Dr. S.K. Singh, Director, Department of Fisheries U.P., Lucknow, Uttar Pradesh
- Prof. S.P. Trivedi, Department of Zoology, University of Lucknow, Lucknow, Uttar Pradesh
- Dr. A.S. Ninawe, Former Advisor, Department of Biotechnology, New Delhi
- Dr. H.N. Dutta, Former Scientist CSIR-National Physical Laboratory, New Delhi
- Dr. Mala Kapoor, Director-Principal, Silver Line Prestige School, Ghaziabad, Uttar Pradesh
- Shri. Nitin Kaushal, Associate Director, WWF-India, New Delhi
- Dr. P.M. Govindakrishnan, Bioversity International, New Delhi
- Prof. Vineeta Shukla, Mahardshi Dayanand University, Rohtak, Haryana
- Prof. K. Vijaykumar, Gulbarga University, Kalaburagi, Karnataka
- Prof. Bechan Sharma, University of Allahabad, Prayagraj, Uttar Pradesh
- Prof. Raghvendra S. Kulkarni, Gulbarga University, Gulbarga, Karnataka

- Dr. A.D. Pathak, Director ICAR-Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh
- Dr. S. Rajan, Director ICAR-Central Institute for Subtropical Horticulture, Lucknow, Uttar Pradesh
- Dr. Roger W. Doyle, President, Genetic Computation Ltd., Victoria, BC, Canada
- Dr. Yuan Derun, Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand
- Prof. Kenton L. Morgan, Chair of Epidemiology, Institute of Ageing and Chronic disease, University of Liverpool, United Kingdom
- 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, Research Institute for Aquaculture, Ho Chi Minh, Vietnam
- Dr. Murray A. Godfrey, Abbey Road, Aberdeen, AB11 9PE, United Kingdom
- Dr. B.R. Pillai, Director, ICAR-Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar, Odisha
- 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. Kamala Adhikari, Senior Fisheries Development Officer, Fisheries Development Office, Banke, Nepal
- Dr. Graham C. Mair, Senior Aquaculture Officer (Genetic Resources), Food and Agriculture Organisation of the UN, Viale delle Terme Di Caracalla Rome, Italy
- Dr. Anup Mandal, Rajiv Gandhi Centre for Aquaculture (RGCA) Director, Sattanathapuram P.O. Sirkazhi Taluk, Nagapattinam, Tamil Nadu
- Dr. Vishwanath T.S., National Fisheries Development Board, Hyderabad, Telangana
- 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
- Dr. Sangeeta Srivastava, Principal Scientist, ICAR-Indian Institute of Sugarcane Research, Lucknow
- Dr. Diksha Joshi, Senior Scientist, ICAR-Indian Institute of Sugarcane Research, Lucknow

COMMITMENT TO SOCIETAL INITIATIVES OF GOVERNMENT OF INDIA AND ICAR

International Yoga Day

International Yoga Day was celebrated at ICAR-NBFGR on June 21, 2019. The yoga session started at 6.15 AM and ended at 7.30 AM, which was open for all staff and their family members. Dr. Basdeo Kushwha, Principal Scientist and Nodal Officer, Yoga welcomed the yoga teachers, Mr. Pavan Kumar Singh and Mr. Ajitabh Vishwakarma and the participants from ICAR-NBFGR. The yoga teachers explained the benefits of practicing yoga in daily life in order to maintain overall body fitness as well as peace of mind. The yoga session was conducted under their guidance with live demonstration of various *Aasanas* and *Pranamayas* as per the International Yoga Day protocol of AYUSH Ministry, Government of India, New Delhi. The same was also observed by staff members of PMFGR Division of ICAR- NBFGR at Kochi.




Yoga Day Celebration 2019

Swachh Bharat Abhiyaan

ICAR-NBFGR undertook great efforts to make its campus and premises more clean and green. A change in people's perception on cleanliness and awareness was noticed during the year. Other than the routine monthly cleaning activities, the institute observed 3 special cleanliness campaigns. The summary of these programs are as follows:

1. Swachhta hi Sewa pakhwada of 17 days duration from September 11 to October 2, 2019 was organised. A total of 16 different cleaning and awareness activities were undertaken by the staff and research scholars of the institute. The pakhwada was kick-started on September 11 by holding a mass swachhta pledge by all the staff and research scholars of the institute. Awareness activity on "Plastic Segregation" was undertaken by the staff in the campus. Lectures on "Plastic Alternatives" and "Mahatama Gandhi ji" were delivered. Tributes were paid to Mahatma Gandhi ji on his birthday, October 2, 2019. Also, an initiative for plastic collection and segregation in residential household was also launched on this day. They were provided with dustbins for collecting wet and dry waste separately.

