ANNUAL REPORT
2020

ICAR-National Bureau of Fish Genetic Resources

Canal Ring Road, P.O. Dilkusha, Lucknow-226 002, INDIA

Front cover

The year 2020 was challenging due to covid-19 pandemic. In this period of uncertainty, new strategies were undertaken to ensure continuation of ongoing research activities with increased support to farmers, entrepreneurs and researchers

Description

1. Harvest of Indian Major Carps at ICAR-NBFGR fish farm, Lucknow
2. Experimental fishing with the help of local fishermen
3. Milt collection of IMCs
4. Sale of *Dawkinsia rubrotinctus* and *Pethia setnai* seed to ornamental entrepreneur
5. Exploration and collection of marine invertebrate specimens off Lakshadweep coast

a) Cage fish farming facility developed by ICAR-NBFGR
b) Captive raised young ones of *Pethia setnai*
c) Fingerlings of *Horabagrus brachysoma* supplied to fishermen
d) Diseased koi carp
e) Revision of the *Sperata* catfish genus in India

Front inner cover background

Experimental fishing in the river Tons at Chakghat, near Prayagraj

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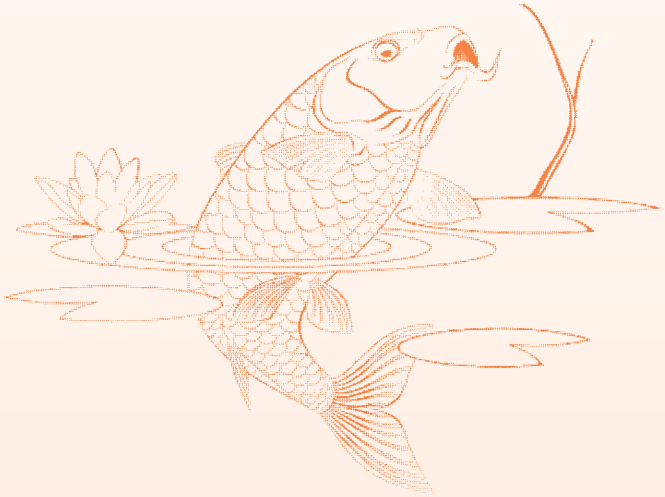

भा.कृ.अनु.प.–राष्ट्रीय मत्स्य आनुवंशिक संसाधन ब्यूरो

ICAR-National Bureau of Fish Genetic Resources

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PREFACE

India is among a few countries having institutionalized and systematic scientific research system on aquatic genetic resource management through ICAR-National Bureau of Fish Genetic Resources (NBFGR)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.

ICAR-NBFGR has been a focal point to address research pertaining to documenting the aquatic genetic resources and the diversity therein, mainstreaming the genetic diversity and capacity building of stakeholders and peer researchers, and scientific inputs for policy making and compliance to international obligations. With the mission of collecting, cataloguing and documentation of fish genetic resources using operational strategies of partnership and cutting edge technologies, ICAR-NBFGR envisages to assess and conserve fish genetic resources for intellectual property protection and sustainable utilization. In addition to these, institute also works on evaluating indigenous and exotic germplasm for risk assessment and fish health. Multi-faceted research taken up by the proficient researchers of the institute, with the support of advanced technologies has helped ICAR-NBFGR scale greater heights since its inception in 1983. The output has enabled the institute to provide technical support to not only national organizations/ bodies like MPEDA and NFDB; but also to International organizations like FAO and OIE. Over the years, the institute has emerged as a Centre of Excellence for research on fish genetic resource management and has made significant contributions in its mandated research areas.

The historical 2020 was a challenging year considering the COVID-19 pandemic, affecting all aspects of research & development initiatives including health, travel and economy. In this year of uncertainty, fear and crisis, new strategies were undertaken to ensure continuation of ongoing research activities with increased focus on safety of researchers. Sampling and exploratory surveys were undertaken following COVID-19 guidelines and quarantine rules. Exploratory surveys for documentation of fish diversity was undertaken for various river systems like the Godavari, Luni, Banas, Gandak, Burhi Gandak, Bagmati and Saraiyamaun wetland. Survey for documentation of alien fish species was undertaken at Yamuna, Ganga and Tons rivers. Exploratory survey to collect live specimens of *Tor putitora* and *Schizothorax richardsonii* for thermal tolerance study, *Hemibagrus punctatus* and *Clarias dussumieri* for breeding purposes among many others was also carried out. Lockdown period was fully utilized by our researchers in dissemination of research findings through research manuscripts, popular articles etc. which resulted in a record submission of 123 research manuscripts. Farm activities and farmer services were continuously rendered to different partner hatcheries situated in Bihar, Haryana, Madhya Pradesh, Rajasthan and Uttar Pradesh to supply cryopreserved milt for commercial seed production following COVID-19 guidelines. The efforts were fruitful as this initiative resulted in the production of 25 lakhs spawn. Information on economic losses due to fish diseases in Uttar Pradesh was collected through telephonic discussion with 126 farmers. Institute produced 1017 lakhs fish seed from its Lucknow based hatcheries during this disturbed year too. Seed of ornamental fishes, *Dawkinsia rubrotinctus* and *Pethia setnai* and fingerlings of *Clarias dussumieri*,

Horabgrus brachysoma, *Labeo dussumieri* etc., were produced successfully and provided to needy entrepreneurs and farmers. The ICAR-NBFGR and DBT Germplasm Resource Centre for Marine Ornamental Invertebrates has been established in Agatti Island, Lakshadweep, funded by the Department of Biotechnology, Government of India, which is a new approach in the country. Over fifteen species of ornamental shrimps collected from the wild are maintained in this facility for germplasm conservation and captive propagation. Retail sale facility of marine ornamental fishes has also been established in Thane district of Maharashtra.

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 Dr. Yasmin Basade & Dr. Prem Kumar, Principal Scientists and other staff at Fisheries Division of ICAR for their cooperation.

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 also acknowledge to Dr. Rishi Tyagi, APCoAB Coordinator, APAARI for his repeated faith and confidence in some flagship activities of institute.

I express my heartfelt thanks to Chairman of Research Advisory Committee (RAC), Dr. A.G. Ponniah and all the esteemed members with gratitude for their valuable and consistent guidance in shaping the institute's programmes.

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 2020 of the institute.

Date : March 31, 2021

(Kuldeep K. Lal)
Director

CONTENTS

EXECUTIVE SUMMARY

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

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

  For documenting fish diversity in three least studied mid-Himalayan tributaries namely, Gandak, Burhi Gandak, Bagmati and Saraiyaman wetland in North Bihar, exploratory surveys were conducted in these rivers. The upstream segments of Burhi Gandak and Bagmati Rivers were observed to be in fragmented state due to formation of channels. As a result, the stretches were excessively exploited for fishing activities. The substratum of all the rivers gradually changed from cobbles, pebbles, gravel, sand and silt laden in up-stream segments to sand, silt and clay towards mid and downstream stretches. The water temperature during winters varied between 18.01 °C (Belwaghat, Bagmati) and 18.5 °C (Valmikinagar, Gandak). The water was alkaline in nature (pH 7.6-7.8) with moderately high dissolved oxygen content (10.0-10.6 mg/l). Values of total dissolved solids (TDS), and conductance were between 137.0 - 238.0 mg/l & 272.0-483.0 µmhos, respectively. The rivers are under excessive fishing operations particularly in up and mid-stream segments. Collected a total of 24 fish species from Gandak, 18 from Burhi Gandak and 21 from Bagmati rivers. All the species collected during present exploration were already listed in earlier explorations. Hence, a total of 104 fish species were collected and identified from the rivers so far and categorized under 8 orders, 24 families and 66 genera. The fishes of the studied rivers were categorized as Endangered (1), Near Threatened (9), Data Deficient (1), Not Evaluated (3) and Least Concern (90), as per IUCN categorization. Further, 23 fish species have been encountered during the period in Saraiyaman wetland, Bettiah, West Champaran district, North Bihar, among these 19 were listed earlier. Four species were added to the existing fish diversity - *Ctenops nobilis, Labeo gonius, Cirrhinus reba* and *Parambassis lala*. *C. nobilis*, a rare species, commonly known as frail gouramy and categorized as Near Threatened by IUCN was collected for the first time in the wetland. Among the recorded species in the wetland 47 species are Least Concern and 4 Not Evaluated. Studied length-weight profile of 238 samples of *Rasbora daniconius* collected from Saraiyaman. The length varied from 63-85 mm with corresponding weight of 2.02 to 5.96 g. The average fish catch of fisher families dwelling in the wetland area was 0.3 to 1.5 kg/ day.

- **Cauvery River**

  Exploratory surveys were conducted in the upper reaches of the Cauvery in Kerala, the Kabini River, its tributary (2 stations) between its source and its confluence with the Cauvery, including the Banasurasagar Dam and Karaphuzha Dam. The survey yielded a total of 14 species of freshwater fish, bringing the total diversity to 117 fish 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 species, 4 stocked and 10 exotic species. Furthermore, 50 COI sequences were generated from the species having taxonomic ambiguity.

- **Luni and Banas River**

  Explorations were conducted in river Luni to document fish diversity pattern of fish diversity and to analyze the land use/ land cover (LULC) features at different time scale. The detailed LULC class attributes (level 2) were classified and grouped into 10 major classes *viz.* Cropland, Shrub land, Broadleaf forest, Needleleaf forest, Grassland, Wasteland, Wetlands, Urban area, Barren land and waterbodies. This LULC map can be used for the assessment of hydrological

changes and river corridor management by resource managers. Moreover, a total of 29 fish species have been reported so far from the river Luni and its tributaries. The occurrence data of the fish species from the survey and works reported by other workers in the published literatures were compiled and digitized. This data can be used later for distribution modelling. The present survey updated the fish diversity list of river Luni to 29 species with inclusion of *Notopterus notopterus* and *Cirrhinus reba*. A total of 12 sampling sites were identified along the river Banas covering different hydrological units like streams, pools, lakes and reservoirs and confluence points. The wetted width of the river was wider in the midstream than the upstream. The pH of the water ranged from 7.13 to 9.14, while dissolved oxygen was between 3.4 and 6.4 mg/l. The total dissolved solids content ranged from 109.85 to 746.5 ppm. The fish diversity of the river Banas revealed the occurrence of 32 species belonging to 26 genera of 13 families and 7 orders. Cyprinidae was the richest family in terms of species diversity (15 species) followed by Bagridae (4 species). The exotic fish namely Nile tilapia and common carp were reported from the midstream segment of this river.

- **Andaman and Lakshadweep Islands**

  Exploratory surveys were carried out in five islands of Lakshadweep *viz.* Agatti, Thinnakara, Bangaram, Parali I and II. A total of 53 fish specimens were collected from different islands comprising of 26 species belonging to 13 families. This added to the earlier collection, resulting in 110 species of marine fishes belonging to 40 families and 70 genera. Thirty individuals of 23 species, belonging to 9 families were collected from Junglighat, Rose Island and Chidiya Tapu regions of Andaman Islands. COI sequences were generated for 23 specimens collected from both the island regions. The project led to the discovery of new species *Alpheus* sp. from Gulf of Mannar, new distribution record of Palaemonid shrimp, *Urocaridella antonbruunii* in Indian waters and new distribution record of *Anchistus miersi* from Lakshadweep Sea.

- **Evolutionary study of Indian clupeiform fishes**

  For assessing the species-wise genetic diversity in clupeiform species distributed in Indian waters, explorations were carried out in Vizhinjam, Calicut and Kochi (Kerala), Mangaluru (Karnataka), Nagarjuna Sagar Dam (Telangana) and Gulf of Mannar (Tamil Nadu) for collection of clupeiform species. Surveys were also conducted in Andaman and Lakshadweep Islands through secondary sources. A total of 56 tissue samples and voucher specimens of clupeiform fishes were collected. From the 15 clupeiform species collected from West Bengal Coast, a total of 71 COI sequences were generated. For vertebral counts and other osteological studies, specimens were X-ray scanned. Comparison of morphomeristic characters using classical taxonomy was carried out for the species of the family Chirocentridae, Engraulidae, Dussumieriidae, Pristigasteridae and Clupeidae. The NGS sequencing (Illumina NovaSeq 6000) has been completed for 3 species namely, *Amblygaster clupeiodes* (Clupeidae), *Dussumieria acuta* (Dussumieriidae) and *Coilia dussumieri* (Engraulidae). The time-scaled phylogenetic and evolutionary analyses showed that the speciation events in *Dussumieria* genus started around 82 thousand years ago (tya) starting zero from today. Before that, *Dussumieria* had only one species.

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

- **Evaluation of prioritized fish genetic resources**

  Endemic species *viz. Clarias dussumieri*, *Hemibagrus punctatus*, *Horabagrus brachysoma* and *Labeo dussumieri* collected from their natural habitat in Western Ghats, were developed as brooders and seeds were produced after induced spawning. Mass scale captive propagation of *C. dussumieri, H. brachysoma* and *L. dussumieri* and its evaluation in farmer ponds for aquaculture is underway. Young ones of these species were distributed to the Department of Fisheries, Government of Kerala for culture and developing them as broodstock and also to farmers for on-farm evaluation in their ponds. The possibility of hybridizing two clariid species was explored using fresh milt from *C. dussumieri* males and *C. magur* eggs. Hybrid progeny are being developed as brooder. At Nagarjuna Sagar dam, Telangana, 85 nos. of *Ompok bimaculatus,* 60 nos. of *Labeo*

calbasu, 40 nos. of *Notopterus notopterus* and 7 nos. of *Pangasius silasi* were collected and stocked in the cages installed for monitoring individual growth and for broodstock development.

- **Stock characterization**

  Chitala chitala: Genetic diversity and population structure in *C. chitala* (Hamilton, 1822) was deciphered by combined analyses of two full length mitochondrial genes, ATPase 6/8 and Cytochrome b. A total of 403 individuals collected from 14 rivers yielded 61 haplotypes. The mean coefficient of genetic differentiation (F_{ST}) was observed to be 0.26.

  Silonia silondia: Sequencing of combined mitochondrial genes (Cytochrome b + ATPase 6/8) exhibited 38 haplotypes in 247 individuals, belonging to 6 natural populations of Ganga and Mahanadi River systems. Average haplotype and nucleotide diversities were 0.8508 and 0.00231, respectively.

  Tor tor: Analysis of concatenated genes (1963 bp) of 140 individuals yielded 23 haplotypes. The total F_{ST} was found to be significant 0.51687 ($p < 0.05$), which revealed sub-structuring in the *T. tor* natural populations. Results point out the presence of four genetic stocks in the populations studied.

  Mugil cephalus: Mitochondrial gene sequence analysis revealed that the natural populations are sub structured. Microsatellite genotyping was done for n=510 samples at 19 polymorphic loci.

  Systomus sarana: Genetic diversity in *S. sarana* (n=228) individuals, collected from Son, Bhagirathi, Mahanadi, Godavari and Krishna was analysed using two mitochondrial genes, which indicate that populations of *S. sarana* were genetically structured and mean F_{ST} observed was 0.37.

  Anguilla bengalensis: Analysis of 88 samples from three locations of two rivers, Godavari (Dowleshwaram- 20 and Rajahmundry- 5) and Krishna (15) showed high haplotype diversity and low nucleotide diversity for both the mitochondrial genes.

  Shape morphometry: Truss network analysis was done in 343 specimens of *M. cephalus* collected from 17 sites. CDFA identified seven distinct stocks based on important truss variables. In *C. chitala*, PCA provided 6 significant principal components and contributed significantly up to 93.23% of total variation. In *S. silondia*, the truss network analysis was carried out by interconnecting 12 landmarks from digital images of specimens to identify phenotypic stocks. The morphological shape analysis clearly pointed out that variation in the insertion of adipose fin is important parameter, influencing the morphological discrimination in *S. silondia*. Truss analysis in *S. sarana*, identified parameters linked to caudal fin origin at dorsal side and the centre possibly indicate plasticity in response to locomotive adaptations.

  Length-weight relationship (LWR) in 476 specimen of *M. cephalus* showed 'b' value in the range between 2.235 (Ratnagiri) and 3.173 (Punnakkayal). LWR study in *C. chitala* (N=439 samples from 14 locations) indicated the value of *b* to range from 2.24 (Gomti) to 3.24 (Son). Further, the age and growth studies conducted for *M. cephalus*, *C. chitala*, *T. tor* and *S. sarana* showed the location with maximum growth rate was at Thengapattanam (*M. cephalus*), Bansagar (*C. chitala*) and in Narmada for both *T. tor* and *S. sarana*. The age classes varied from 0+ to 4+ in *M. cephalus* and *C. chitala,* while it varied from 0+ to 3+ in *T. tor* and *S. sarana.*

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

  A total of 16 sites were surveyed for the habitat and water quality assessment in Godavari River basin. Fish landing centres and markets associated with the study areas were visited to understand and document the fish diversity. The fish species sampled during the survey comprised of 10 orders, 20 families and 32 genera. Among these, four species belonged to Near Threatened category, while one species each was recorded as Endangered and two as Vulnerable. The pH in West Godavari landscape varied from 8.71-9.16, Karimnagar 8.3-8.74 and 8.43-8.62 in Adilabad landscape. Dissolved oxygen in West Godavari landscape varied from 10.1-13.06 ppm, Karimnagar landscape from 8.6-12.6 ppm while in Adilabad landscape varied between 7.6-12.8 ppm. Conductivity in West Godavari landscape varied from 0.14-0.17 mS/cm, Karimnagar landscape from 0.33-0.47 mS/cm while in Adilabad landscape varied between 0.38-0.50 mS/cm. The quantitative assessment of

sedimentation (river water) by different land use classes was studied in two watersheds *viz.* Hivra, a watershed in the upstream and Konta, a watershed in the downstream. The results showed that the sediment export (mean over all the classes) was 3.08 t/ha/yr in Konta, while it was only 0.73 t/ha/yr in Hivra watershed. Among the different land use classes, the highest sediment export was from grassland (5.36 t/ha/yr), followed by shrub land (5.32 t/ha/yr) and crop land (2.77 t/ha/yr) in Konta watershed, while the corresponding values in Hivra watershed were 0.72, 2.45 and 0.65 t/ha/yr, respectively. The mean sediment retention in Konta watershed was 118.43 t/ha/yr, while it was 15.49 t/ha/yr in Hivra. The study also showed that rainfall erosivity was the major factor for the difference in sediment export and retention between the two watersheds.

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

  Morphology of the specimens of *Lates calcarifer* collected from Tuticorin (15), Farakka (9) Chilika Lake (3), Alibag (25) and Kakinada (30) were compared with 25 specimens of *L. calcarifer* (Australia). Along with these, the morphometric details of 2 paratypes of *L. lakdiva,* holotype and 3 paratypes of *L. uwisara* and 11 specimens of *L. japonicas* were also compared. Microsatellite-marker based genotyping in *L. calcarifer* samples (n=64), collected from five different locations showed that the loci are independently inherited and can be used for genetic characterization. Sequencing of mitochondrial gene Cytb revealed the haplotype diversity ranging from 0.000 (Mahanadi and Farakka) to 0.833 (Goa). Nucleotide diversity (π) was observed with a range of 0.000 (Mahanadi and Farakka) to 0.0034 (Goa).

- **Phylogenetic relationships of Indian species of goatfishes**

  Exploratory survey for collection of goatfishes was undertaken during the reporting period and sample was collected from 9 different locations in Kerala, Tamil Nadu and Karnataka. A total of 85 specimens belonging to 7 species were collected. Meristic and morphometric data for 25 specimens were documented.

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

  Studying the expression of innate immune genes related to *TLR* pathway, especially fish-specific TLRs could serve as important immune mediators for understanding disease resistance in fish population. *TLR22* homologue in Indian magur, *Clarias magur* with specific signature domains were identified and characterized. 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*. The basal level expression of these important immune sentinels will be useful in delineating stocks with comparatively better health profile. Further, the levels of expression were differentially regulated at different time intervals for different tissues following *Aeromonas hydrophila* or poly I:C injection with significant up-regulation in gills, spleen and kidney at 8 to 72 hours post-injection. The regulation of *CmTLR22* in these important immune organs of *C. magur* indicates its PAMP sensing ability corresponding to Gram-negative pathogenic bacteria or dsRNA virus, which might aid in the molecular surveillance of innate immune of system of catfishes against different microbial invaders.

Program: Genomic resources for important fishes

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

  A total of 552 BAC clones of *Clarias magur* genome were revived and isolation of BAC insert DNA was accomplished. From these clones a total of 192 genes of *C. magur* were identified. Two FISH experiments using fluorescein and rhodamine probes were conducted for localising genes on *C. magur* metaphase chromosomes and it was observed that the clones were located in different chromosomes such as chromosome 11 (Sub-metacentric), 12 (Sub-metacentric), 18 (Sub-metacentric) and 20 (Sub-telocentric).

  Two genomic resource databases were updated using data available in public domain. FMiR was updated by 95 records of 95 species to contain 2432 records of 2432 species and Fish Karyome was updated by 61 records to contain 1256 records of 987 species.