2. A special plastic waste disposal campaign called Samuchit Niptaan campaign of 25 days was held from October 3 to 27, 2019. In this program, emphasis was on disposal of plastic waste collected during earlier cleanliness programs. Awareness programs were conducted in institute and residential premises on safe and clean plastic disposal.

3. Another Swachhta hi Sewa pakhwada of 15 days was celebrated during December 16-31, 2019. A total of 13 cleaning related programmes and activities were carried out. To foster a spirit of competition, certain events like debate on "Swachh Bharat Abhiyaan has been effective", painting contest for school children on "Plastic Pollution" were organised. Various cleanliness drives were undertaken by the institute during the pakhwada both in office premises and in public places.

Sneak peek of various Swachh Bharat Abhiyaan activities

Digital India

Cashless transactions

The ICAR-NBFGR, Lucknow continued implementing the digital mode in its financial transactions. During the year under report, a total of 6745 transactions amounting to Rs. 4420.61 lakhs was carried out electronically.

Government E-Market (GeM)

The Institute is implementing e-procurement policy of Government of India. During the year under report, about 100 different kind of items were processed through GEM (Govt. e-marketing). 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 reduced use of single use plastic, paper 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 माह

संस्थान में 13 सितंबर – 14 अक्टूबर, 2019 के दौरान हिंदी चेतना मास का आयोजन किया गया। इस अवधि के दौरान राजभाषा हिंदी के महत्व को ध्यान में रखते हुए कई कार्यक्रमों एवं प्रतियोगिताओं का आयोजन किया गया। हिंदी माह का उद्घाटन 13 सितंबर, 2019 को किया गया, जिसमें संस्थान के सभी कर्मचारियों ने भाग लिया। कार्यक्रम के समापन समारोह का आयोजन दिनांक 14 अक्टूबर, 2019 को किया गया, जिसकी अध्यक्षता डॉ. कुलदीप कुमार लाल, निदेशक, भा.कृ.अनु.प.–रा.म.आ.सं. ब्यूरो, लखनऊ ने की। हिंदी माह के दौरान 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 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 30 मार्च, 2019, 26 जून, 2019, 26 सितम्बर, 2019, तथा 26 नवम्बर, 2019 को किया गया।

हिंदी कार्यशालाओं 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।

पुरस्कार

संस्थान द्वारा प्रकाशित हिंदी पत्रिका 'मत्स्यलोक' सप्तम 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

नगर राजभाषा कार्यान्वयन समिति (कार्यालय-3), लखनऊ

भाकृअनुप-भारतीय गन्ना अनुसंधान संस्थान, लखनऊ

क्रमांक : 01 दिनांक : 26 नवम्बर, 2019

प्रमाण पत्र

प्रमाणित किया जाता है कि भाकृअनुप-राष्ट्रीय मत्स्य आनुवांशिक संसाधन ब्यूरो, लखनऊ ने अप्रैल-सितम्बर छमाही अवधि (2019–20) में 'राजभाषा पत्रिका : मत्स्य लोक' हेतु प्रथम स्थान प्राप्त किया।

राजभाषा कार्यान्वयन में इस कार्यालय के अधिकारियों/ कर्मचारियों का यह प्रयास अत्यंत सराहनीय है।

(अजय कुमार साह)
सचिव
नराकास (कार्यालय-3), लखनऊ
एवं
प्रधान वैज्ञानिक
भाकृअनुप-भारतीय गन्ना अनुसंधान संस्थान, लखनऊ

(श्रीमती दीप्ति पाठक)
अध्यक्ष
नराकास (कार्यालय-3), लखनऊ
एवं
निदेशक
भाकृअनुप-भारतीय गन्ना अनुसंधान संस्थान, लखनऊ

GANGA AQUARIUM: PUBLIC AWARENESS OF 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 48 freshwater and 7 marine aquaria that display more than 60 fish species (100 variants) of both fresh and marine water. Decorative glass roof fitted at the top of the fountain gives a unique appealing look to the aquaria. General information of fishes is displayed through digital display boards. RAS system was installed to supply filter water to mermaid tank at the entrance.