- **Genomic factors responsible for growth performance in *Clarias magur***

A total of 183 growth-related genes could be identified from the available data sources and these genes were successfully mapped into the *Clarias magur* genome. From the available broodstock of *C. magur*, mating was done for creating 5 different families. Young-ones of different families are being reared and monitored for estimating growth performance. Moreover, genomic resource databases, *viz*. FBIS, FMiR, FishMicrosat, Fish Karyome and HRGFish, hosted through FisOmics web portal, were maintained and updated regularly.

- **Stress tolerance response in cultivable species**

  The critical highest temperature tolerance limits were determined in cold-water species in *Tor putitora* and *Scizothorax richardsonii*, which were recorded as 35 and 31.5 °C, respectively. In *Clarias magur* and *Labeo rohita* exposed to sub-lethal low water temperature (11 and 9 °C, respectively) for 45 days, thyroxin, triiodothyronine and cortisol decreased, whereas estradiol and testosterone levels were increased. Tissue specific proteome expression was also studied in seven tissues of *L. rohita* exposed to sub-lethal low temperature, in which a total of 2,765 proteins were retrieved from the control samples of *L. rohita* and 4,639 proteins were retrieved from experimental samples. The differential-protein expression profile can provide insight for understanding mechanism of protein regulation for stress management and adaptation to climate change.

- **Genome sequencing**

  The genome of *Catla catla* contained 1.094 Gb with 8,282 unique genes, which were categorized under metabolism (1,598 genes), genetic information process (1,087 genes), environmental information process (1,369 genes), cellular process (819 genes) and organismal system (995 genes). Further, comparative orthology of *C. catla* draft genome was done with other 41 teleosts genome available. DEG analysis of two growth stages revealed up-regulation of 535 genes, while 267 genes were down-regulated along with certain growth specific genes. Moreover, novel miRNA in *C. catla* genome was also predicted using small RNA sequencing technology and referencing zebrafish and human genome.

- **Genomic markers for cataloguing diversity below species level**

  For developing microsatellite panel in *Ompok bimaculatus*, a 1.5 kb library was constructed and sequenced on PacBio RSII. From the retrieved sequence, a total of 458 primers were designed for different type of repeats. In *Rita rita*, 198.3 Mb read data has been generated through Illumina NovaSeq 6000 for identifying microsatellite repeats.

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

  For comparative transcriptomics analysis of *Tor putitora*, transcriptome resources from different tissues (brain and liver) were generated for gene prospecting, allele mining and understanding of temperature adaptation in two different agroclimatic condition i.e., upstream of river Ganga (Uttarakhand) and Mahanadi. In brain, a total of 609 and 725 transcripts, representing 496 and 537 genes, were found to be up-regulated and down-regulated, respectively, in river Mahanadi as compared to Gangetic population. Maximum number of genes were found to be involved in chaperone complex (17 genes) followed by ionotropic glutamate receptor signalling pathways (17 genes), synaptic cleft (14 genes), *'de novo'* protein folding (14 genes) and positive regulation of telomerase activity (14 genes). In liver, a total of 1,030 and 634 transcripts representing 817 and 461 uni-genes were found to be up-regulated and down-regulated, respectively in Mahanadi, as compared to Gangetic population. Maximum numbers of genes were found to be involved in ER-nucleus signalling pathway (21 genes), followed by fatty acid binding (19), neutral amino acid transport (16), Cajal body (16), regulation of transforming growth factor beta production (16) and transforming growth factor beta production (16).

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

  The indigenous freshwater catfishes, *Clarias magur* and *Heteropneustes fossilis* are usually found in habitats with low dissolved oxygen and high ammonia content, hence, prone to ammonia toxicity. *H. fossilis* exposed to 25 mM of NH_4Cl showed elevated level of blood ammonia by 3, 4 and 6 fold at 3, 6 and 9 h respectively, as compared to control. Blood urea concentration gradually increased with the increase in duration of exposure of NH_4Cl upto 6 h, followed by reduction at 9 h

irrespective of respiratory burst. However, blood sugar level, SGOT and SGPT level in blood and other blood and serum parameter did not show any significant difference between ammonium chloride treated group and control. In histological analysis, some of the important changes noticed were congestion of blood capillaries, apical disintegration, deterioration and fusion of secondary lamellae, hyperplasia of primary epithelial cells and oedema of the gill lamellae. The transcriptome profiling in kidney tissue of 25 mM NH_4Cl exposed animals showed majority of gene ontology in biological process, molecular function and cellular components.

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

- **Establishing National germplasm repository and museum**

  The project aims to establish a National Germplasm Repository and Museum as an integrated aquatic genetic resource centre. Architectural design of the interpretation centre was finalized in coordination with CPWD. Posters and display materials were designed. Furniture for sperm, cell line and microbial repository were designed and tendered. Fish specimens from different water bodies were procured and preserved for display. Various boats model has been procured for display.

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

  For diploid germplasm cryobanking, *in vitro* culture from caudal fin cells of *Labeo bata* and *L. gonius* were carried out. Both the primary cultures formed complete monolayer after 20th day of culture. Furthermore, previously cryopreserved primary cells from mrigal and rohu caudal fin were revived after 24 months to check the viability of cryopreserved cells, wherein cell growth was observed.

- **Culture of tissue-specific cells**

  Culture of tissue specific cells like sertoli and leydig cells of testis could be a valuable resource for management of aquatic genetic resources. Several genes associated in reproduction has been identified and the expression of these genes in testis cells can be correlated to develop molecular markers.

- **Conservation and sustainable propagation of near threatened catfish**

  The near-threatened catfish *Clarias dussumieri* was identified at 3 places in Kerala *viz.* Kasargod (Chandragiri River basin), Malappuram (Bharathapuzha River basin) and Idukki (Periyar River basin) and samples were collected. For developing microsatellite marker, the PacBio RSII platform was used and eighteen panels of 42 microsatellite loci were identified. The developed primers were validated in natural population of *C. dussumieri* samples from Periyar and Bharathapuzha.

- **Livelihood improvement through freshwater aquaculture**

  To improve livelihood of scheduled caste farmers through training and demonstration in freshwater aquaculture for selected districts of Uttar Pradesh, beneficiaries were selected from Bakshi Ka Talab, Lucknow and Barabanki. Scientific hand-holding and technical inputs have been provided to the farmers about pond management, species composition and feeding regimes.

- **Ornamental fish breeding and culture**

  Prioritised ornamental fish namely *Dawkinsia arulius*, *Horabagrus nigricollaris*, *Sahyadria chalakkudiensis* and *Pethia setnai* were collected from different parts of Western Ghats and transported to the hatchery at Kochi. Breeding and rearing protocol for Setnai barb, *P. setnai*, was successfully developed. Total 6 breeding trials were conducted and on an average 300 spawn were collected from each trial. First batch of 200 young ones of 3-4 cm size were marketed to an ornamental fish entrepreneur. Further, the possibility of natural spawning of *P. nigripinna* without hormonal interventions was evaluated. Total 7 breeding trials were conducted and on an average 250 spawn were collected from each trial. This is the first report of a successful spawning of *P. nigripinna* in captivity. Apart from these, up-scaling of breeding of *Dawkinsia rubrotinctus*, was done using F1 stock and produced more than 1000 young ones.

- **Marine ornamental fish village**

  The captive production of *Amphiprion percula* and *A. ocellaris* was scaled up. Other clownfish

viz., A. frenatus, A. clarkii, A. ephippium, A. sebae, A. nigripes, A. akallopisos, A. perideraion and *Premnas biaculeatus* were also being maintained in the hatchery. Larval rearing and juvenile production were also attempted for four of them. The cluster mode beneficiaries rearing unit was established in Dive Kevani village at Thane and Gandhinagar, Vengurla, at Sindhudurg district of Maharasahtra, where hatchery produced juveniles of cowfishes were stocked.

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

  Exploratory surveys were carried out in five islands of Lakshadweep - Agatti, Bangaram, Thinnakara, Parali I and Parali II islands and 115 individual of ornamental shrimps and 25 sea anemones were collected. Collected shrimps belonged to 6 families, 7 genera and 8 species. Among the collected shrimps, captive propagation technology has been standardized for *Thor hainanensis* and *Ancylocaris brevicarpalis*. Scaling up of the production is in progress for *Gnathophyllum americanum, Saron marmoratus, Periclimenella agattii* and *Cuapetes* sp. Moreover, sexual and asexual propagation methods were experimented for sea anemone, *Heteractis magnifica* and captive spawning were achieved for another sea anemone, *Entacmaea quadricolor*.

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

  National repository of fish cell lines (NRFC) is engaged in collection and maintenance of fish cell lines developed in the country and to fulfil the demand of fish cell lines for research and development works. During the reporting period, eight new fish cell lines, namely CMgM-1 (*Clarias magur*, muscle), CMgB-1 (*Clarias magur*, barbels), DDaF-1 (*Dario dario*, fin), ZFiM-1 (*Danio rerio*, muscle) and LRoF-1 (*Labeo rohita*, fin), CyCKG (*Cyprinus carpio*, gill), PSF (*Etroplus suratensis*, fin) and OnH (*Oreochromis niloticus*, heart) developed by ICAR-NBFGR, were included in the repository after proper authentication. With these, the NRFC accession increased to 71 fish cell lines. Besides, twenty-four fish cell lines were revived, passaged and cryopreserved and fourteen cell lines were distributed to 6 researchers belonging to 5 national institutions.

- **Production of *Clarias magur* spermatozoa through surrogacy**

  Attempt has been made to produce *Clarias magur* spermatozoa without sacrificing males through surrogacy technique in *Pangasianodon hypophthalmus*. Stripped milt from a few of *P. hypophthalmus* was watery and appeared like milt of *C. magur*. This needs to be further verified with fertility trials of *C. magur* eggs with presumptive *C. magur* milt.

- **Indian major carp milt cryobank**

  In early breeding season, approximately 3000 vials of 2 ml capacity milt from evaluated stocks of Indian major carp were cryopreserved. During July, stored cryomilt was supplied to different hatcheries situated in Bihar, Haryana, Madhya Pradesh, Rajasthan & Uttar Pradesh and commercial seed production was done. At every hatchery, 13 lakhs eggs were fertilized and spawn were produced. In current breeding season, 25 lakhs spawn were produced and cumulatively in two breeding seasons, approximately 62 lakhs spawn were produced in 20 hatcheries situated in 7 states. Furthermore, experiments were also conducted to check viability of cryopreserved milt using larger cryovials for up-scale the milt cryopreservation. Under capacity building objective of the programme, four trainings on fish milt cryopreservation and seed production were conducted for state fisheries officials, hatchery managers, entrepreneurs, research scholars and post-graduate fishery students.

Program: Documentation of fish genetic resources of India

- **Fish germplasm resources of India**

  India possesses rich aquatic diversity spread across different ecosystems, owing to its vast and varied geographical features. The updated list of fin fishes comprise 3157 species, including 1545 marine, 892 freshwater, 391 brackishwater-marine, 115 freswater-brackishwater, 197 freshwater-brackishwater-marine and 17 brackishwater species. While approximately 35,797 fish species have been recorded throughout the globe.

- **Fisheries-based entrepreneurship for socio-economic development of tribals and sustainable utilization of fisheries resources**

  Fisheries-based entrepreneurship can serve as a valuable intervention to improve the economic status of the marginal farmers. For this, tribal entrepreneurs and other tribal farmers from the Sonebhadra district were identified and major focus will be on breeding and seed production of locally available minor carps and thus species diversification in the region. Further, a collaborative component of the programme has been planned with ICAR-CIFE, Mumbai on preparation and demonstration of fish feed using locally available resources in the study area.

- **Database for commercially important shellfish resources in India**

  Development of a database for the commercially important shellfish of India is crucial to understand spatial patterns of species and for the sustainable utilization of the resource. In the crustacean fisheries, mollusc reported from Indian waters was initially identified as the target organism for collecting the data on different parameters such as taxonomy, inhabitation type, shell types, sex, food and feeding, life cycle, body shape and size etc. The database structure to record the information on the parameters for the mollusc species was designed using SQL Server relational database management system under the Windows operating environment. Further, trade oriented crabs and shrimp species were identified for collecting the data on the various parameters and developing the database and the information system.

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

  Research in fish genetic resources has a plethora of potential to generate a number of technologies that can attract protection in the form of IPR. The important programmes of the institute which have the potential to generate new technologies were identified, and some of these are sperm cryobanking of commercially important fishes, captive breeding of marine high-value ornamentals, therapeutics for commercially important fish diseases and cell lines for research and commercial applications. A design developed by the institute is under process of IP protection. Under capacity building on IPR, the personnel from the institute has undergone several relevant training programmes.

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

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

  The National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) was operational through 31 collaborating centres in the country. In the reporting year, an expert consultation was held to discuss the status and preparedness on Decapod Iridescent Virus-1 (DIV-1) in India. Further, documents were prepared and submitted to the Expert Committee constituted to undertake third party evaluation of 1st Phase of NSPAAD. Technical inputs on export rejection of frozen shrimps by China due to presence of White Spot Syndrome Virus (WSSV) and Infectious Hypodermal and Haematopoietic Necrosis Virus (IHHNV) were provided. Inputs were also given to the Department of Fisheries for exclusion of IHHNV from OIE-listed diseases of crustaceans in consultation with members of scientific core committee of NSPAAD following request of Government of Ecuador. Three QAAD Reports in the year 2020 were prepared and submitted to DoF, Ministry of Fisheries, Animal Husbandry and Dairying.

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

  Disease surveillance in aquaculture farms located in the states of Uttar Pradesh and Haryana were carried out, for which a total of 414 farmers were contacted over phone to know disease incidence. Subsequently, a WhatsApp group was created comprising of 187 farmers culturing pangasius to report the disease problems faced by them. Following report of disease cases in different districts of Uttar Pradesh, disease investigation was undertaken and scientific advice provided to 45 farmers. Furthermore, fourteen disease cases were reported and cause of mortality was ascertained.

- **Surveillance of ornamental fish diseases**

  During the year, isolated the infectious spleen and kidney necrosis virus from diseased giant gourami, *Osphronemus goramy*. The disease

was confirmed by histopathological analysis, transmission electron microscopy and molecular analysis. ISKNV was propagated in *Astronotus ocellatus* fin (AOF) cell line and in bioassay 60% mortality was observed.

- **Antimicrobial resistance in fisheries and aquaculture**

  A total of 154 fish farms in the districts of Lucknow (n=85), Varanasi (n=16) and Barabanki (n=53) were sampled during the reporting period for isolation of *Escherichia coli*, *Aeromonas* spp., and *Staphylococcus* spp. From the collected samples, a total of 437 isolates of 154 (35%) *Aeromonas* spp., 132 (30%) *E. coli* and 151 (35%) *Staphylococcus* spp. were recovered from the samples. Antibiotic Sensitivity Testing was done for 142 isolates; 48 of *Aeromonas* spp., 47 of *E. coli* and 48 of *Staphylococcus* spp. in the reporting period. Among the 47 isolates of *E. coli*, highest resistance of 26.1% was seen against nalidixic acid, 17.4% and 15.2% isolates were resistant to cefotaxime and ceftriaxone, respectively. A total of 4.3% of isolates were found to be resistant to tetracycline. In case of *Staphylococcus*, 64% isolates were found to be resistant to penicillin, and 41% isolates were resistant to trimethoprim/sulfamethoxazole. A total of 31% of isolates were resistant to erythromycin. Cefoxitin resistance was seen in 6% of the isolates. In 48 isolates of *Aeromonas* spp., 16% were resistant to cefoxitin and 8% to cefotaxime. For rest all other antibiotics, resistance was observed in less than 4% isolates.

  A programme has been initiated in the reporting year pertaining to assess the AMR risk associated with Asian aquaculture having specific objective focusing on Indian aquaculture farms. Samples from 80 farms i.e 40 each from Lucknow and Barabanki districts of Uttar Pradesh were collected. Bacterial isolation and their antimicrobial susceptibility testing are under progress. Questionnaire for AMU was developed and used to collect data from the farmers on farming practices and antimicrobial usage.

- **Exotic species in open waters**

  Five alien fish species in the selected stretches of Ganga River system comprising common carp, Nile tilapia, African magur, Amazon sailfin catfish, sucker-mouth catfish and silver carp were recorded. Among these, 4 species were observed from the river Yamuna and Gomti, and tilapia and common carp formed sizeable fishery in the rivers Ganga, Yamuna, Tons and Gomti round the year. A varied size ranges of these fishes were reported from the rivers surveyed. Further, different physicochemical parameters in these rivers also recorded. Experimental fishing conducted in the river Yamuna near Prayagraj yielded catch of different species like Nile tilapia (50.81%), followed by common carp (25.47%), *Sperata seenghala* (16.84%) and *Cirrhinus mrigala* (6.84%), the total biomass of exotic fish was 76.29%. However, rare occasional sighting of a few specimens of exotic fish species was also recorded from the sampling sites of the rivers Ganga, Yamuna, Gomti and their tributaries. Exploration in the Meenkara dam, in Bharathapuzha River basin at Palakkad district of Kerala revealed that the fishery is mostly comprised of Indian major carps and tilapia. Karapuzha dam comprised of four alien fish species namely common carp, Nile tilapia, grass carp and African catfish. Survey in Ashtamudi Lake and back waters of Kochi revealed high abundance of invasive mussel, *Mytilla strigata* and abundance of mussel population was linked to salinity of water. Moreover, a mobile app named as "Exotic Fish Survey" has been developed with the objective to monitor occurrence, spread and establishment of alien fishes across the country.

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

  A cell line developed from heart of *Oreochromis niloticus* (OnH) was found to be susceptible to TiLV. The optimum temperature for virus replication was found to be 28 °C and the virus titre was determined to be $10^{5.3}$/mL. TEM of infected cells revealed electron dense virus particles in the cytoplasmic vesicles. Using the cell culture supernatant from TiLV-infected OnH cell line, a reproducible experimental infection model for TiLV was developed. In transcriptome profile of TiLV-infected tilapia, a total of 4640 differentially expressed genes (DEGs) were identified belonging to antigen processing and presentation, MAPK, apoptosis, necroptosis, chemokine signaling, interferon, NF-kB, acute phase response and JAK-STAT pathways. Besides, in an experimental infection trial on some of the important cultured fishes including silver carp, catla, tilapia, grass carp, mrigal and pacu, none of the fish species

(except tilapia) were found to be susceptible to TiLV.

- **Vaccines and diagnostics**

  For vaccination trial against CyHV-2, whole cell CyHV-2 was inactivated in 0.1% formalin and at 80 °C for 1 h (heat-inactivated CyHV-2). For both the formalin and heat inactivated CyHV-2, a significant up-regulation was noticed for the genes CD8, GINF, IL-12 by the 6th h itself, whereas for the genes IL-10 and CD4, a significant up-regulation was observed in the 6th h for the heat inactivated virus. The experimental fish were challenged intraperitonially with CyHV-2 virus of concentration $10^{5.2}$ TCID50/mL after 30 days of post vaccination, in which a high protection rate of 81.3% for formalin inactivated CyHV-2 and 86.7% for heat inactivated CyHV-2 was observed. In order to develop recombinant protein for immunization of goldfish against CyHV-2, certain ORF and major capsid protein were cloned and expressed in a bacterial expression system.

- **Therapeutics against major finfish pathogens**

  To collect information on economic losses due to fish diseases in Uttar Pradesh during the year, 126 fish farmers were contacted over phone. Among the farmers, 28 reported water quality management problems in their farms, whereas disease problems were reported by 38 farmers. No incidence of any diseases were encountered by 60 farmers in their farms. A formulation developed by ICAR-NBFGR was applied in 52 farms culturing pangasius, IMCs and pacu in Uttar Pradesh having active infection with oomycete pathogens.

  A total of 57 pond water samples collected from different locations of Lucknow district were processed. Bacteriophage was isolated against *Aeromonas hydrophila* bacterial strain Mhg06. In the diffusion method, Mhg06 phage had titre >10^9 pfu/mL. Mhg06 phage was found to have an efficient lytic activity, hence taken up for phenotypic characterization. Purified and concentrated bacteriophage Mhg06 had a titre of 2.85 × 10^{10} pfu/mL. The *A. hydrophila* bacteriophage Mhg06 was phenotypically characterized using several method such as one step growth experiment, adsorption curve, time of death, lysogenization frequency, and effect of pH, temperature and chloroform on viability. The phage showed endurance to be a potential phage for therapy against *A. hydrophila*, however, with limited host range.

Publications

The institute published 52 research papers in different peer reviewed journals, along with various popular articles during the year 2020.

Expert consultations/ conferences/ workshops/ meetings organized

ICAR-NBFGR in collaboration with Bharathiar University organized an International Conference on "Recent Biotechnological Innovation in Aquaculture (Live Aqua 2020)" at Bharathiar University, Coimbatore during February 27-28, 2020.

ICAR-NBFGR & DBT Germplasm resource centre for marine ornamental invertebrates has been declared open at Agatti Island, Lakshadweep on March 8, 2020.

An expert consultation was held under National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) on April 17, 2020 to discuss the status and preparedness on Decapod Iridescent Virus-1 (DIV1) in India.