Recently, the aquarium has thrust to display indigenous fish species. New species added to the collection this year includes *Aphanius dispar, Labeo rajasthanicus, Sperata seenghala, Schizothorax richardsonii* among others. Public can also enjoy watching the freshwater fishes like arowana, flower horn, alligator gar, ghost fish, etc. The live aesthetic displays serve as an avenue to enhance awareness towards fish diversity and its conservation among public.

Revenue Generation

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 18771 person visited the aquarium which resulted in a collection of Rs. 3.72 lakh from entry ticket sales.

LIST OF PERSONNEL

Research Management

S. No.	Name		Designation
Dr. Kuldeep K. Lal		-	**Director**
1.	Dr. Ravindra Kumar	-	Head of Division (MBB)
2.	Dr. Vindhya Mohindra	-	Head of Division (FC)
3.	Dr. Gaurav Rathore	-	Head of Division (FHM&E)
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. Raja Swaminathan	-	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 (Relieved on 10.07.2019)
23.	Dr. Sangeeta Mandal	-	Scientist
24.	Dr. Rejani Chandran	-	Scientist
25.	Dr. Santosh Kumar	-	Scientist
26.	Dr. Aditya Kumar	-	Scientist
27.	Dr. Labrechai Mog Chowdhury	-	Scientist
28.	Dr. Charan Ravi	-	Scientist
29.	Dr. Murali S.	-	Scientist
30.	Shri Trivesh Suresh Mayekar	-	Scientist (Transferred on 07.12.2019)
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

Technical Staff

S. 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.	Smt. 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 Kumar	-	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

Administrative Staff

S. No.	Name		Designation
1.	Shri Darvesh Kumar	-	Administrative Officer (relieved from 07.09.2019)
2.	Shri Ravi Bhadra	-	Assistant Finance & Accounts Officer
3.	Shri Navin Kumar	-	Assistant Administrative Officer (transferred on 30.08.2019)
4.	Shri Tej Singh Seepal	-	Assistant Administrative Officer
5.	Smt. Mamta Chakraborty	-	Private Secretary
6.	Shri Ram Sakal Chaurasia	-	Personal Assistant
7.	Shri Sandeep	-	Junior Stenographer
8.	Smt. Kaneez Fatima	-	Assistant
9.	Shri Swapan Debnath	-	Assistant

S. No.	Name		Designation
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

S. No.	Name		Designation
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 (Up to 23.04.2019)
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 at Lucknow

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 Uttar Pradesh
- Baba Bhimrao Ambedkar University (Central University)
- Lucknow University
- King George's Medical University
- Sanjay Gandhi Post-Graduate Institute of Medical Sciences
- Biotechnology 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

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 (CARE), 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 (CUSAT), 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 (KUFOS), Kochi, Kerala
- College of Fisheries, Odisha University of Agriculture & Technology, Odisha
- College of Fishery Sciences, Sri Venkateswara Veterinary University, Andhra Pradesh
- College of Fisheries, Udaipur, M.P.U.A.T, Rajasthan
- College of Fisheries, Chandra Shekhar Azad Agricultural University, Kanpur, Uttar Pradesh

- Department of Marine and Coastal Studies, Madurai Kamaraj University, Tamil Nadu
- Department of Life Sciences, Assam University, Silchar, Assam.
- Department of Life Sciences, Manipur University, Manipur.
- Department of Zoology, Guwahati 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
- Dr. Ram Manohar Lohia Avadh University, Ayodhya, Uttar Pradesh
- Fisheries 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, Pusa, New Delhi
- ICAR-National Bureau of Animal Genetic Resources, Karnal
- ICAR-National Bureau of Plant Genetic Resources, New Delhi, Delhi
- ICAR-National Institute of Veterinary Epidemiology and Disease Informatics, Bengaluru, Karnataka
- ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana
- Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana
- Hemvanti Nandan Bahuguna Garhwal University, Srinagar, Garhwal, Uttarakhand
- National Remote Sensing Centre, Hyderabad, Telangana
- Kerala Forest Research Institute, Thrissur, Kerala
- CSIR-National Institute of Oceanography, Panaji, 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