An inception workshop was organized jointly by ICAR-NBFGR & ICAR-CIFT virtually on December 10, 2020 to formally launch the FAO-ICAR-TCP entitled "Support mitigation of Antimicrobial Resistance (AMR) risk associated with aquaculture in Asia" in India.

Capacity building programs

An eOffice training for the administrative staff of ICAR-NBFGR was conducted during January 27-28, 2020.

A three days training programme on "Awareness for utilization of natural resources under constitutional frame" was organized at ICAR-NBFGR, Lucknow during January 30 - February 1, 2020.

A hands-on training programme on "Determination of viral load by quantitative real time PCR in aquatic animals" for officials of NFDB Aquatic Animal Health & Quality Testing Laboratory was organised during February 24-28, 2020.

PMFGR Centre, Kochi of ICAR-NBFGR conducted a training programme on "Fish milt

cryopreservation for genetic improvement of IMC broodstock" at Peechi, Thrissur, Kerala during March 10-12, 2020.

A short training program on "Effective health management for enhancing work efficiency of employees" in physical mode, at ICAR-NBFGR, Lucknow during November 26-28, 2020 was organized, in which 16 skilled supporting staff participated.

ICAR-NBFGR and Asia Pacific Associations of Agricultural Research Institutions (APAARI), Bangkok, Thailand, organized a virtual International training programme on "Regional capacity building on biotechnological tools in aquatic genetic resource management and *ex-situ* conservation for Asia-Pacific countries" during December 07-18, 2020.

Extension activities

A training programme on "Fish culture and breeding" was organised for tribal farmers of Baksa at Guwahati, Assam in collaboration with the Aquaculture & Biodiversity Center, Dept. of Zoology, Gauhati University, Guwahati in which 30 tribal farmers were trained.

ICAR-NBFGR, Lucknow, in collaboration with the Department of Zoology, Bharathiar University, Coimbatore organized an awareness programme on Biodiversity Conservation in Western Ghats as part of Scheduled Tribe Component (STC) at Coimbatore.

ICAR-NBFGR, Lucknow in collaboration with Centre for Marine Living Resources and Ecology (Ministry of Earth Sciences) and Department of Fisheries, Union Territory of Lakshadweep, organized a two-day outreach programme on "Awareness about marine biodiversity conservation at Agatti Island, Lakshadweep" as part of Scheduled Tribe Component (STC).

ICAR-NBFGR in collaboration with Fish For All Research and Training Centre, M.S. Swaminathan Research Foundation, Tsunami Nagar, Nagapattinam district, Tamil Nadu carried out a training-cum-demonstration on brood stock development of indigenous carps for seed production as potential livelihood option of the tribal villagers at Thenpathi village, Nagapattinam district, Tamil Nadu.

ICAR-NBFGR in association with the Mangrove Cell and Mangrove Foundation, Department of Forest, Government of Maharashtra conducted a training programme on "Clownfish Aquaculture" as a part of the NBFGR's ongoing program on "Establishment of marine ornamental fish village at Maharashtra".

ICAR-NBFGR organized a residential training programme of 5 days duration at ARTU, Chinhat for officials from different states, entrepreneur and progressive fish farmers under NFDB sponsored ToT on Re-Circulatory Aquaculture System (RAS) for 25 participants.

ICAR-NBFGR organized a three-day residential training programme for farmers across India under NFDB sponsored SDP on Re-Circulatory Aquaculture System (RAS) for 35 participants at ARTU, Chinhat.

One skill development training programme for beneficiaries under RKVY in collaboration with ICAR-ATARI, Kanpur and Agricultural Skill Council of India (ASCI) on freshwater aquaculture farmer was successfully conducted for 20 young participants.

ICAR-NBFGR conducted a four-day SDP programme on Fish Farmer Training on Fish Production for fish farmers of Chandauli, Varanasi, Ghazipur and Sonbhadra districts of U.P. under Foundation for Advancement of Agriculture and Rural Development (FAARD), Varanasi for 23 participants.

ICAR-NBFGR organized a COVID-19 awareness cum- sensitization programme along with fish culture scientist-farmer interaction under Mera Gaon Mera Gaurav programme at Rajauli Village, Bakshi Ka Talab, Lucknow.

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 1017 lakhs seed in the form of spawn, fry and fingerlings of Indian Major Carps, minor and exotic carps.

INTRODUCTION

Brief History

India is blessed with a vast and diverse topographical feature that possess rich natural resources, which not only maintains ecological integrity and a valuable gene pool but also offers immense opportunities for livelihood support. Aquatic genetic resources are important components of biodiversity which provide nutritional security to our fast-growing population and is one of the prioritized areas for both policymakers and researchers. Though, India possesses immense aquatic resources spread across the country, the majority is unutilized, underutilized or facing serious threats due to both anthropogenic activities and environmental changes. In this context, over time, the conservation of aquatic germplasm resources has gained immense significance. 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 in elite group of countries which has taken the lead to accelerate scientific research on fish genetic resource management.

ICAR-National Bureau of Fish Genetic Resources (NBFGR) was established during the 6th five-year plan to provide scientific inputs for fish germplasm resource management of the country under the aegis of Indian Council of Agricultural Research, by Government of India. Since its modest beginning at Prayagraj in 1983, ICAR-NBFGR has transformed into a leading institute to address research related to the conservation of aquatic genetic resources. In 1999, the institute shifted to the magnificent campus

of Lucknow with well planned administrative and laboratory facilities. Over the years, the institute has grown to leading research centre with advanced capabilities in genomics, bioinformatics, disease diagnostics and management, *ex situ* conservation measures, environment-controlled units, etc. to cater the needs of multi-faceted research. Besides, institute also possess farm, wetlab, animal house, public aquarium, guest house and staff quarters. The institute is presently operating with four divisions (three at HQ and one at Kochi) along with Aquaculture Research & Training Unit (ARTU) 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 the 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 and aquatic microbes, and other areas of germplasm conservation with special focus on prioritized agrobiodiversity fish species of indigenous and exotic origin.

ICAR-NBFGR has worked to develop in-house capacity to generate knowledge and address researchable issues relevant to the changing needs of FGR management in India, with a thrust on keeping pace with technological advancements. The institute has seen splendid growth not only in terms of the creation of new infrastructure but also in the extension of research programmes in important areas *viz.* whole-genome sequencing, population genetics, transcriptomics, sperm cryobanking, molecular disease diagnostics & therapeutics, national surveillance programme for aquatic animal diseases, antimicrobial resistance in fisheries & aquaculture, exploration of newer and unexplored geographical areas for assessment of fish diversity, etc. to name a few. Bureau has spread its wings in different parts of the country through partnership in genetic resource management and creating livelihood for stakeholders through sustainable use of resources.

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

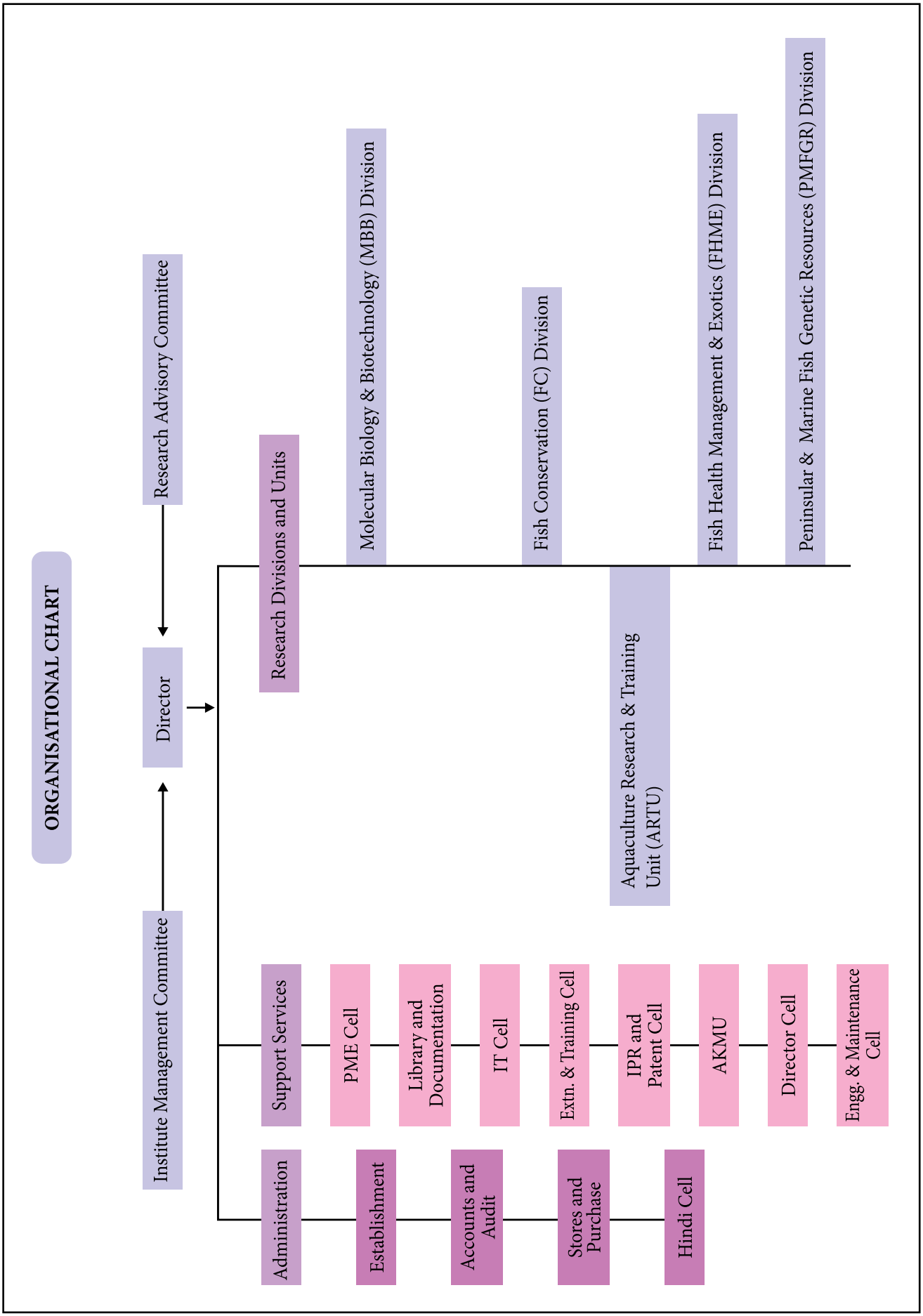
MANDATE

- 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, 2020 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	33	08
3.	Technical	38	27	11
4.	Administrative	21	17	04
5.	Supporting	20	18	02
	Total	121	96	25


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

RESEARCH ACHIEVEMENTS

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

Freshwater fishes account to about 25% of living vertebrates, while inhabiting only <1% of the earth's surface. It is of deep concern that this important resource is being increasingly impacted by human dependence on freshwater ecosystem services. Areas of high species richness, endemism, extinction risk or habitat degradation are often targeted for conservation efforts. Species with smaller distribution range have a lower probability of being described than species with larger ranges, and in turn, face higher risk of extinction than known species. Lack of formal taxonomic status jointly with the small distribution range makes these undescribed centres of endemic freshwater fishes disproportionately vulnerable. Identifying these fauna through targeted exploration and discovery is an essential first step towards their conservation. Exploration has always been an ongoing activity of ICAR-NBFGR, 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 exploration and discovery in hydro geographically and climatically isolated regions with high endemism and underestimated diversity.

Project: Fish diversity pattern of fish communities from river basins of Thar Desert, India

Period: April, 2018 - March, 2021

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

Funding Support: Institutional, ICAR-NBFGR

The project aims to assess and document fish diversity pattern of fish communities from the river basins of Thar Desert, map and analyse the land use/ land cover features at different time scale.

Land use/ land cover study

A portion of the watershed of the Luni upper basin was delineated using ArcMap 9.3 software under Windows operating environment, which has a total area of 35047.47 km^2. The land use/ land cover (LULC) raster dataset (300 m spatial resolution) of this portion was derived from European Space Agency Climate Change Initiative (ESA CCI) Land Cover project for the years 2000, 2005, 2010 and 2015. The detailed LULC class attributes (level 2) were further reclassified and grouped into 10 major classes *viz.* Cropland, Shrub land, Broadleaf forest, Needleleaf forest, Grassland, Wasteland, Wetlands, Urban area, Barren land and Waterbodies. The class wise LULC change detection analysis was performed using Spatial Analyst Tools of ArcGIS. The analysis revealed a steady increase in the area under the Urban area class (65 km^2 in year 2000 to 185 km^2 in year 2015), while area under the classes such as Cropland, Grassland and Barren land decreased from year 2000 to 2015. Further, based on the change detection analysis, Sukri watershed of the Luni River basin was selected for LULC mapping and was prepared using the Landsat dataset of the year 2019 (30 m spatial resolution) downloaded from USGS Earth Explorer. The preliminary data processing, image classification was performed using ERDAS Imagine Professional 11 software under the Windows operating environment. A supervised classification using maximum likelihood algorithm was used for classification of the images based on the field observation. The classified land use/ cover map of the Sukri watershed area for the year 2019 is depicted in Fig. 1. This LULC map can be used for the assessment of hydrological changes and river corridor management by the resource managers.

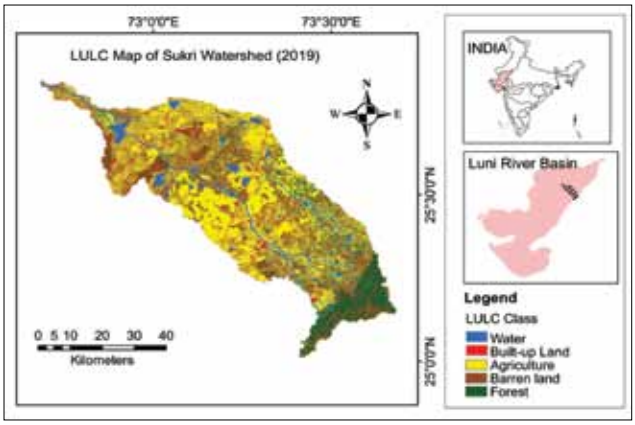


Fig. 1. Land use/land cover map of the Sukri watershed for the year 2019

Comparative analysis of species distribution

A total of 29 fish species have been reported so far from the river Luni and its tributaries. The occurrence data of the fish species from our survey and secondary data reported by other workers were compiled, digitised and documented using MS Excel software. The worksheet of the file created in MS Excel contains records on occurrence of fish species with values on species name, geographic coordinates (Latitude, Longitude), location, year of reporting and source. This data documented in the worksheet is in the process of screening and verification, which will be used later for distribution modelling.

Fish diversity, habitat structure and physico-chemical parameters

Survey and sampling in the entire stretch of the Luni and Banas rivers were conducted during October, 2020. The sampling sites identified during earlier surveys were revisited to document the fish diversity of the river Luni. The present survey updated the fish diversity of river Luni to 29 species with inclusion of *Notopterus notopterus* and *Cirrhinus reba*.

For the river Banas, sampling sites were identified by taking into account, equal representation from each habitat type along the whole river stretch from origin to its confluence to river Chambal at Sawai Madhopur. A total of 12 sampling sites were identified along the river Banas covering different hydrological units like stream, pools, lakes and reservoirs and confluence points (Fig. 2). During survey, the general land use and land cover pattern were recorded in addition to geographical location details. Experimental fishing was done in all the selected sampling sites using various fishing gears like gill nets, cast nets, hapa and push net

(Fig. 3). The collected fish specimens were observed for recording data on morphology and meristic counts (Fig. 4). The habitat characterisation (river bed ecology and estimation of water quality parameters) of the river Banas was done for all the selected sites located in the upstream, midstream and downstream zones of the river (Fig. 5). The shallow water pools and slow water riffles were the most commonly observed habitat types in the hilly upstream region of the river Banas during the post-monsoon season. The habitat in the midstream and downstream segment of the river was characterized by the slow-moving water with shallow pools and sandy bottom. The wetted width of the river was wider in the midstream than the upstream. The pH of the water ranged from 7.13 to 9.14, while dissolved oxygen was between 3.4 and 6.4 mg/l. The total dissolved solids content ranged from 109.85 to 746.5 ppm. The fish diversity of the river Banas revealed the occurrence of 32 species belonging to 26 genera of 13 families and 7 orders. Cyprinidae was the richest family in terms of species diversity (15 species) followed by Bagridae (4 species) (Fig. 6). The exotic fish namely, Nile tilapia and common carp were reported from the midstream segment of this river.

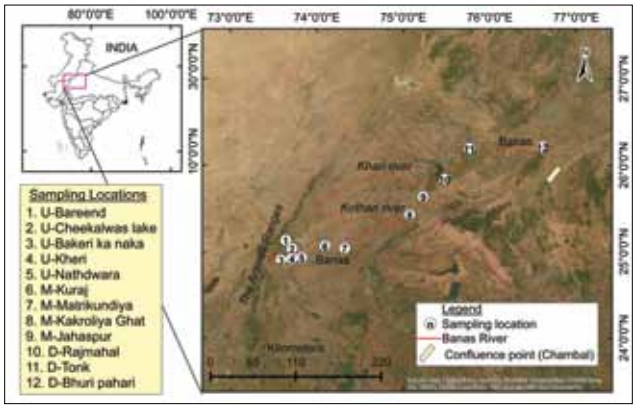


Fig. 2. Map showing the sampling sites in the river Banas

Fig. 3. Experimental fishing in the river Banas using cast net at the outlet of Bakerikanaka dam

Fig. 4. Collection on biological data of fishes from river Banas

Fig. 5. Recording of water quality parameters from river Banas

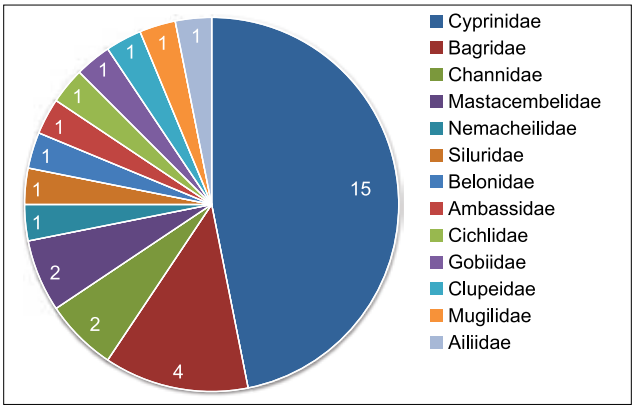


Fig. 6: Family-wise distribution of fish species collected from the different sampling sites along the river Banas

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 fishes belonging to Clupeiformes order are commercially important in terms of food, forage

and pharmacological uses. The project envisages to assess the species-wise genetic diversity in the fishes of this order distributed in Indian waters. During the reporting period, explorations were carried out in Vizhinjam, Calicut and Kochi (Kerala), Mangaluru (Karnataka), Nagarjuna Sagar Dam (Telangana) and Gulf of Mannar (Tamil Nadu) for collection of clupeiform species. Surveys were also conducted in Andaman and Lakshadweep Islands through secondary sources. A total of 56 tissue samples and voucher specimens of clupeiform fishes were collected. The species collected include *Sardinella melanura*, *S. gibbosa, S. longiceps, Hilsa kelee, Anodontostoma chacunda, Escualosa thoracata, Nematalosa nasus, Spratelloides gracilis, Ehirava fluviatilis, Opisthopterus tardoore, Thryssa dussumieri, T. setirostris, T. mystax, T. hamiltonii, T. malabarica, Stolephorous indicus*, *S. commersonii* and *Chirocentrus dorab.* A total of 71 COI sequences were generated from specimens of 15 clupeiform species collected from West Bengal. The fishes were *Anadontostoma* sp., *Coilia ramacarati, E. thoracata, H. kelee, Ilisha* sp., *I. melastoma, Raconda russeliana, S. fimbriata, S. melanura, Setipinna phasa, S. taty, Stolephorous* sp., *Tenualosa ilisha, Thryssa* sp., and *T. kammalensis*.

For vertebral counts and other osteological studies, specimens were X-ray imaged. Comparison of morphomeristic characters using classical taxonomy was carried out for the species of the family Chirocentridae (*C. dorab* and *C. nudus*), Engraulidae (*T. mystax, T. malabarica, T. setirostris, T. vitrirostris, S. taty, C. dussumieri, C. ramcarati, S. indicus,* and *S. commersonii),* Dussumieriidae *(Dussumieria acuta* and *D. elopsoides*) (Fig. 7), Pristigasteridae *(Ilisha melastoma, I. striatula,* and *O. tardoore)* and Clupeidae

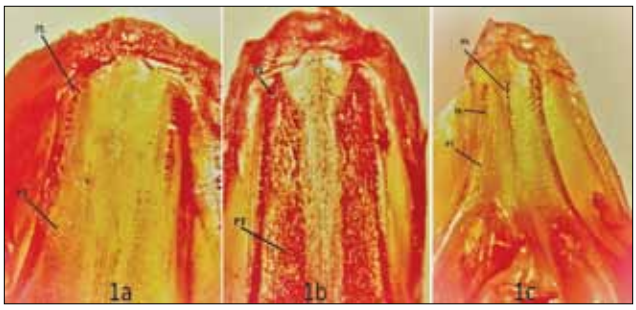


Fig. 7. Ventral view of roof of mouth of *Dussumieria* sp.nov (1a, TCPM 218, 148.55 mm SL), *D. elopsoides* (1b, PY 230, 140.64 mm SL), *D. acuta* (1c, TMP 31, 110.16 mm SL); *PL*, palatine; *PT*, pterygoid; *PS*, parasphenoid; alizarin Red S stain.

(*S. gibbosa, S. longiceps, D. malabarica*, *E. fluviatilis*, *H. kelee, A. chacunda, A. selangkat, E. thoracata, N. nasus, T. toli, T. ilisha, Herklotsichthys quadrimaculatus, Amblygaster sirm, A. clupeoides* and *A. indiana).*

Mitochondrial genomes of 89 clupeiform species, available in NCBI were downloaded, of which 21 species were found in Indian waters. The Indian clupeiform species were separated for which mitochondrial genomes were not available in NCBI. From this list, 10 species were selected for mitochondrial genome sequencing using NGS platform, so that all families are covered to elucidate the evolutionary relationship in order Clupeiformes. The NGS sequencing (Illumina NovaSeq 6000) has been completed for 3 species namely, *A. clupeiodes* (Clupeidae), *D. acuta* (Dussumieriidae) and *C. dussumieri* (Engraulidae). The quality checking and trimming of 150 base paired end data has been completed using NGS QC Toolkit software. Reference-based as well as *de novo* genome assembly of *C. dussumieri* is being done (Ref. *C. anasus*, GenBank assembly accession: GCA_007927625.1). NGS sequencing of 7 species namely, *D. malabarica* and *G. manmina* (Clupeidae); *I. melastoma* and *R. russeliana* (Pristigasteridae); *S. phasa, S. indicus* and *T. malabarica* (Engraulidae) is being carried out.

The canonical discriminant function analysis (CDFA) of morphological data of *Dussumieria* sp. nov., *D. acuta* and *D. elopsoides* resolved the 3 species as well separated and distinct centroids in the graph of discriminant function-1 vs. function-2. Re-sequencing of outlier specimens of *Dussumieria* spp. was also done to rule out the sample flickering at any stage of analysis. Forty COI sequences of 3 *Dussumieria* spp. were submitted to NCBI GenBank. The species and NCBI accession numbers are *Dussumieria* sp. nov. (MT803585-MT803592), *D. acuta* (MT803553-MT803570), *D. elopsoides* (MT803571-MT803584). To elucidate time-scaled phylogenetic and evolutionary analyses, Bayesian Analysis (BA) was conducted in BEAST software (Bayesian Evolutionary Analysis by Sampling Trees). To elucidate, the speciation events in *Dussumieria* genus, the geologic time scale in thousand years ago (tya) starting zero from today is shown above the branches in Fig. 8. The BA showed that the speciation events in *Dussumieria* genus started around 82 tya. Before that, *Dussumieria* had only one species.

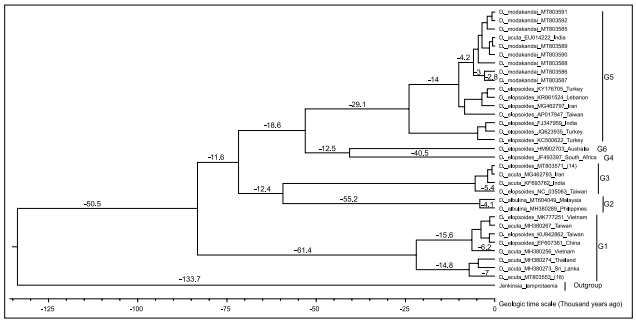


Fig. 8. Bayesian analysis with 62 COI sequences of *Dussumieria* species and *Jenkinsia lamprotaenia* as out group. Geologic time scale is given in thousand years ago starting zero from today. Number within parentheses is number of individuals.

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

Period: **April, 2017 - March, 2021**

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

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

The project aims to document fish diversity in three least studied mid-Himalayan tributaries namely, Gandak, Burhi Gandak and Bagmati of the river Ganga in North Bihar. An exploration of the rivers Gandak, Burhi Gandak, Bagmati and Saraiyaman wetland in North Bihar was conducted during November-December 2020 (Fig. 9). Assessment of river habitats, water quality, fish diversity etc. was carried out.

The upstream segments of Burhi Gandak and Bagmati rivers were observed to be in the fragmented state due to formation of channels. As a result, the stretches were excessively exploited for fishing activities. The substratum of all the rivers gradually changed from cobbles, pebbles, gravel, sand and silt laden in up-stream segments to sand, silt and clay towards mid and downstream stretches. River Gandak had sufficient volume and flow in comparison to Burhi Gandak and Bagmati. Middle and downstream stretches of river Burhi Gandak comprises of a number of deep pools, which are home of some larger sized fishes and brood stocks. The water temperature during winters varied between 18.01 ºC (Belwaghat, Bagmati) and 18.5 ºC (Valmikinagar, Gandak). The water was alkaline in nature (pH 7.6-7.8) with moderately high dissolved oxygen content (10.0-10.6 mgl^{-1}). Values of total dissolved solids (TDS) and conductance were between 137.0 to 238.0 mgl^{-1} & 272.0-483.0 µmhos, respectively.

The rivers are under excessive fishing operations particularly in up and mid-stream segments. Hence, mostly small sized fishes are caught in these stretches. Small sized minnows form sizeable fishery (60-70 % of total fish catch) at Valmiki Nagar, Dhanaha bridge and Dumariyagaon sites of the river Gandak. A total of 24 fish species from Gandak, 18 from Burhi Gandak and 21 from Bagmati rivers were collected. All the species collected during present exploration were already listed in earlier explorations. Hence, a total of 104 fish species were collected and identified from the rivers so far categorized under 8 orders, 24 families and 66 genera. The total number of fish species recorded from the rivers, Gandak, Burhi Gandak and Bagmati were 85, 73 and 81, respectively. The upstream stretch of river Gandak comprises of small sized fishes like *Cabdio morar*, *Salmophasia bacaila* and *Securicula gora*. *Chitala chitala, Sperata seenghala* and *Channa marulius* also form some fishery in this stretch. Small sized Cyprinid, *C. morar* available abundantly in the river Gandak between Dhanaha bridge to Valmikinagar, has good market in the area and is relished at the local road side hotels in the name of Chepua. Bagmati River in its upstream segment harbours *Chagunius chagunio, Wallago attu, S. aor,*

Fig. 9a. Experimental fishing at Valmiki Nagar in Gandak River

Fig. 9b. Interaction with stakeholders on Gandak basin

S. seenghala, Labeo gonius, Cirrhinus reba and the rest are small sized minnows. Downstream of Burhi Gandak mainly comprises *Notopterus notopterus*, *W. attu, L. calbasu, S. seenghala* and the rest being small sized fishes.

The fishes of the studied rivers were categorized as Endangered (*Tor putitora*), Near Threatened (9 species), Data Deficient (1), Not Evaluated (3) and Least Concern (90), as per IUCN categorization (Fig. 10). The river banks are inhabited by good number of active fishermen population engaged in fishing using all sorts of gears including cast and gill nets of varying mesh sizes, rod & lining and traps. As a result of excessive fishing activities, the fish catch is poor in quantity and quality (comprises mostly smaller fishes) at most of sites.

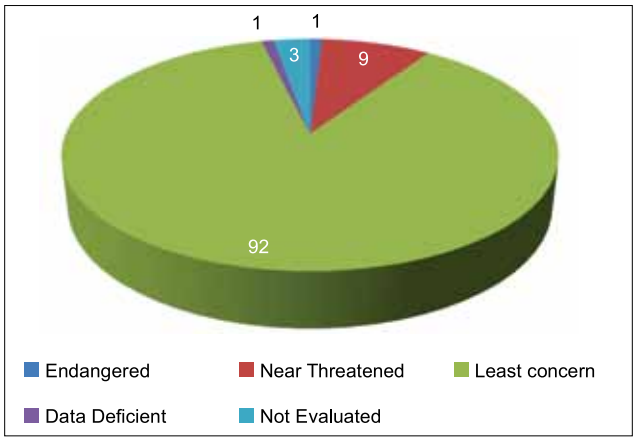


Fig. 10. Conservation status of fishes of the rivers of North Bihar

Saraiyaman wetland, Bettiah, West Champaran district, North Bihar was studied during the period, to assess the fish and fishery parameters. The wetland witnessed high flood conditions during monsoon season. Saraiyaman is under control of state forests/ wildlife department (Divisional Forest Officer-cum-Wildlife Warden, Bettiah). The wetland is under massive infestation of submerged, floating and emerged macrophytes, which are major causative factors of shrinkage of water spread area. Due to its location and occasional connectivity with the tributary of the Ganga, the fish diversity of the wetland is of Gangetic origin. A total of 23 fish species have been encountered during the period, among these 19 were already listed earlier. Four species were added to the existing fish diversity - *Ctenops nobilis, L. gonius, C. reba* and *Parambassis lala*. *C. nobilis* (Fig. 11), a rare species, commonly known as frail gouramy and categorized as Near Threatened by IUCN was collected for the first time.

Fig. 11. *Ctenops nobilis* from Saraiyaman wetland

Fig. 12. *Puntius* spp. from Saraiyaman wetland

In addition of four species, the fish diversity of the wetland now comprises of a total of 59 fish species under 7 orders, 20 families and 37 genera. Among these, stray samples of exotic fishes- grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*) were also caught from the wetland. Fish catch of the wetland mostly comprised of small sized fishes. The weight of the samples caught during the sampling varied from 3.40 g (*Puntius chola*) to 510.42 g (*C. marulius*) during the study. *Rasbora daniconius, C. punctatus, Puntius chola, P. conchonius, Parambassis lala, Colisa fasciatus* formed sizeable catch from the wetland.

The wetland comprises number of fish species having ornamental value under genera- *Pethia, Puntius* (Fig. 12), *Mystus, Parambassis, Colisa, Ctenops, Rasbora, Esomus* while the rest are food fishes. Out of total 59 fish species reported from the wetland, six species- *Chitala chitala, Ompok bimaculatus, O. pabda, Bagarius bagarius, P. lala* and *C. nobilis* are categorized under Near Threatened. A total of 47 species are Least Concern and 4 Not Evaluated (Fig. 13). *R. daniconius* is abundantly available in Saraiyaman wetland (Fig. 14).

Among the alien fish, *C. carpio* is categorized as Vulnerable under IUCN list, but the status is not valid for our context because of its alien nature.

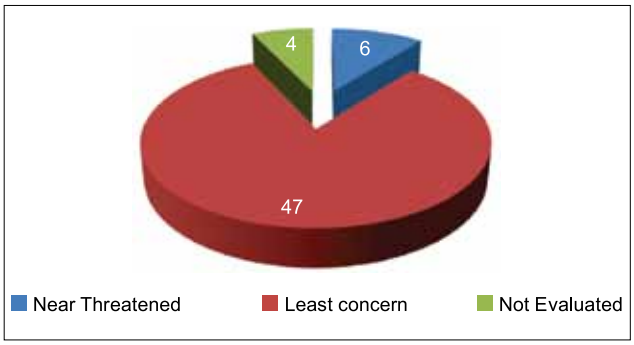


Fig. 13. Conservation status of fish diversity of Saraiyaman

Fig. 14. *Rasbora daniconius* - abundantly available in Saraiyaman wetland

Studied length-weight profile of 238 samples of *R. daniconius* collected from Saraiyaman. The length varied from 63-85 mm with corresponding weight of 2.02 to 5.96 g (Fig. 15).

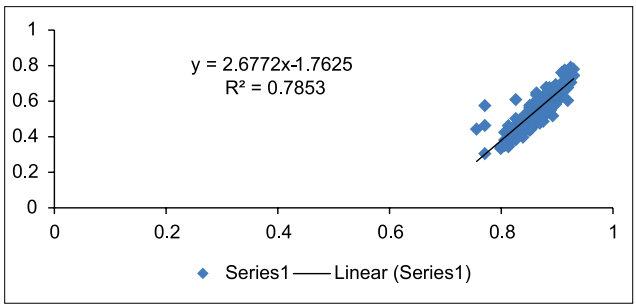


Fig. 15. Length-weight relationship of *Rasbora daniconius* from Saraiyaman

Assessment of socio-economic profile and livelihood issues of more than 100 fisher families of Sisaiya Saraiya, Bindtola and Majhariya hamlet situated on the wetland banks was conducted to evaluate some vital socio-economic attributes. The age group of active fishers ranged between 18 and 88 years, but the majority were between 22 and 60 years. The most of the fishers belong to OBC category and are landless; however, some of them have marginal agricultural land. Average fish catch of the individual fishers varied from 0.3 to 1.5 kg/ day.

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 Cauveri River basin**

Period : **April, 2016 – March, 2021**

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

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

Documentation and cataloguing of biodiversity rich island ecosystems and Cauvery River basin are the main aims of the project. Exploratory surveys were conducted in the upper reaches of the Cauvery in Kerala, the Kabini River, a tributary (2 stations) between its source and its confluence with the Cauvery, including the Banasurasagar Dam and Karaphuzha Dam. Kabini flows through forest area with canopy cover extending over the river in upper stretches. Sampling was done using cast net, gill net and scoop nets. The survey yielded a total of 14 species of freshwater fish, bringing the total diversity to 117 fish species belonging to 8 orders, 25 families and 68 genera. Out of the 117 species, 25 are endemic to Cauvery River, 75 native, 4 stocked and 10 exotic species. A total of 50 COI sequences were generated from *Sperata* spp., *Labeo cf. nigrescens, L. bata, L. kontius*, *Pangasius* spp. and *Tor* spp. which are having taxonomic ambiguities. Sequences of *L. kontius* showed 100% similarity with *L. lankae* from Sri Lanka. Sequence generated of *L. cf. nigrescens* differs from all other species of *Labeo* spp. by more than 4%. Specimens of *L. calbasu* collected from protected area in the Cauvery differ from calbasu from the reservoirs by more than 3%.

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, 2021**

Personnel: **T.T. Ajith Kumar (PI) and Teena Jayakumar T.K.**

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

Project envisages detailed documentation of ichthyodiversity from selected island ecosystems of

the country. Exploratory surveys were carried out in five islands of Lakshadweep *viz.* Agatti, Thinnakara, Bangaram, Parali I and II. A total of 53 fish specimens were collected from different islands comprising of 26 species belonging to 13 families. This added to the earlier collection, resulted in 110 species of marine fishes belonging to 40 families and 70 genera. Thirty individuals of 23 species, belonging 9 families were collected from Junglighat, Rose Island and Chidiya Tapu regions of Andaman Islands. Till date 117 species of marine fishes belonging to 41 families and 82 genera have been recorded. Molecular analysis has been done for few species belonging to the families Apogonidae, Gobiidae, Blennidae and Pomacentridae to resolve taxonomic ambiguities. COI sequences were generated for 23 specimens collected from both the island regions.

The project led to the discovery of new species *Alpheus* sp. (Fig. 16) from Gulf of Mannar, new distribution record of Palaemonid shrimp, *Urocaridella antonbruunii* (Fig. 17) in Indian waters and new distribution record of *Anchistus miersi* (Fig. 18) from Lakshadweep Sea.

Fig. 16. *Alpheus* sp.

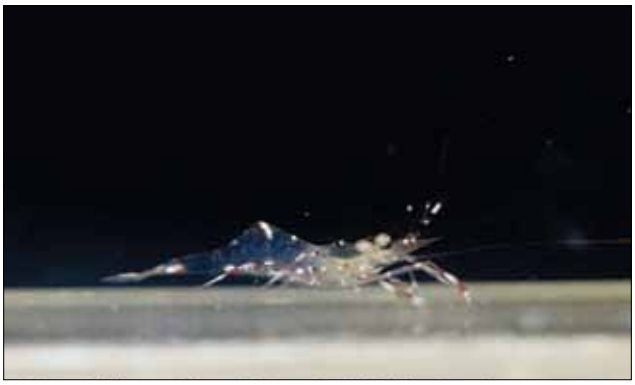


Fig. 17. *Urocaridella antonbruunii*

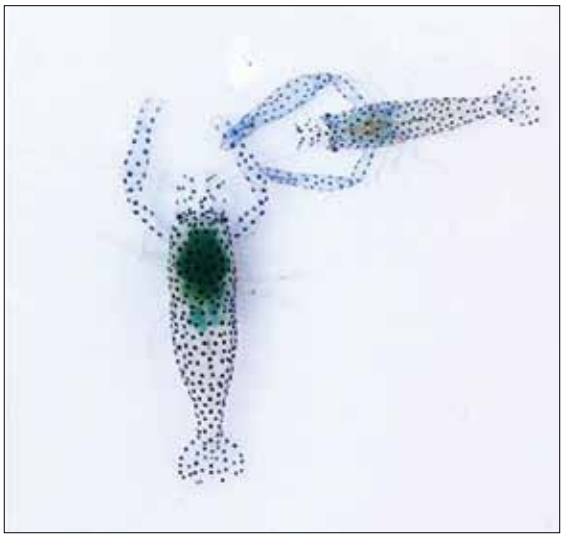


Fig. 18. *Anchistus miersi*

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

Each species harbours a unique set of genetic material and therefore conservation requires sound knowledge about its biology, biogeography and within species genetic diversity. At the population level of organization, identification of stock and studying genetic variability among individuals within a population has been a major cornerstone to fisheries management. The presence of genetic variation plays a vital role not only in survival but also in their successful evolution in response to short and long-term environmental changes. Intra-specific variability in the species is a useful trait with potential application in domestication and genetic improvement. As phenotypic variation and production performance, especially in wild relatives, is not clearly apparent; indirect methods like scale reading for growth and shape morphometry analysis for the phenotypes is employed for stock identification. DNA marker is an effective tool to study population genetics, phylogeny and phylogeography. ICAR-NBFGR has been engaged in population genetic studies of prioritized cultivable species, potentially cultivable or important exploited stocks from various ecosystems of India using standardized molecular markers and biological methods.

Project: Outreach activity on fish genetic stocks-Phase II

Period: April, 2014 - May, 2020

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

Funding Support: Institutional, ICAR-NBFGR

Assessment of genetic variability, responsive to evolutionary forces such as migration, mutation, selection and genetic drift is crucial for management of natural fish genetic resources. Under this project, eight important species are being investigated using molecular markers along with their morphological descriptors, to quantify baseline information on genetic variability existing in natural populations.

Genetic diversity analysis

***Chitala chitala*:** Genetic diversity and population structure in *C. chitala* (Hamilton, 1822) was deciphered by combined analyses of two full length mitochondrial genes, ATPase 6/8 and Cytochrome b. A total of 403 individuals collected from 14 rivers yielded 61 haplotypes. AMOVA analysis indicated 19.01% variance among populations. The mean coefficient of genetic differentiation (F_{ST}) was observed to be 0.26. The principal coordinate analyses indicated that natural populations were sub-structured and comprised of four genetic stocks of *C. chitala* in Indian rivers. Microsatellite analysis demonstrated observed heterozygosity (H_{obs}) ranged between 0.3698 and 0.6567, while expected heterozygosity (H_{exp}) 0.4751-0.6793. The F_{ST} ranged between 0.1782 and 0.0428 with an average of 0.0821.

***Silonia silondia*:** In *S. silondia,* sequencing of combined mitochondrial genes (Cytochrome b + ATPase 6/8) exhibited 38 haplotypes in 247 individuals, belonging to 6 natural populations of Ganga and Mahanadi river systems. Average haplotype and nucleotide diversities were 0.8508 and 0.00231, respectively. AMOVA indicated that 21.91% of the total variance among populations and 78.09% variation within population with significant F_{ST} (0.22). The analysis resulted into three management units or genetic stocks. Microsatellite markers (21) revealed maximum alleles in Sis96 (34) followed by locus Sis1 with 24 alleles. Overall F_{ST} value of 0.03182 was found to be significant.

***Tor tor*:** Genetic divergence studies were conducted in natural populations of *T. tor* using two mitochondrial genes, Cytb (Cytochrome b) and ATPase6/8. Analysis of concatenated genes (1963 bp) of 140 individuals yielded 23 haplotypes. The total F_{ST} was found to be 0.51687 ($p<0.05$), which revealed sub-structuring in the *T. tor* natural populations. Results point out the presence of four genetic stocks in the populations studied. Microsatellite studies resulted in H_{obs} and H_{exp} to range from 0.1245 to 0.4983 and 0.4813 to 0.9194, respectively. Overall F_{ST} 0.1069 was found to be significant. Outlier loci were identified, which indicated genomic signatures for divergent selection, affecting fitness in various environments.