On the international level, NBFGR had 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 Office
- Bioversity International, South and South-East Asia Office
- 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
- Universidad Nacional De Tumbes – Incabiotech, Tumbes, Peru

D. Extension and Development Agencies

The NBFGR has established good working relationship 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:

- National Fisheries Development Board, Hyderabad.
- Mangrove Cell, Government of Maharashtra, Maharashtra
- Marine Products Export Development Authority, Kochi
- Department of Biotechnology, Ministry of Science and Technology, New Delhi
- Department of Science and Technology, Ministry of Science and Technology, New Delhi
- National Biodiversity Authority, Chennai, India
- Department of Animal Husbandry, Dairying and Fisheries, Govt. of India, New Delhi
- University Grants Commission, New Delhi
- Science and Engineering Research Board, New Delhi
- 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

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 details of training program organized and attended by all the staff in ICAR & Non-ICAR institutes are as follows:

A. Physical targets and achievements

S. No.	Category	Total No. of Employee	No. of trainings planned for year 2019 (Jan-Dec) as per ATP	No. of employees undergone training during Jan-June 2019	No. of employees undergone training during July -Dec 2019	Total number of employees undergone training during Jan -Dec. 2019	% realization of trainings planned during (Jan-Dec) 2019
1	2	3	4	5	6	7 (5+6)	8
1	Scientist	34	5	0	4	4	80
2	Technical Staff	30	3	0	3	3	100
3	Administrative Staff	20	..	0	1	1	100
4	SSS	18	1	0	18	18	100

B. Financial targets and achievements (Rs. in lakhs)

S. No.	RE for HRD 2019-20			Actual Expenditure			% Utilization
	Plan	Non-plan	Total	Plan	Non-plan	Total	
1	2	3	4 (2+3)	5	6	Col. 5+6=7	(Col 7*100/Col.4)=8
1	5.43	0	5.43	5.42	0	5.42	99.82

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 Jan to June 2019	No. of trainings organized during July to Dec. 2019	Total number of trainings organized during Jan - Dec. 2019	No. of participants (only ICAR employees)		
					Organizing Institute	Other ICAR Institutes	Total
1	2	3	4	Col. 3+4=5	6	7	6+7=8
1	Scientist		1	1	38	4	42
2	Technical Staff		1	1	30	0	30
3	Administrative Staff		1	1	20	0	20
4	SSS		1	1	18	0	18

Coordination & management

- Coordinated the capacity building activities through training of researchers in different field of fishery science by ICAR-NBFGR. The details of the training programmes as follows: graduate students (08), PG diploma students (06), post graduate students (05), Ph.D. students (05), faculty (01). The students underwent training belongs to 1. Amity Institute of Biotechnology, Lucknow, 2. M.E.S. college, Kerala, 3. Shree Narayana College, Cherthala, Kerala, 4. Amity Institute of Marine Science & Tech., Noida, U.P., 5. Bundelkhand University, Jhansi, U.P., 6. University of North Bengal, Darjeeling, West Bengal, 7. College of Fishery Science & Research, CSA University of Agriculture & Technology, Kanpur, U.P., 8. Lucknow University, Lucknow, U.P. and 9. Allahabad University, Prayagraj.
- A revenue of Rs. 1.80 Lakh as a nominal fee from students/researchers during the period was received.

Back cover background

Fishing boats at Anjarle, Ratnagiri, Maharashtra

Back Inner cover background

Fishing boat at Lakshadweep Island

Back cover description

1. *Lysmata hochi* Baeza & Anker, 2008, New distributional record to India
2. *Thor hainanensis* Xu & Li, 2014, New distributional record from India; Hatchery bred young ones with anemone
3. *Urocaridella arabianensis*, New discovery
4. Captive raised broodstock of *Gnathophyllum americanum* Guérin-Méneville, 1855
5. *Periclimenella agattii*, New discovery
6. Hatchery bred young ones of *Periclimenes brevicarpalis* (Schenkel, 1902)
7. Asexually propagated individual of *Heteractis magnifica* (Quoy & Gaimard, 1833)

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