***Mugil cephalus*:** Mitochondrial sequence variations were analysed on the basis of two mitochondrial genes. Mean coefficient of genetic differentiation was 0.158 for Cytb, while 11.39% variance among groups, and within population variance contributed to most of the variation (84.18%). The results revealed that the natural populations are sub structured. Microsatellite genotyping was done for 510 samples at 19 polymorphic loci. Highest H_{exp} (0.7893) was observed in Hooghly, while lowest (0.648) in Karwar. H_{obs} was found to range from 0.4836 to 0.6339.

***Systomus sarana*:** Genetic diversity in *S. sarana* (n=228) individuals, collected from Son, Bhagirathi, Mahanadi, Godavari and Krishna were analysed for two concatenated genes of Mitochondrial genome. The mean F_{ST} observed was 0.37. Hierarchical partitioning of genetic variance indicated 37.15% variation among groups and 62.84% within populations. The results indicate that populations of *S. sarana* were genetically structured, as evidenced from mitochondrial markers. Microsatellite analysis revealed H_{exp} ranged from 0.4342 to 0.5915. The mean number of alleles per locus ranged between 3.136 and 5.39. Deviation from Hardy-Weinberg expectations was observed maximum in river Son.

***Anguilla bengalensis*:** Analysis of 88 samples from three locations of two rivers, Godavari (Dowleshwaram-20 and Rajahmundry-5) and Krishna (15) showed high haplotype diversity and low nucleotide diversity for both the mitochondrial genes. Among populations, within group variance was 19.77% (ATPase6/8) and 15.19% (Cytb). The genetic data revealed insignificant genetic differentiation. Microsatellite analysis revealed 7 loci that exhibited linkage disequilibrium. Analysis

of 22 loci demonstrated H_{exp} to range from 0.5631to 0.7316. Pairwise F_{ST} was non-significant for all pairs. Deviation from Hardy-Weinberg expectations was maximum in river Godavari.

Biological Studies

Shape morphometry

Truss network analysis was done in 343 specimens of *M. cephalus* collected from 17 sites. A total of 12 landmarks generated 65 truss variables that provided 12 principal components (eigen values >1) contributing significantly up to 95.07% of total variation. Canonical discriminant function analysis (CDFA) exhibited two significant functions attributing 34.48% of total variation. Classification results from predicted group membership showed correct classification of individuals into their original population to be 58.9% while for cross-validated classification it was 39.1%. CDFA identified seven distinct stocks based on important truss variables.

In *C. chitala*, PCA provided 6 significant principal components and contributed significantly up to 93.23% of total variation. Eight truss variables, mostly associated with fins, were identified on PC-1 and PC-2 with significant and highest loading. Discriminant analysis on principal components (DAPC) was employed to identify variation between the locations. Receiver operating characteristics (ROC) curve analysis, functional distribution and warp density score also indicated difference in stock between locations. Shape based variation between locations was also studied employing Procrustes ANOVA.

In *S. silondia*, the truss network analysis was carried out by interconnecting 12 landmarks from digital images of specimens to identify phenotypic stocks. Principal component analysis (PCA; eigen values >1) identified 12 components contributing up to 94.77% of total variation. Classification results from predicted group membership showed correct classification of individuals into their original population varied between 68.2% and 86.1%, and cross-validated classification between 40.9% and 76.5% by CDFA. Sixty-five truss morphometric variables were analysed for geometric shape variation which revealed morphological divergence in river Son specimens. The morphological shape analysis clearly pointed out that variation in the insertion of adipose fin is important parameter, influencing the morphological discrimination.

In *S. sarana*, PCA identified eight truss variables with significant loadings, while CDFA designated two truss variables with potential for explaining discrimination between populations. Four most significant truss variables out of the analyses namely; anterior attachment of dorsal membrane from caudal fin to operculum end, posterior end of vertebrae column to eye center, snout tip to anterior attachment of dorsal membrane from caudal fin and posterior aspect of neurocranium to anterior attachment of dorsal membrane from caudal fin; differentiated collections from different basins *viz.* Mahanadi, Middle Ganga, Lower Ganga, Godavari and Krishna. It should be noted that these variables were linked to caudal fin origin at dorsal side and the centre and thus, possibly indicate plasticity in response to locomotive adaptations.

Length weight relationship and age & growth studies

A total of 476 specimens of *M. cephalus* collected from various locations across the country during 2013 to 2019 were employed to establish Length weight relationship (LWR). Mean value of estimates "b" ranged from 2.235 (Ratnagiri) to 3.173 (Punnakkayal) while "a" ranged from 0.005321 (Punnakayal) to 0.22182 (Ratnagiri). Average value of Fulton's condition factor, K ranged from 0.92 to 1.41 between the locations. The monthly data on nine environmental parameters were downloaded from PO.DAAC and CMEMS for 15 years (2002 to 2017) and loaded onto ArcMap 9.3 platform. Partial least square (PLS) score scatter plot matrix on environmental parameters indicated variation between the locations studied. PLS regression analysis of increase in fish weight per unit length on environmental parameters was highest at locations Chennai, Marakkanam and Puducherry, which were also the locations having highest "b" value, indicating the positive influence of environmental factors in growth. LWR study in *C. chitala* (N=439 samples from 14 locations) indicated the value of "b" to range from 2.24 (Gomti) to 3.24 (Son). Fulton's condition factor and relative condition factor were greater for *N. notopterus* than *C. chitala* in common sites of collection (Gomti and Son).

Age and growth studies were conducted for *M. cephalus*, *C. chitala*, *T. tor* and *S. sarana*. Specific linear growth rate and growth constant were assessed for all these species from the back calculated length using scales. The location with maximum growth rate was

Thengapattanam (*M. cephalus*), Bansagar (*C. chitala*) and Narmada for both *T. tor* and *S. sarana*. The age classes varied from 0+ to 4+ in *M. cephalus* and *C. chitala,* while it varied from 0+ to 3+ in *T. tor* and *S. sarana.* There was no dominance of any particular age class in the samples which indicated normalised sampling.

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, 2021**

Personnel: **Gaurav Rathore (PI), Chinmayee Muduli, Anutosh Paria and Ranjana Srivastava**

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

Pathogen-associated molecular patterns (PAMP) are recognized by toll-like receptors (TLR) and they produce inflammatory cytokines and other effector molecules associated with host immunity. Studying the expression of innate immune genes related to TLR pathway could serve as important immune mediators for understanding disease resistance in fish population. Among the fish-specific TLRs, *TLR22* is recognized for its functional importance as an immune sentinel for extracellular viral dsRNA and bacteria.

The project aims in identifying *TLR22* homologue in Indian magur, *Clarias magur* with specific signature domains like other teleosts *TLR22* and phylogenetic relatedness with other piscine TLR homologues (Fig. 19). 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*. The basal level expression of these important immune sentinels will be useful in delineating stocks with comparatively better health profile.

Healthy *C. magur* (~60 g) were randomly divided into three groups i.e. control (PBS injected), *Aeromonas hydrophila* injected and synthetic ligand related to dsRNA virus i.e. poly (I:C). Each group consisted of 40 fish and was 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 and 100 µL of poly (I:C). The control group was injected with 100 µL of PBS and kept separately. After 3, 8, 24, 72 and 144 h or 6 days post-injection, gill, liver, spleen, intestine and kidney tissue from control and injected groups were collected in RNAlater and stored at -80 °C until RNA extraction. Three fish as biological replicate were sacrificed at each time point. Gene expression profile of *CmTLR22*, was studied at each time point. The levels of expression were differentially regulated at different time intervals for different tissues. In

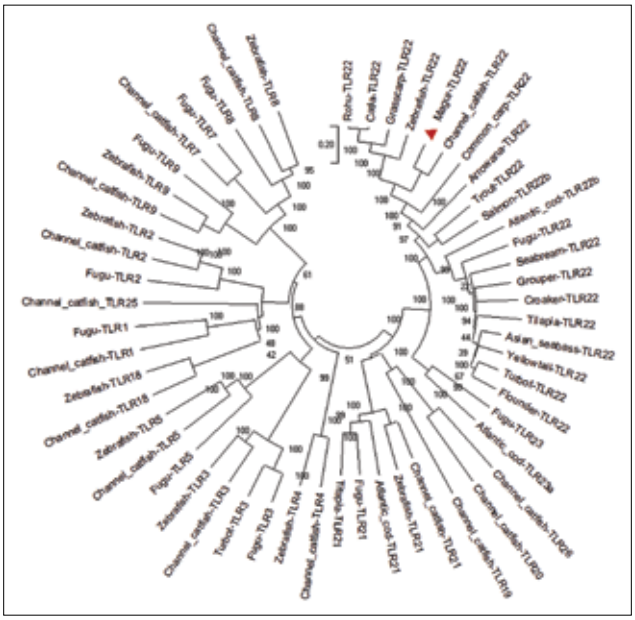


Fig. 19. Phylogenetic tree of deduced amino acid sequences of *CmTLR22* and other teleost TLRs

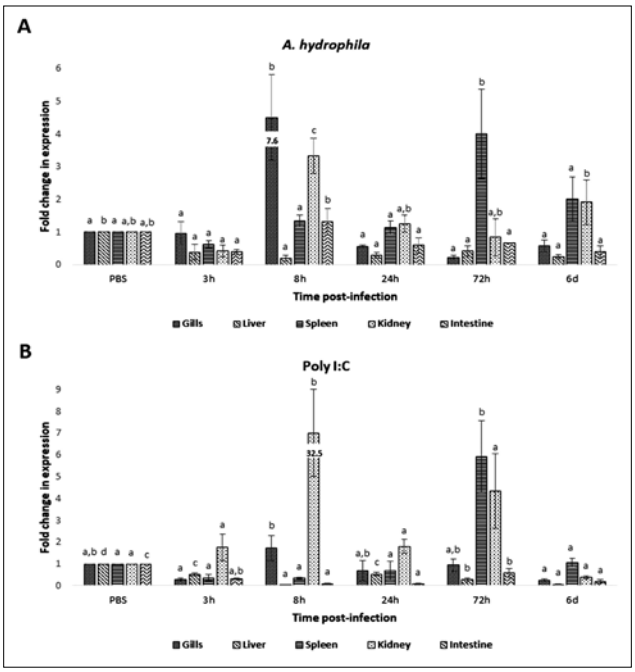


Fig. 20. Expression profiles of *CmTLR22* in different tissues of *Aeromonas hydrophila* (A) infected or poly (I:C)-injected (B) *Clarias magur*

both the injected groups, significant up-regulation of *CmTLR22* expression was noticed in gills, spleen and kidney at 8 to 72 hours post-injection (Fig. 20). The regulation of *CmTLR22* in these important immune organs of *C. magur* indicates its PAMP sensing ability corresponding to Gram-negative pathogenic bacteria or dsRNA virus, which might aid in the molecular surveillance of innate immune of system of catfishes against different microbial invaders.

Project: **Capacity building and feasibility studies on new areas of research on AqGR management**

Sub Project II: **Genetic tagging of brooders of *Labeo rohita* using low depth sequencing**

Period: **April, 2020 - March, 2022**

Personnel: **Mahender Singh (PI)**

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

The project aims in developing a strategy for genetic tagging of broodstock through capacity building. Literature on tagging of breeds/ stocks with genetic markers was studied in domestic animals like sheep, cow as well as aquaculture species. It was clear that development of suitable genetic markers which took years can be developed in one go from NGS data. It was found that this type of study has been used in farmed animals. Similar approach has also been used in fishes for tracing strains and identifying farmed, wild, hybrids (F1) and hatchery escapee individuals. Based on literature studied and expert opinion, it was decided to collect 10 individuals each of 3 populations from Ganga, Brahmaputra and Sutlej River systems. Voucher specimens will be photographed on graph paper for statistical analysis and tissue samples from these individuals will be used for low depth (20X) sequencing (~30GB). Population specific SNPs were observed in analysis of RAD data of 3 populations in *Clarias magur*. In total, more than 14000 SNPs were found to be population specific. Low depth sequencing is similar and expected to give more population specific markers in *Labeo rohita*.

Project: **CRP-Agro Biodiversity National network on agro-biodiversity**

Management: **On-farm evaluation of prioritized fish genetic resources for conservation aquaculture**

Period: **August, 2017 - July, 2021**

Personnel: **Kuldeep K. Lal (PI), T.T. Ajith Kumar, V.S. Basheer, Santosh Kumar, Charan Ravi, Aditya Kumar and Ajay Kumar Singh**

Funding Support: **ICAR, New Delhi**

The project aims to develop facility for establishing fish germplasm resource centres at three locations, ICAR-NBFGR Headquarters, Lucknow; PMFGR Centre of ICAR-NBFGR, Kochi and Nagarjuna Sagar, Telangana. During the year, live fishes were collected from locations across India (Table 1). Few endemic species *viz. Clarias dussumieri*, *Hemibagrus punctatus*, *Horabagrus brachysoma* and *Labeo dussumieri* collected from their natural habitat in Western Ghats, were developed as brooders and produced seeds after induced spawning. For these species, F1 and F2 seeds are being developed as brooders. These seeds are being reared and evaluated for growth in cages. Critically endangered catfish *H. punctatus* (45 nos.) were collected from Thalakkadu, Karnataka, during October 2020 and maintained in FRP tanks. Sixty numbers of *C. dussumieri*, were collected from three different locations *viz.* Thodupuzha, Peechi Dam and Malapuram (Bharthaphuza River) Kerala. A total of 100 nos. of yellow catfish, *H. brachysoma* collected from Nandikara, Kerala were tagged and maintained in cages installed in ponds. Moreover, 50 nos. of adult *H. nigricollaris* were collected and maintained in FRP tanks.

Table 1. New live fish added in germplasm resource centre of ICAR-NBFGR, Lucknow

S. N.	Species	Total no.	From where	Avg. size (cm)
1	*Labeo rohita* (PIT Tagged)	478	Ghaghra River (Masauli village, Barabanki)	23.5
2	*Labeo rohita* (PIT Tagged)	294	Ganga River (Allahabad)	30
3	*Catla catla* (PIT Tagged)	91	Ganga River (Allahabad)	20.6
4	*Labeo rohita*	105	Gomti River (Lucknow)	5-6
5	*L. rajasthanicus*	608	Rajasthan	5-6
6	*M. cavasius*	55	Rajasthan	8-10
7	*L. dero*	8	Rajasthan	8-10
8	*Garra gotyla*	90	Rajasthan	5-6
9	*Catla catla*	3	Allahabad	5-6
10	*Ompok bimaculatus*	300	Gomti River (Lucknow)	7-8
11	*Sperata seenghala*	45	Gomti River (Lucknow)	5-6
12	*Notopterus notopterus*	5	Gomti River (Lucknow)	10-12
13	*Labeo bata*	259	Gomti River (Lucknow)	5-6
14	*Mastacembalus armatus*	249	Gomti River (Lucknow)	10-12
15	*Labeo calbasu*	16	Gomti River (Lucknow)	5-6
16	*Rita rita*	66	Gomti River (Lucknow)	7-8
17	*Barilius ngawa*	15	Koshi River (Ram Nagar)	8-10

Fig. 21. Fingerlings of *Clarias dussumieri*

Mass scale captive propagation of *C. dussumieri, H. brachysoma* and *L. dussumieri* and its evaluation in farmer ponds for aquaculture is underway. Up-scaling the breeding of *C. dussumieri* was done in June - September, 2020. A total of 12 induced breeding trials were successfully carried out in captivity using 30 pairs of brood fishes (weighing 80-200 g) using hormone Wova-FH. Nearly 25,000 hatchlings were produced and 1000 nos. of *C. dussumieri* fingerlings (Fig. 21) were distributed to the Department of Fisheries, Government of Kerala for culture and developing them as broodstock and also to farmers for on-farm evaluation in their ponds.

Mass-scale breeding of *H. brachysoma* was successfully carried out during July–September, 2020 using broodstocks, weighing 150-250 g (Fig. 22a). A total of 6 trials were conducted using 12 pairs of brooders. Six females spawned naturally having mean fecundity of about 22,000-33,000 eggs with hatching rate of 80%. After two months, 10,000 nos. of fingerlings of size 2 inches (Fig. 22b) were harvested

Fig. 22a. *Horabagrus brachysoma* brooders

Fig. 22b. Finglerlings of *Horabagrus brachysoma*

Fig. 23a. *Labeo dussumieri* brooder

Fig. 23b. Eggs of *Labeo dussumieri*

Fig. 23c. Spawn of *Labeo dussumieri*

Fig. 23d. Harvesting fingerlings of *Labeo dussumieri*

and distributed to the Department of Fisheries, Government of Kerala for culture and raising to broodstock and also to farmers for on-farm evaluation in their culture ponds and promoting as ornamental fish. Similarly, *L. dussumieri* were bred and seed was supplied to department of fisheries and fish farmers for growth evaluation and developing them as brooder (Fig. 23 a, b, c, d).

In India, there are two clariid species *viz. C. magur* and *C. dussumieri*. Spawning cannot normally be induced in *C. magur* in captive conditions hence, sperm suspension is made after sacrificing males for commercial seed production. However, spawning can be induced in *C. dussumieri* in captive condition. Based on these observations, the possibility of hybridizing two clariid species was explored. Experiment was done in Kochi using *C. dussumieri* females and cryopreserved milt (2017) of *C. magur* transported from Lucknow to Kochi. Hybrid seeds produced are being reared to develop as brooder (Fig. 24). Likewise, crosses were also made using fresh milt from *C. dussumieri* males and *C. magur* eggs at ICAR-NBFGR, Lucknow. Hybrid progeny are being developed as brooder.

Fig. 24. Captive raised F1 Hybrids

At Nagarjuna Sagar Dam, Telangana, 85 nos. of *Ompok bimaculatus,* 60 nos. of *Labeo calbasu,* 40 nos. of *Notopterus notopterus* and 7 nos. of *Pangasius silasi* were collected and stocked in the cages installed for monitoring individual growth and for broodstock development.

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

Period: April, 2019 - April, 2022

Personnel: Rajeev Kumar Singh (PI), Sangeeta Mandal, Rejani Chandran and Kantharajan. G.

Funding Support: Department of Biotechnology (DBT)

Documentation of population genomics and genetic signatures of *Lates calcarifer*, an important candidate species for culture in our country, is the major objective of the project. Samples of *L. calcarifer* were collected from the commercial catches of different locations of east and west coasts of India (Fig. 25). Tissue samples (blood, muscle and fin clips) from each fish, were collected and fixed in 95% ethanol and stored at 4 °C.

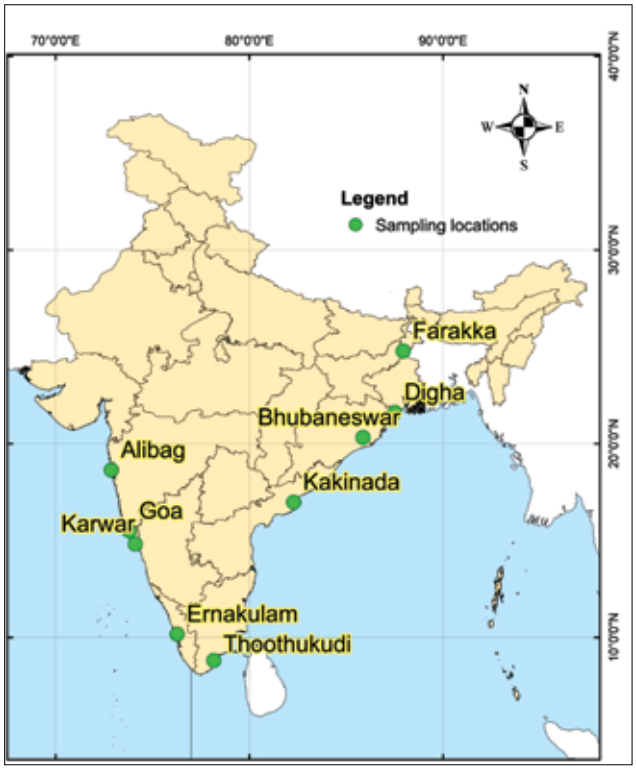


Fig. 25. Sampling locations of *Lates calcarifer*

Morphological studies

The specimens of *L. calcarifer* collected from Tuticorin (15), Farakka (9), Chilika Lake (3), Alibag (25) and Kakinada (30) were compared with 25 specimens of *L. calcarifer* (Australia). Along with these, the morphometric details of 2 paratypes of *L. lakdiva,* holotype and 3 paratypes of *L. uwisara* and 11 specimens of *L. japonicus* were also compared.

Microsatellite markers

Total genomic DNA was isolated from seabass individuals using phenol-chloroform method. The quality of DNA was checked on 0.8% agarose gel and DeNovix® DS-11 spectrophotometer and the DNA concentration was adjusted to 50 ng/µl and stored at 4 °C.

The primers designed on the repetitive sequences, obtained from PacBio RS II, were used to amplify and genotype *L. calcarifer* samples (n=64), collected from five different locations. Individual genotype data was analysed to validate the loci for population level studies. No null allele was observed for all characterized loci. In this analysis, no linkage disequilibrium was found for any pair of loci. This indicated that the loci are independently inherited and can be used for genetic characterization. Number of allele ranged from 5 (*LSS567**) to 23 (*LSS1258**). Observed heterozygosity and expected heterozygosity ranged from 0.484 - 0.887 and 0.712 - 0.938, respectively. Polymorphic information content (PIC) value ranged from 0.653 (*LSS567*) to 0.926 (*LSS1258*).

Mitochondrial markers

As the universal primer for amplifying cytochrome b gene did not consistently amplify the individuals of *L. calcarifer,* a new primer was designed and used for amplification of full-length gene. A total of 118 samples were amplified and visualised on agarose gel. The gene was amplified in a final reaction volume of 25 µl, which contained 1X reaction buffer (10 mM Tris, 50 mM KCl, 0.01% gelatin, pH 9.0), 200 µM of each dNTP, 1.5 mM $MgCl_2$, 5 pmol of each primer, 3U Taq polymerase and approximately 50 ng of template DNA. PCR conditions were: denaturation at 94 °C for 5 min, 30 cycles of 94 °C for 30 s, 55 °C for 1 min and 72 °C for 1 min 30 s; final extension at 72 °C for 10 min. Upon bidirectional sequencing, the analysis yielded 9 haplotypes. Cytb gene was characterized by 14 variable sites with 12 parsimony informative, one singleton site. The average frequency of nucleotides was A: 25.40%, T: 30.0%, G: 14.10%, C: 30.50%, with a transition to transversion ratio (Ts:Tv) of 5.815. The haplotype diversity *(Hd)* ranged from 0.000 (Mahanadi and Farakka) to 0.833 (Goa). Nucleotide diversity (π) was observed with a range of 0.000 (Mahanadi and Farakka) to 0.0034 (Goa) (Table 1)

Table 2. Molecular diversity (Cytb) from different locations in *L. calcarifer*

	Haplotype diversity (*Hd*)	Nucleotide diversity (π)
Farakka	0.0000	0.0000
Mahanadi	0.0000	0.0000
Tuticorin	0.7080	0.0032
Goa	0.8330	0.0034
Alibag	0.4500	0.0005
Overall	0.7813	0.0036

Project: Quantifying agro-biodiversity and ecosystem services in Godavari River basin landscape

Period: September, 2020 – August, 2021

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

Funding Support: Bioversity International

The project aims to study impact of agriculture effluents on the aquatic ecosystems of river Godavari and developing recommendations for sustainable aquatic ecosystems in harmony with agriculture development. Three landscapes were selected in the study *viz*. Adilabad, Karimnagar and West Godavari. A field exploratory survey was undertaken to document fish diversity and habitat parameters from the selected landscapes (Fig. 26) during December 13-20, 2020. A total of 16 sites were surveyed for the habitat and water quality assessment. Experimental fishing was conducted at 4 sampling sites (Fig. 27). These sampling sites were selected based on the criteria such as river confluence points / tail ends of reservoirs and barrages/ sites near industrial waste discharge points, urban development zone, intensive/ traditional agriculture areas/ sites in elevated hilly areas and reserve forest. Fish landing centres and markets associated with the study areas were visited to understand and document the aquatic diversity. A total of 43 fish species, including brackish and freshwater were recorded from the study area (Fig. 28). The fish diversity comprised of 10 orders, 20 families and 32 genera (Fig. 29). Four species belonged to Near Threatened category, while one species each was recorded as Endangered and two as Vulnerable (Fig. 30).

Vital water quality parameters were taken at the time of the survey using sensor based multi parameter equipment (Fig. 31). The pH in West Godavari landscape varied from 8.71-9.16, Karimnagar 8.3-8.74, while 8.43-8.62 in Adilabad landscape. Dissolved oxygen in West Godavari landscape varied from 10.1-13.06 ppm, Karimnagar landscape from 8.6-12.6 ppm, while in Adilabad landscape varied between 7.6-12.8 ppm. Conductivity in West Godavari landscape varied from 0.14-0.17 mS/cm, Karimnagar landscape from 0.33-0.47 mS/cm, while in Adilabad landscape varied between 0.38-0.50 mS/cm. Samples collected from Chinnur and Seetharampally in Karimnagar landscape were recorded with highest copper content (0.049 mg/l).

The plankton were collected from the selected landscapes at 16 locations. Stomach contents of *Rita* spp. *Cirrhinus reba*, *Osteobrama* sp. and *Clupisoma* sp. were stored in 10% formalin and brought to laboratory for further analysis.

The quantitative assessment of sedimentation (river water) by different land use classes was studied in two watersheds *viz.* Hivra, a watershed in the upstream and Konta, a watershed in the downstream (Fig. 32). Sediment Delivery Ratio module of InVEST model was used to assess the sediment losses and retention in different land use land cover (LULC) classes in two selected watersheds. The input data used in the study included ESA LULC classification (2014) at 300 m resolution, elevation value raster dataset (ASTER DEM) at 30 m resolution, a normalized raster dataset with an erodibility value for each cell derived using information on sand/ silt/ clay/ organic carbon and rainfall erosivity raster dataset generated using gridded rainfall datasets of IMD (1993-2014). Published procedures were used to derive values of cover management factor (C) and support practice factor (P). The parameters Borselli K, Borselli IC0 and SDRmax were set as default. The model was then used to study the sediment export and sediment retention in different land use classes. The results showed that the sediment export (mean over all the classes) was 3.08 t/ha/yr in Konta, while it was only 0.73 t/ha/yr in Hivra watershed. Among the different land use classes, the highest sediment export was from grassland (5.36 t/ha/yr), followed by shrub land (5.32 t/ha/yr) and

crop land (2.77 t/ha/yr) in Konta watershed, while the corresponding values in Hivra watershed were 0.72, 2.45 and 0.65 t/ha/yr, respectively. Critical analysis of the data showed that the low sediment exports from the two watersheds were due to high sediment retention. The mean sediment retention in Konta watershed was 118.43 t/ha/yr, while it was 15.49 t/ha/yr in Hivra. The study also showed that rainfall erosivity was the major factor for the difference in sediment export and retention between the two watersheds.

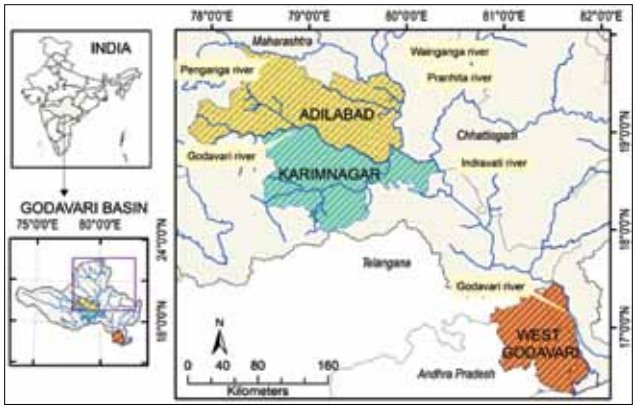


Fig. 26. Boundary and natural elements of the selected landscapes

Fig. 27. Experimental fishing in deep pools in Adilabad landscape

Fig. 28. Commercially important fishes recorded at Narsapur, an estuarine area in West Godavari landscape

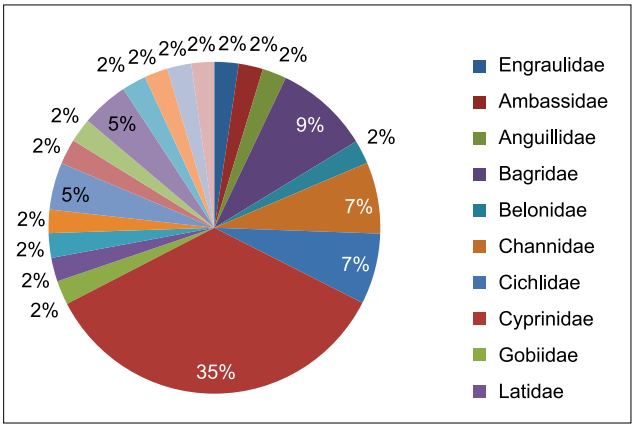


Fig. 29. Family-wise distribution of aquatic resources reported across the landscapes

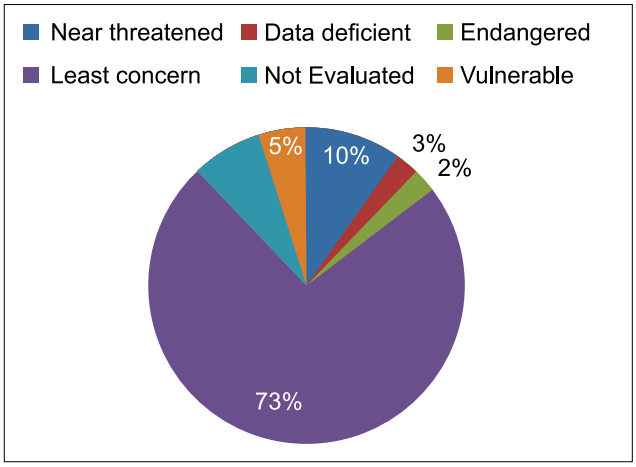


Fig. 30. IUCN status of aquatic species reported across the landscapes

Fig. 31. Onsite analysis of water quality and nutrient parameters

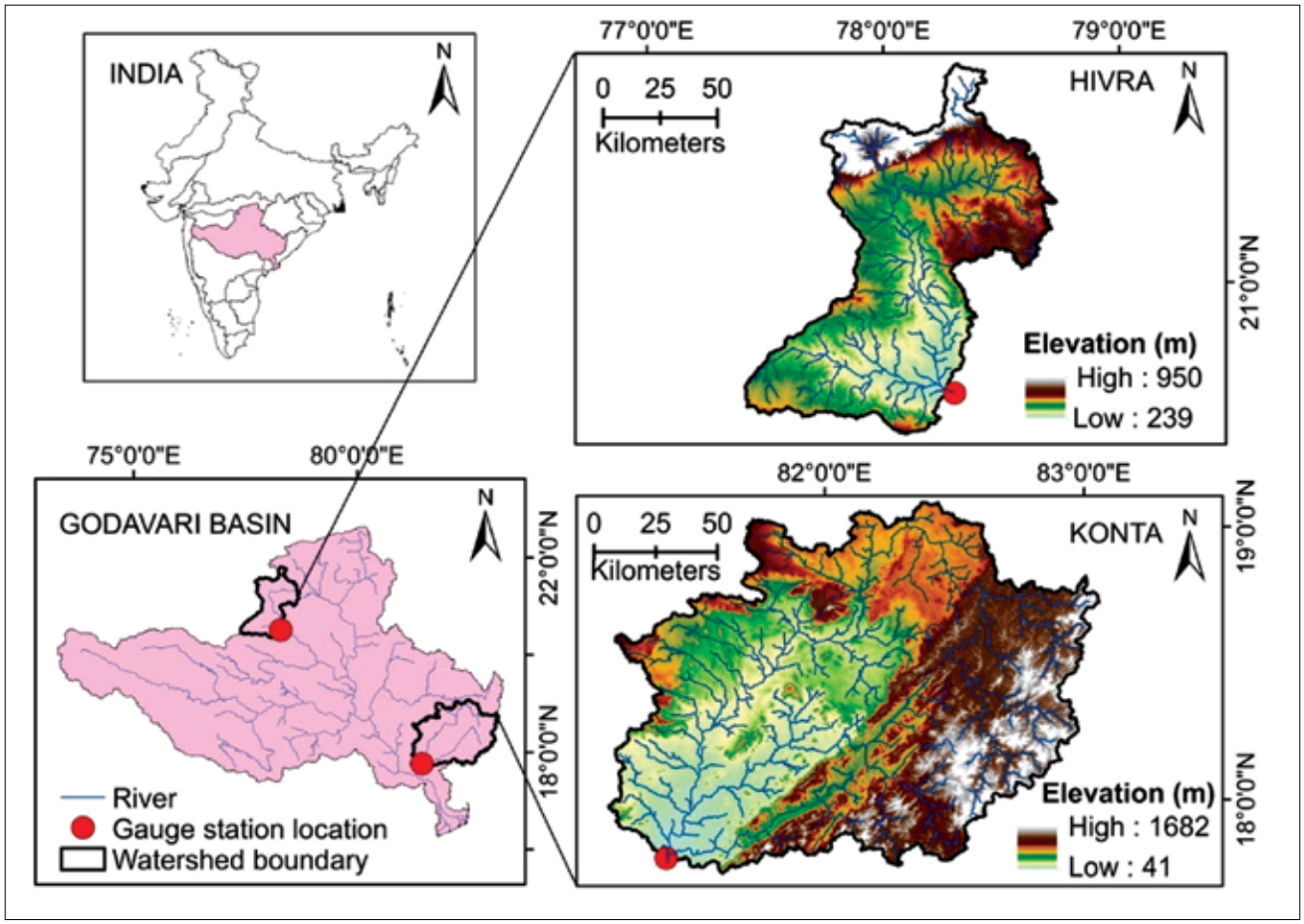


Fig. 32. Location and elevation details of the study area in Godavari River basin

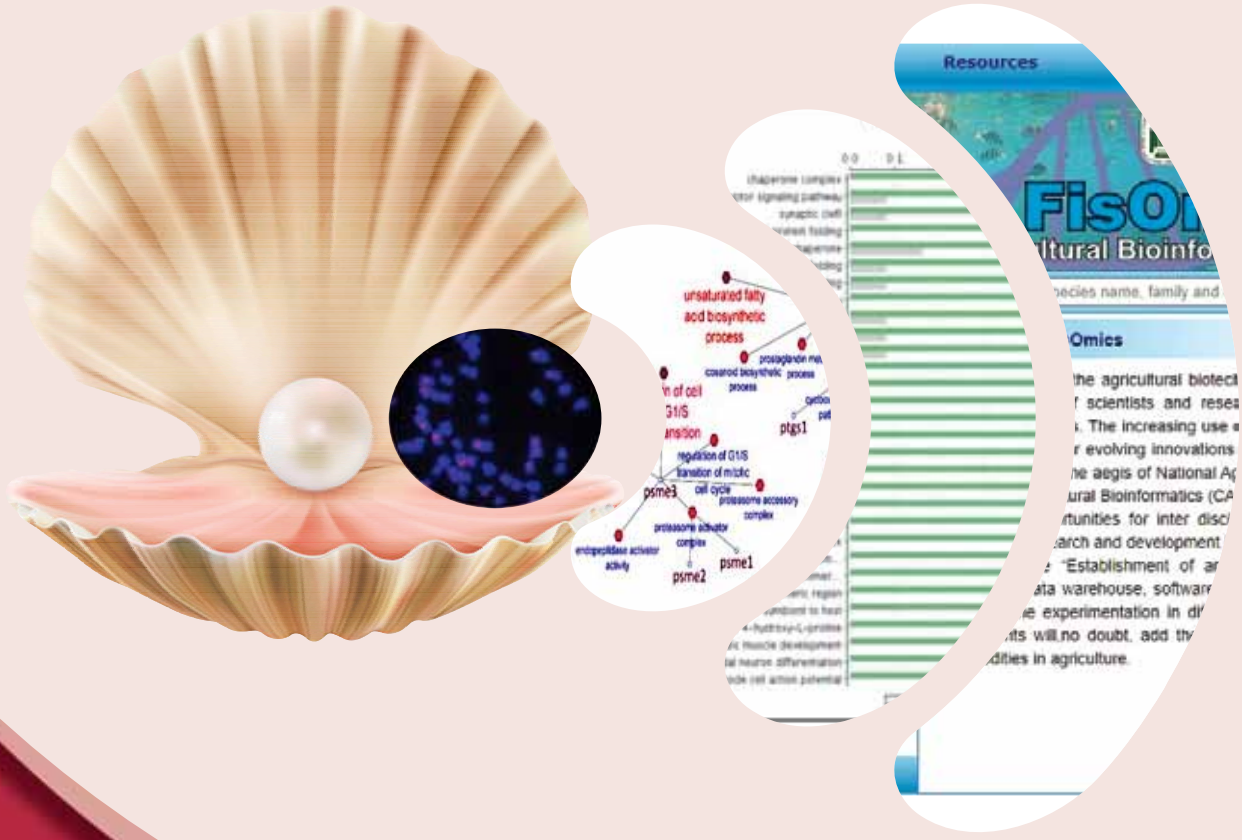
Project: **Phylogenetic relationships of Indian species of goatfishes (Family: Mullidae) inferred from genetic and morphologic data**

Period: **January, 2020 - December, 2022**

Personnel: **Jasmine Anand (PI) and T.T. Ajith Kumar (Mentor)**

Funding Support: **DST-SERB-TARE Scheme**

The project aims to establish and infer phylogenetic relationship of goatfishes found in Indian waters. Exploratory surveys for collection of goatfishes were undertaken during the reporting period. Sampling has been done in Kerala (4 locations), Tamil Nadu (3 locations) and Karnataka (2 locations), wherein 85 specimens belonging to 7 species were collected. Meristic and morphometric data for 25 specimens were documented.



Program 4.3: Genomic resources for important fishes

ICAR-NBFGR is one of the leading institutes in the field of genomics, transcriptomics and bioinformatics research in fisheries sector. The genetic technologies mainly relevant to genomics in fisheries sectors are DNA banking, DNA markers, genome mapping, sequencing and molecular breeding. In this context, the institute is leading an ICAR-Consortium Research Project on Genomics. In addition, institute is one of the domain partners in Network Project for Agricultural Bioinformatics and Computational Biology Scheme of ICAR implemented through CABin Division of ICAR-IASRI, New Delhi. 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 aquaculture industry with considerable economical repercussions. Therefore, institute is working to elucidate unique biochemical adaptational strategies that fishes employ against abiotic stresses like temperature and ammonia, through genomic and proteomic approaches. 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: **Stress tolerance response in cultivable freshwater fish species**

Period: **April, 2017 - March, 2021**

Personnel: **Satish Kumar Srivastava (PI), Ravindra Kumar and Poonam Jayant Singh**

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

Stress tolerance ability differs from species to species. Higher the ability to tolerate stress, will be easier for the species to cope with changing climate scenario. Conventionally, the upper and lower water temperature tolerances of fishes were quantified through various experiments. The project aims to estimate critical limits of temperature, and investigate the biochemical changes taking place in the fish to understand how fishes develop adaptive strategies towards thermal stress. During the reporting period, *Tor putitora* were collected from Bhimtal, Pancheshwar and *Scizothorax richardsonii* from Champawat in Uttarakhand. The critical highest temperature tolerance limit in *T. putitora* and *S. richardsonii* were recorded as 35 and 31.5 °C, respectively. To study the longterm effects on hormonal levels including cortisol, estradiol, thyroxin, testosterone and triiodothyronine, *Clarias magur* and *Labeo rohita* were exposed to sub-lethal low water temperature 11 and 9 °C, respectively for 45 days. Decrease of thyroxin, triiodothyronine and cortisol, but increase of estradiol and testosterone were observed in experimental group as compared to control in both the species.

Tissue specific proteome expression was also studied in seven tissues of *L. rohita* (brain, eye, gill, liver, muscle, serum, swim bladder) using Liquid Chromatography-Mass Spectrometry (LC-MS/MS) in control and experimental groups of *L. rohita* exposed to sub-lethal low temperature (9 °C) for 45 days in temperature controlled water circulatory system. Retrieved peptides were compared with existing reviewed proteins of zebrafish from UniProt for commonly expressed (CEP), uniquely expressed (UEP) and differentially expressed (DEP) proteins. A total of 2,765 proteins were retrieved from the control samples of *L. rohita* and 4,639 proteins were retrieved from experimental samples. The results of protein expression in control and experimental groups of *L. rohita* are presented in Fig. 33. Protein expression in brain, gill, liver, muscle and serum were higher, except in eye and swim bladder tissue (Fig. 34). Gene Ontology analysis of DEP for brain, eye, gill, liver, swim bladder and serum for biological process, cellular component, and molecular function is depicted in Fig. 35. The DEPs can provide insight for understanding mechanism of protein regulation for stress management and adaptation for climate change. Tissue specific proteome study will bring clarity on pathway specific metabolism adapted by fishes for ameliorating stress.

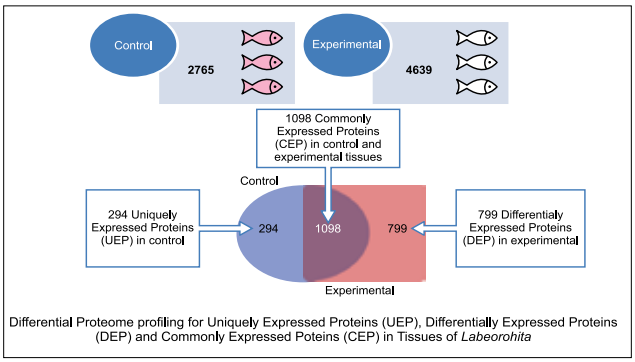


Fig. 33. Profiles of uniquely, commonly and differentially expressed proteins

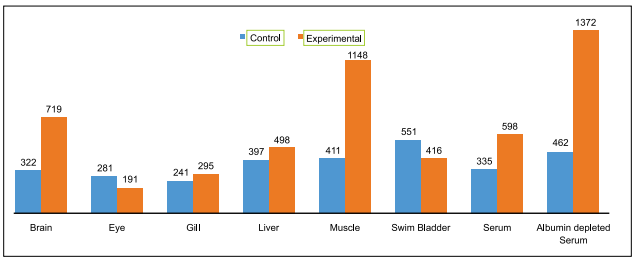


Fig. 34. Protein profiles of *Labeo rohita* exposed to cold temperature

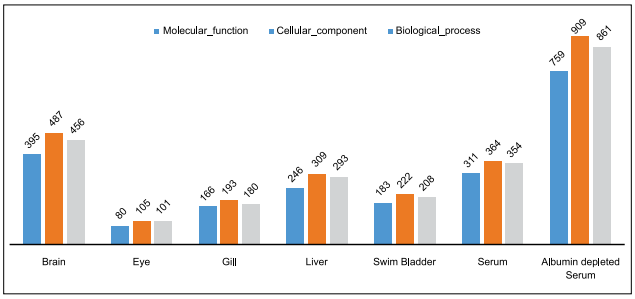


Fig. 35. Gene Ontology function of differentially expressed proteins for molecular, biological and cellular process

Project: **Establishment of standardised genomic markers for cataloguing diversity below species level**

Period: **August, 2020 to March, 2023**

Personnel: **Sangeeta Mandal (PI), Vindhya Mohindra, Rajeev Kumar Singh and Divya P.R.**

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

Sequence generation for microsatellite repeat identification and primer designing in *Ompok bimaculatus*

During the reporting period, 1.5 kb library was constructed and sequenced on PacBio RSII. A total of 51,219 sequences were examined. Among 53,730 repetitive motifs from 20,284 SSR containing sequences, 39,448 were dinucleotides (73.41%), 6,302 trinucleotide (11.72%), 7,546 tetra repeats (14.04%), 373 penta repeats (0.69%) and 61 hexa repeats (0.11%). A total of 10,706 sequences were found to contain more than one repetitive region, while 24,242 comprised of compound repeats. The majority of repeats were dinucleotide (73.41%), followed by tetranucleotide (14.04%) and trinucleotide (11.72%). A total of 509 sequences were analyzed for primer designing. Primers were designed from contig sequences containing microsatellite repeats with sufficient flanking nucleotides, using Primer3. Total 206 primers were designed for dinucleotide repeats, 145 for trinucleotide repeats, 96 for tetranucleotide repeats, 10 for penta repeats and 1 for hexa repeat. Range of repeat units varied between 6-29 for dinucleotide, 5-18 for trinucleotide, 5-12 for tetranucleotide, 5-12 for penta and 5 for hexa repeat.

Sequence generation and microsatellite repeat identification in *Rita rita*

Short read sequences were generated and sequenced with illumina NovaSeq 6000. A total of 198.3 Mb polymerase read data, was generated upon sequencing 400-500 bp library and Q30 bases data was 27.31 G (94.33%). The assembly was 954 Mb in size with a scaffold N50 value of 49,542 bp. Total number of sequences examined were 17,86,941 out of which, number of SSR containing sequences were 4,50,840. SSR marker identification was performed using the MISA tool. A total of 2,00,391 sequences were found to contain more than one repetitive region, while 3,06,311 comprised of compound and/or imperfect repeat units. More than 40% of the genome was covered with repeats.

Project: Network project on agricultural bioinformatics and computational biology

Sub-project: Construction of physical map of *Clarias magur* genome

Period: May, 2017 – June, 2020

Personnel: Ravindra Kumar (CPI), Basdeo Kushwaha, Mahender Singh, Ajey Kumar Pathak and Murali S.

Funding Support: CABin Scheme of ICAR, implemented through ICAR-Indian Agricultural Statistics Research Institute, New Delhi

Physical genome map of a species represents the physical locations of genes and other DNA sequences. BAC library are useful resources for construction of a physical map. These resources have various genomic applications, such as genome assembly, understanding genome organization, mining genes, positional cloning, targeted marker development, selection of candidate genes of economic traits for molecular breeding etc. During this year, a total of 552 BAC clones of *Clarias magur* genome were revived and isolation of BAC insert DNA was accomplished. Of these, end sequencing of 285 clones were generated using T7 forward (129) and pbRP1 reverse (156) primers and were mapped on the genome scaffolds of *C. magur* using in-house developed bioinformatics server, BAC2GENOM. Out of 285 end sequences, a total of 229 mapped on the scaffolds of the *C. magur* genome with 59 BAC ends mapped on same scaffolds. A total of 192 genes were present on those BAC clones. Two FISH experiments using fluorescein and rhodamine probes were conducted for localising genes on *C. magur* metaphase chromosomes. It was found that for BAC clones 010A12 (Fluorescein labelled) and 010P13 (Rhodamine labelled), the signals were observed on Chromosome 11 (Sub-metacentric) and 12 (Sub-metacentric) (Fig. 36 a, b). Similarly, for BAC clones 010L11 (Fluorescein labelled) and 010P19 (Rhodamine labelled), the signals were observed on Chromosome 11 (Sub-metacentric), chromosome 18 (Sub-metacentric) and chromosome 20 (Sub-telocentric) (Fig. 37 a, b). Two genomic resource databases were updated using data available in public domain (Fig. 38). FMiR was updated by 95 records of

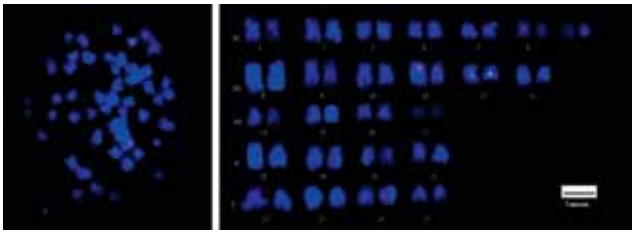


Fig. 36. Metaphase spread and karyotype showing (a) 010A12 (fluorescein), (b) 010P13 (rhodamine) probes signals

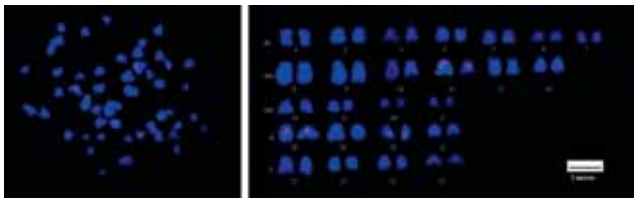


Fig. 37. Metaphase spread and karyotype showing (a) 010L11 (fluorescein), (b) 010P19 (rhodamine) probes signals

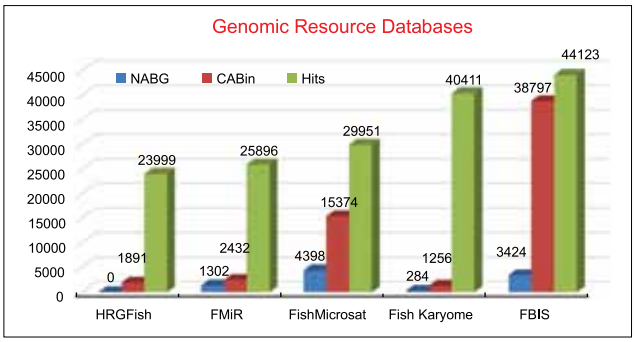


Fig. 38. Genomic resource database

95 species to contain 2,432 records of 2,432 species and Fish Karyome was updated by 61 records to contain 1,256 records of 987 species.

Project: **Network project on agricultural bioinformatics and computational biology**

Sub-project: **Understanding genomic factors responsible for growth performance in *Clarias magur***

Period: **July, 2020 – March, 2026**

Personnel: **Ravindra Kumar (PI), Basdeo Kushwaha, Mahender Singh, Murali S. and Reeta Chaturvedi from ICAR-NBFGR; and K.K. Chaturvedi, S.B. Lal and Neeraj Budhlakoti from ICAR-IASRI**

Funding Support: **CABin Scheme of ICAR, implemented through ICAR-Indian Agricultural Statistics Research Institute, New Delhi**

Most of the species under aquaculture are basically wild and limited knowledge is available about their genomes and genes affecting economic traits. Modern genomic tools with epigenetics may significantly help to interpret the molecular processes involved in traits determination as well as differentiation. During the reporting period, a total of 11,36,697 genes related to growth and metabolic activity in vertebrates were mined from the NCBI database. The list contained lots of duplicate genes, hence, local BLAST program was used to mine and map these genes from *Clarias magur* genome. A total of 183 growth-related genes could successfully be identified. Similar exercise was also carried out using *Labeo rohita* and *Cyrpinus carpio* genome that resulted in the identification of 128 and 140 growth-related genes, respectively. Comparative analysis of growth-related genes between the above three species is underway. *C. magur* individuals were procured from local fish markets of Lucknow for creation of magur families. All the fishes were tagged using PIT tags, their length and weight recorded and then acclimatized in a FRP tank at indoor hatchery of the institute. Mating was designed to create 5 families using males and females which were prepped for breeding. COI sequence for all the individuals used for breeding was generated for species confirmation. Milt collected from *C. magur* male through partial harvesting of testes and fertilized with eggs collected from female *C. magur*. The family-wise fertilized eggs were reared in flow-through system for hatching and then pooled family wise and transferred to 60 litre capacity plastic tubs. Dead/unfertilized eggs were removed through pipetting (Fig. 39). After 3 days of

Fig. 39. Removal of dead and unfertilized eggs

Fig. 40. Transfer of fry to circular FRP tank

hatching, the fry were fed with plankton and artemia. After 10 days, fry were transferred to circular FRP tanks after counting (Fig. 40). After 2 weeks, they were fed with prepared feed supplemented with minerals, twice a day. After two months, the fingerlings were transferred to cement tanks.

Moreover, genomic resource databases, *viz*. FBIS, FMiR, FishMicrosat, Fish Karyome and HRGFish, hosted through FisOmics web portal, were maintained and updated regularly. FisOmics web portal had a total of 33,135 visitor hits. The FBIS was updated by 1,339 records of 14 species to contain 40,136 records of 1,848 species. FMiR was updated by 7 records of 7 species to contain 2,439 records of 2,439 species and FishMicrosat was updated by 1,996 records to contain 17,370 records of 204 species.

Project: **ICAR-CRP Genomics: *De-novo* genome sequencing of anadromous Indian shad, *Tenualosa ilisha* (Hamilton 1822) and Indian major carp, *Catla catla***

Period: **July, 2015 - March, 2021**

Co-ordinator: **Joykrushna Jena, Deputy Director General (Fisheries Science)**

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

Funding Agency: **ICAR, New Delhi**

Draft genome of Indian major carp, *Catla catla* - Gene prediction and functional annotation

The assembled genome contained 1.094 Gb, with mean N50 1.70 Mb and longest contig 11.7 Mb and 97% BUSCO completeness and a total of 31,344 (68.27%) genes predicted to have blast hits and mapped with Swisprot/ Uniprot database, 27,207 (59.26%) gene models annotated and 39,309 (85.62%) gene models InterPro scanned. The KASS analysis classified the total predicted gene models in three protein families including metabolism (3,280 genes), genetic information process (8,430 genes) and signalling and cellular process (5,941 genes). Total of 8,282 unique genes were predicted in five categories namely, metabolism (1,598), genetic information process (1,087), environmental information process (1,369), cellular process (819) and organismal system (995).

Genes associated with immune system: On the basis of GO databases and literature, all these genes predicted were classified into different categories and 750 immune transcripts from KAAS and 9,811 immune transcripts from quick GO were assessed in immune system category. Based on literature, a total of 832 uni immune genes were classified in different categories i.e., innate immune system, adaptive immune system, negative regulation of immune system and miscellaneous immune system.

Comparative genomics through orthology: Orthology of *catla catla* draft genome was carried out along with other 41 teleosts available in uniprot database for comparative orthology inference. Comparative analysis revealed a total of 30,641 orthogroups and a total of 6,581 species-specific orthogroups in 42 species. In *C. catla* a total of 15,536 orthogropus were detected and 40,038 predicted gene models were found to be present in orthogroups and remaining 5,872 genes were reported to be unassigned. Further out of total orthogroups, a total of 849 were found to be specific with a total of 5,726 predicted genes.

Differential gene expression (DGE) analysis in two different growth stages of *Catla catla*

Differential genes expression analysis was carried out in two life stages, juveniles stage 1 (35-70 g) and stage 2 (237-320 g) to identify relative gene expression patterns. DGE analysis of these stages (stage 1 vs stage 2) revealed up-regulation of 535 genes, while 267 genes were down-regulated. Networking analysis shows interaction among 9 pathways, major pathways including metabolic pathways (52 genes), focal adhesion (15), spliceosome (10), ECM-receptor interaction (9) and pyrimidine metabolism (9).

Growth-specific gene expression analysis in two different growth stages of *Catla catla*

Gene expression analysis of the growth gene was carried out for a total of 55 genes with housekeeping genes, in stage 1 and stage 2. Differential gene expression analysis of a total of 18 genes, i.e. 15 and 3 genes were up and down regulated, respectively. Highest up-regulation was found to be in MYH10 (13.58 fold), followed by MYH9 (10.66 fold), whereas genes such as IGF2, AZIN1 and PIMT were down-regulated (Fig. 41).

Table 3. miRNA Analysis result

	No. of Known miRNAs (*Danio rerio*)	No. of Known miRNAs (Human)	No. of Novel miRNAs (*Danio rerio*)	No. of Novel miRNAs (Human)
Stage 2	512	144	144	26
Stage 1	492	115	94	25

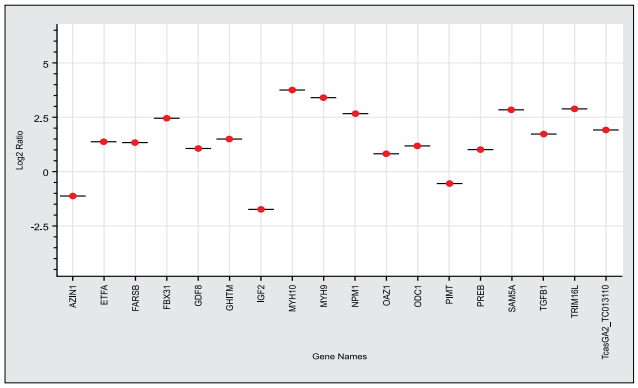


Fig. 41. Gene expression analysis in two different growth stages of *Catla catla*

miRNA Analysis

Raw data of 5.366 GB comprising of total raw reads 10,73,30,225 were generated from 50 bp single end library for small RNA sequencing. The novel miRNA was predicted based on reference genome of zebrafish and human. Unique reads with length of 17-24 bp after contamination filter were used for known miRNA identification with reference to zebrafish using miRBase-22. The unaligned reads from zebrafish were used further for miRNA identification with human reference.

All the predicted miRNA were used for target prediction using Miranda tools (Table 3). The functional annotations comprising biological process, cellular component and molecular functions were performed.

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

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

Personnel: **Vindhya Mohindra (PI) and Labrechai Mog Chowdhury**

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

The project aims at generating genomic resource base to facilitate gene prospecting and allele mining in golden mahseer, *Tor putitora* and prospecting of genes and alleles responsible for adaptation to thermal stress from two diverse habitats.

Identification of hub genes for thermal tolerance

For comparative transcriptomics analysis of *T. putitora*, transcriptome resources from different tissues were generated for gene prospecting, allele mining and understanding of temperature adaptation in two different agro-climatic condition i.e., upstream of river Ganga (Uttarakhand) and Mahanadi (Odisha).

Brain: In brain, a total of 609 and 725 transcripts, representing 496 and 537 genes, were found to be up-regulated and down-regulated, respectively, in river Mahanadi as compared to Gangetic population. Further, to gain mechanistic insight into gene lists from generated Differential Gene Expression (DGE) experiments, Gene Set Enrichment Analysis (GSEA) (p-value <0.05; FDR value 0.25; minimum gene set of 5) identified a total of 78 Gene Ontology (GO) terms (Core and Non-Core) with 48 cores, of which 43 GO term were found to be involved in biological pathways (Fig. 42). Maximum number of genes were found to be involved in chaperone complex (17) followed by ionotropic glutamate receptor signalling pathways (17), synaptic cleft (14), *de novo* protein folding (14) and positive regulation of telomerase activity (14).

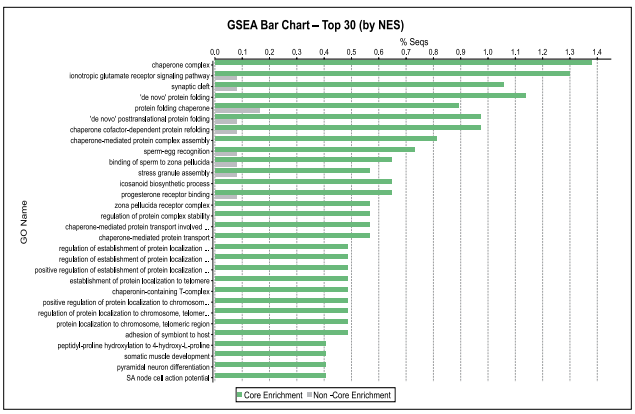


Fig. 42. Gene Set Enrichment Analysis for differential gene expression in brain of *Tor putitora*

To understand genes interaction networks and functional enrichment a STRING (Search Tools for Retrieval of Interacting Genes/Proteins) biological database of known and predicted protein-protein interactions (PPI) were used with reference to zebrafish. A total of 97 genes were found to be significantly involved in function regulatory network for important regulatory functions. Out of which, a

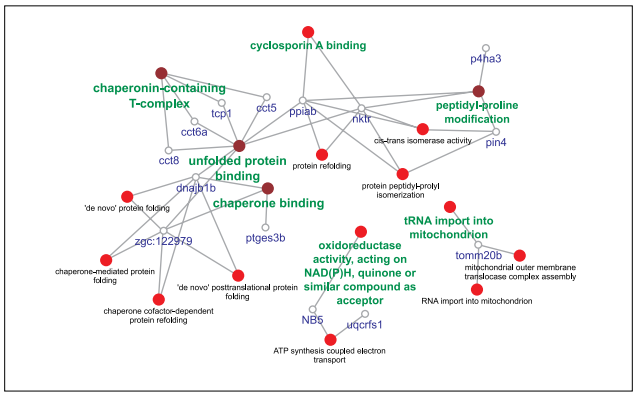


Fig. 43. Hub genes of differential expressed genes in brain of *Tor putitora*

total of 11 hub genes were identified i.e., cct5, cct6a, cct8, dnajb1b, nktr, ptges3b, tcp1, zgc:122979, p4ha3, pin4, and ppiab for adaptation to thermal stress in different agro-climatic conditions (Fig. 43).

Liver: In liver, a total of 1,030 and 634 transcripts representing 817 and 461 uni-genes were found to be up-regulated and down-regulated, respectively in Mahanadi, as compared to Gangetic population. GSEA of DGE genes (p value <0.05; FDR value 0.25; minimum gene set of 5) identified a total of 37 GO terms, with a total of 26 GO were involved in biological pathways that are enriched in a gene set (Fig. 44). Maximum numbers of genes were found to be involved in ER-nucleus signalling pathway (21), followed by fatty acid binding (19), neutral amino acid transport (16), cajal body (16), regulation of transforming growth factor beta production (16) and transforming growth factor beta production (16).

A total of 73 core genes were found to be involved in biological processes and 36 core genes were significantly involved in molecular function, whereas no genes were found to be involved in cellular components.

Identification of hub genes and pathways through DEG PPI network analysis using zebrafish as reference with STRING tool predicted a total of 109 genes that were significantly involved in functional network

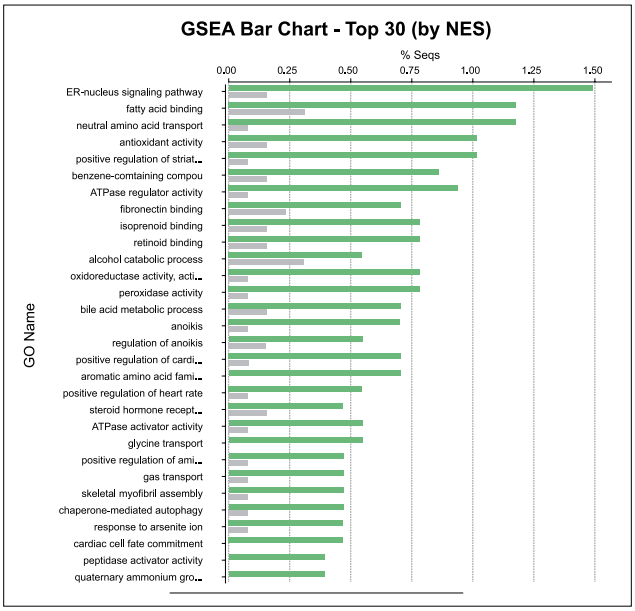


Fig. 44. Gene Set Enrichment Analysis for differential gene expression in liver of *Tor putitora*

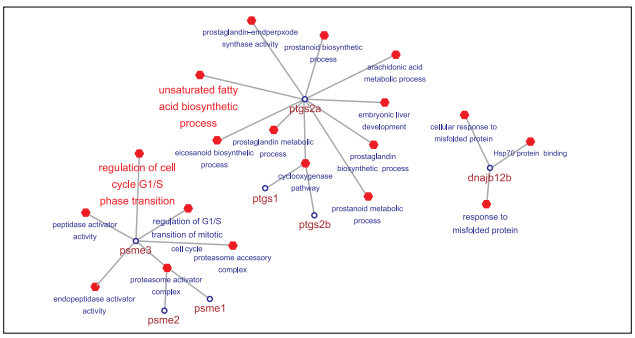


Fig. 45. Hub genes of differential expressed genes in liver of *Tor putitora*

interaction. Out of these, a total of 7 hub genes were identified (ptgs2a, ptgs1, ptgs2b, dnajb12b, psme3, psme2 and psme1) that may play important role in thermal adaptation (Fig. 45).

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 Labrechai Mog Chowdhury**

Funding Support: **NASF-ICAR, New Delhi**

The indigenous freshwater catfishes *Clarias magur* and *Heteropneustes fossilis* are usually found

in habitats with stagnant water bodies where oxygen is limited, primarily because of excessive content of nitrogenous wastes such as ammonia. Due to this, they occasionally face the problem of higher external ammonia toxicity. It is important to elucidate whole set of adaptive genes, factors and regulatory molecules as well as signalling pathways operative in these catfishes and their expression patterns.

Assessment of physiological parameters after treatment with 25 mM ammonium chloride (NH_4Cl) in *Heteropneustes fossilis*

H. fossilis collected from commercial catches were maintained for one month in FRP tanks. During this period, fish were fed with powdered commercial feed mixed with minced chicken (1:1) twice daily and 50% water was changed every day to remove extra feed and faecal waste. The experimental set up consisted of fish exposed to 25 mM NH_4Cl and control for a period of 3 h, 6 h, 9 h and 9 h with respiratory burst. During the tissue sampling, blood, liver, kidney, gills, brain, heart and muscle were dissected out and immediately kept into liquid nitrogen and thereafter stored at -80 °C. For histological analysis liver, kidney and gills were preserved in 10% neutral buffered formalin. Analyzed haemoglobin, hematocrit value, blood urea nitrogen, blood urea, serum creatinine, serum protein, blood sugar, SGPT, SGOT, LDH and ammonia accumulation in blood plasma of *H. fossilis* treated with ammonium chloride.

Blood ammonia:

Level of ammonia recorded 3, 4 and 6 fold increase at time interval of 3, 6 and 9 h respectively, as compared to control ($p<0.05$). Following respiratory burst at 9 h, the blood ammonia level reduced to the level of control (Fig. 46).

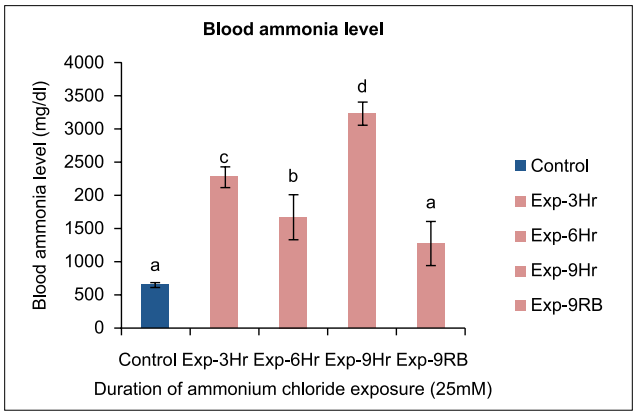


Fig. 46. Blood ammonia level after exposure to 25 mM NH_4Cl

Blood Urea and Blood Urea Nitrogen:

Blood urea concentration gradually increased with the increase in duration of exposure of NH_4Cl upto 6 h, followed by reduction at 9 h irrespective of respiratory burst (Fig. 47). The increase was significant at 3, 6 and 9 h of NH_4Cl treated samples but with

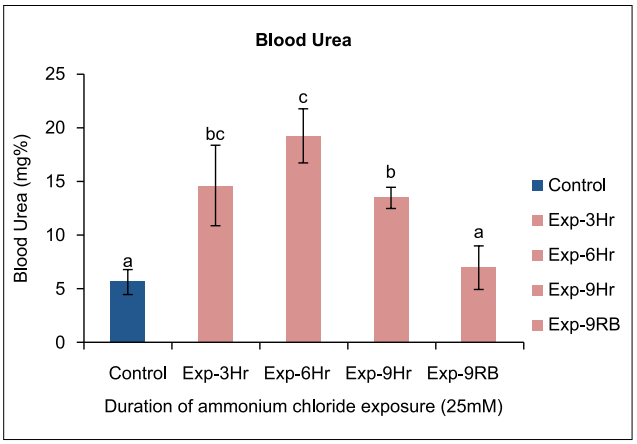


Fig. 47. Blood urea after exposure with 25 mM NH_4Cl

respiratory burst it returned to normal level. At 6 h, level of blood urea was highest with 4 fold increase ($p<0.05$).

Blood sugar level, SGOT and SGPT level and other blood and serum parameters did not show any significant difference between ammonium chloride treated group and control.

Histological analysis:

The analysis of control, experimental 3, 6, 9 h and 9 h with respiratory burst illustrates that the highest percentage of congested blood capillaries were observed in specimens treated for 3 h (60%) with 25 mM NH_4Cl. However, for respiratory burst (38.30%) it declined by 36%. Similarly, the apical regions of primary lamellae were observed without secondary lamellae. The highest percentage of apical disintegration was seen in fish exposed for 3 h to NH_4Cl. Along with deteriorated secondary lamellae, deformed lamellae were also noticed which included shortened, curled and fused secondary lamellae. Most deformed secondary lamellae were observed in fishes at 6 h post NH_4Cl exposure, which is 24% and most fused secondary lamellae were also observed in the same specimens. It has also been noticed that the thickness of secondary lamellae gradually started increasing from 6 h and was observed in both 9 h and 9 h with respiratory burst. Another change that has

been noticed is the hyperplasia of primary epithelial cells which was observed highest (80%) at 3 h post exposure. Oedema of the gill lamellae was observed highest (51%) in 9 h treated group and no oedema was observed in 3 h treated group.

Transcriptome and differential expression in *Clarias magur*

For transcriptome profiling in *C. magur* following NH_4Cl exposure, RNAseq analyses were carried out in kidney tissues of three different conditions i.e., control, 3 h and 9 h exposure using Illumina HiSeq 2500. A total of 39 GB data of sequencing raw reads were generated. After pre-processing, the cleaned reads were assembled using Trinity with default settings and generated 2,30,942 transcripts. Assembled transcripts were clustered using CD-hit-est to remove the redundant and partial transcripts. Final set contained 1,99,894 non-redundant transcripts with longest transcript length of 22,988 bp. Blastp against swissprot database predicted a total of 41,225 transcript with known gene of 12,136 unigenes.

In control, 3 and 9 h exposure to NH_4Cl, differential gene expression pattern showed gradual increasing trends in the number of DEG with increase in exposure time and higher number were observed in control vs 9 h exposure (Table 4).

Table 4. DEG between control and after 25 mM NH_4Cl exposure using DESeq program

DESeq combination	Down-regulated transcripts	Up-regulated transcripts
CM vs EM3 kidney	219	489
CM vs EM9 kideny	197	505
EM3 vs EM9 kidney	288	401

The GO distribution of transcripts at level 2 of top 20 terms in biological process, molecular function and cellular components is depicted in Table 5 and Fig. 48. Majority of GO were involved in biological processes. In biological process, cellular processes showed maximum number of transcript involvement. In molecular function, majority of transcripts were involved in binding and in cellular component, majority of transcripts were involved in cellular anatomic entity.

Table 5. GO terms identified in molecular function, biological process and cellular component category after treatment with 25 mM NH_4Cl

Processes	GO terms
Biological processes	2,614
Molecular functions	1,372
Cellular components	612

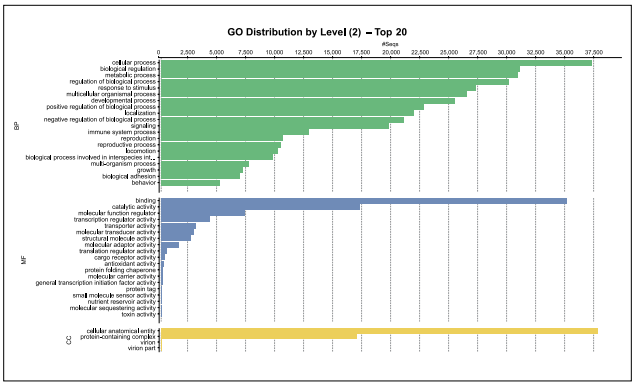


Fig. 48. The top 20 GO terms in biological, cellular and molecular function categories of DEGs in kidney from 3 h and 9 h NH_4Cl treatments in *Clarias magur*

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

India is a biodiversity rich country as four out of the thirty-four globally listed biodiversity hotspots are present. More than 31,000 native fish species have been reported globally and India is home to about 10% of total fish diversity. Climate change, massive anthropogenic activities, environment degradation and over-exploitation have created a stress on ecology and hence, there is 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 signatory to CBD, ICAR-NBFGR, a premier institute, is striving to preserve the native fish genetic resources, regeneration of depleting germplasm of both conservation and aquaculture value, stock enhancement of wild relatives and populations through various research and demonstration programs. The major activities of the institute in this area have been species-specific sperm cryopreservation protocol development, surrogate broodstock development, tissue banking, diploid cell banking, captive breeding and 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 livelihood to local people in fish rearing and breeding activities, which are helpful in minimizing pressure on aquatic resources and lead to biodiversity conservation. Establishment of cryobanks for genetic exchange between hatcheries will help in production of genetically diversified seed for production enhancement in aquaculture and eventually farmers may be benefitted.

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: **Institutional, ICAR-NBFGR**

The project aims to establish a National Germplasm Repository and Museum as an integrated aquatic genetic resource centre. During the reporting period, connecting bridges with main building, third floor and dome were developed. Architectural design of the interpretation centre was finalized in coordination with CPWD. Posters and display materials were designed. Furniture for sperm, cell line and microbial repository were designed and tendered. Fish specimens from different water bodies were procured and preserved for display. Chambers for specimen display has been finalized. Further, development of molluscan repository display is underway. Various boats model has been procured.

Component-II: **Diploid germplasm cryobanking for *ex situ* conservation and multiplication of aquatic resources**

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

Personnel: **Aditya Kumar (PI), Labrechai Mog Chowdhury and Murali S.**

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

The project envisages developing diploid cell bank as part of *ex situ* conservation. For developing primary cell cultures of *Labeo bata* and *L. gonius*, caudal fin explants methods were followed to isolate the cells. Cell growth and radiation started from 5th day and 4th day in *L. bata* and *L. gonius*, respectively. Both the primary cultures formed complete monolayer after 20th day (Fig. 49 and 50). The cells were then cryopreserved in LN_2 after the 3rd passage. The cryopreserved cells will be revived at certain interval to assess the viability. Furthermore, previously cryopreserved primary cells from mrigal and rohu caudal fin were revived after 24 months and cell growth was observed (Fig. 51 and 52).

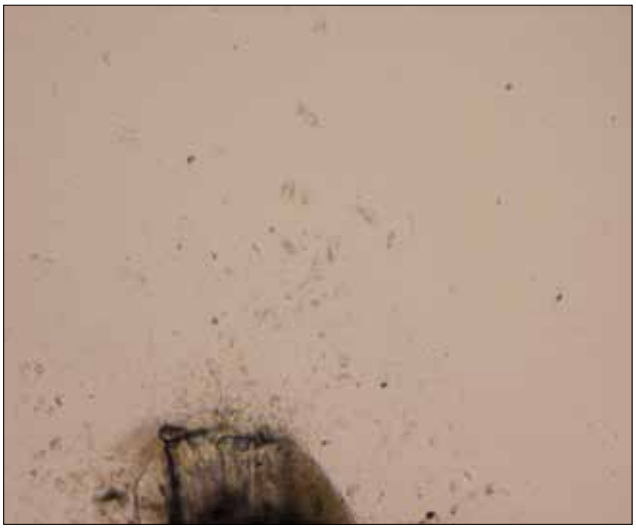


Fig. 49. Explant from caudal fin of *Labeo bata* showing cell growth on 5th day

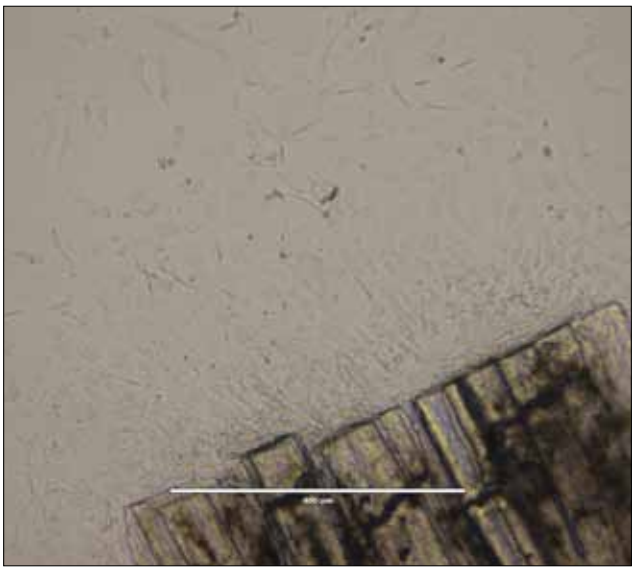


Fig. 50. Primary culture from caudal fin of *Labeo gonius*

Fig. 51. Revived primary cells from mrigal caudal fin after 24 months

Fig. 52. Revived primary cells from rohu caudal fin after 24 months

Project: Capacity building and feasibility studies on new areas of research on AqGR management

Sub-project 1: Culture of tissue specific cells

Period: July, 2020 - March, 2022

Personnel: Basdeo Kushwaha (PI) and Murali S.

Funding Support: Institutional, ICAR-NBFGR

Cell cultures are important tools to study and understand the biological process in key areas of research. The project aims to culture tissue specific cells for further application in aquatic genetic resource management. The culture of testis specific sertoli and leydig cells could be a valuable resource for comparative study of gene expression. A total of 31 genes were found to be directly associated in reproduction (Table 6). The sequences of these genes will be used for developing molecular markers for identification of sertoli and leydig cells through RT-PCR. Further, the availability of these cells will support *in vitro* culture of primordial germ cells/ secondary spermatogonial cells of *Clarias magur*.

Project: Up-scaling of fish milt cryopreservation tools for sustainability of aquaculture seed production

Period: November, 2020 - March, 2023

Coordinator: Kuldeep K. Lal

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

Funding Support: Institutional, ICAR-NBFGR

The project envisages upscaling of cryopreservation technique for commercial seed production of carps and establishment of cryobanks for assisted reproduction in fishes. Literature survey has been done for new protocol development. Brood fishes of common carp, grass carp, pangasius and Indian major carps have been procured and being reared in germplasm resource centre of ICAR-

Table 6: List of identified reproduction genes in *C. magur*

S. No.	Genes	S. No.	Genes
1	Testis-expressed sequence 36 protein	17	Sperm-associated antigen 6
2	Transmembrane protein 184A	18	Gastrula zinc finger protein XlCGF49.1-like
3	Aemaphorin-6A X2	19	Prostaglandin E synthase
4	Sister chromatid cohesion protein PDS5 homolog A X1	20	Sphingomyelin phosphodiesterase 5-like
5	Progesterone receptor	21	Estrogen receptor beta-1-like
6	GRB2-associated-binding protein 1 X1	22	Twisted gastrulation protein homolog 1-A-like
7	Sperm flagellar protein 2	23	Testis-expressed sequence 2 protein
8	Sperm-associated antigen 5	24	Testis-specific gene 10 protein
9	Spermatogenesis-associated protein 4-like	25	Sperm-associated antigen 16 protein
10	Transcription cofactor vestigial-like protein 4 X1	26	Ubiquitin carboxyl-terminal hydrolase 5 X1
11	Zona pellucida sperm-binding protein 3-like	27	Gametocyte-specific factor 1-like
12	Gametocyte-specific factor 1-like	28	Spermatogenesis-associated protein 22 X1
13	Sperm acrosome-associated protein 9	29	Motile sperm domain-containing protein 1
14	Spermatogenesis associated 6-like protein	30	Oogenesis-related protein
15	Estrogen receptor beta X1	31	Tudor domain-containing protein 6
16	Follicle-stimulating hormone receptor		

NBFGR, Lucknow. Cryovials of different capacities have been procured. Customization of equipment for field use has been done. To reduce handling error during cryopreservation, various equipments have been customized and fabrication is being done.

Project title: **Genetic approach and evaluation to aid conservation and sustainable propagation of near threatened catfish *Clarias dussumieri* in natural waters**

Period: **August, 2020 – March, 2023**

Personnel: **Divya P.R. (PI) and V.S. Basheer**

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

This project envisages conserving near threatened catfish *Clarias dussumieri* through genetic approach, evaluation of genetic stocks and sustainable propagation. This species was identified at 3 places in Kerala *viz*. Kasargod (Chandragiri River basin), Malappuram (Bharathapuzha River basin) and Idukki (Periyar River basin). Samples were collected from Idukki (30 nos.) and Malappuram (25 nos.). Development of microsatellite markers was done using third generation sequencing technology in PacBio RS II. In total, 280 primers screened from 7 individuals and 92 loci were found to be polymorphic of which, one was penta repeat, 41 tetra repeats, 27 tri repeats and 23 di repeats. Eighteen panels of 42 microsatellite loci were designed initially and the polymorphic loci were subsequently tested for suitability in population genetics analysis of *C. dussumieri* samples from Periyar and Bharathapuzha.

Project: **Livelihood improvement through freshwater aquaculture human resource development for the Scheduled Caste of the Government of India in prioritized selected district of Uttar Pradesh**

Period: **April, 2020 - March, 2024**

Personnel: **Sharad Kumar Singh (PI), Lalit Kumar Tyagi, Achal Singh, Aditya Kumar, Raghvendra Singh, Amit Singh Bisht and Sanjay Kumar Singh**

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

Project aims to improve livelihood of scheduled caste farmer through training and demonstration in freshwater aquaculture for selected districts of Uttar Pradesh. For demonstration of freshwater aquaculture, beneficiaries were selected.

Case I: Selection of one farmer family, Shri Lalluram S/o Bhabhuti (Family Size-10), in the village Rajauli, Bakshi Ka Talab, Lucknow was done. The 0.25 ha unutilized pond of the selected farmer was renovated for fish farming. Four small ponds, each having area of 0.0625 ha were developed and stocked with rohu (30%), grass carp (20%), pangasius (20%), mrigal (15%), catla (5%), silver carp (5%) and common carp (5%). The average size of stocked carp was 8-10 g and 7-10 g for pangasius at the combined stocking rate of 10,000 nos. fingerlings/ha. After four month of culture, average size of fishes in each pond was 100-250 g. The manure, fertilizer and feed etc. were applied as per recommended practice (Fig. 53).

Fig. 53. Pond management at Rajauli, Bakshi Ka Talab, Lucknow

Case II: Matsya Jivi Sahkari Samiti Ltd. Taikhurda, Deva, Barabanki, Uttar Pradesh was selected for various activities under the project. In this society, 50% members (16 nos.) belong to SC community. Society has got 12.3 ha pond area situated in different villages (Tikariya, Saihara and Miyapur). Scientific hand holding was provided to the society for developing nursery pond of 0.1 ha area each (6 nos.). Carp spawn in the ratio of catla (30%), rohu (40%), mrigal (30%) were stocked at the rate of 0.5 million/ha. Recommended scientific nursery pond management practices were followed. After one month of rearing 40-60% survival was recorded in the nursery pond with 45-75 mm and 3.5-5.5 g size (Fig. 54).

On-farm demonstration on pond management was given for carrying out aquaculture activities in both the cases. Awareness programmes for fish culture and safety of society were conducted in the SC populated area where 400 nos. farmers/villagers participated.

Fig. 54. Pond management at Deva, Barabanki

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

Period: October, 2018 - March, 2022

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

Funding Support: ICAR, New Delhi

Project aims to breed prioritized indigenous ornamental fishes of Western Ghats and popularize them in ornamental fish trade. Prioritised ornamental fish *Dawkinsia arulius* from Shivamoga, Karnataka, *Horabagrus nigricollaris*, *Sahyadria chalakkudiensis* from Chalakudy, Kerala and *Pethia setnai* from Mangalore, Karnataka were collected and transported to the hatchery at Kochi.

Breeding and rearing protocol of Setnai barb, *P. setnai*, was successfully developed. Fishes were conditioned in FRP tanks with live (bloodworm, earthworm) and artificial feeds. Spawning trials were conducted in 200 L FRP tanks provided with spawning traps consisting of a plastic tub with a layer of ceramic rings and mops made of unravelled nylon rope. Males exhibited brighter colours than females (Fig. 55). Fish were introduced in the breeding tank at ratio of one male: three females with aeration. The spawning occurred within 36-48 hours and the eggs were allowed to hatch in the tub only. After one week, spawns were transferred to aquarium tanks (Fig.56) and hatchlings were fed with artemia nauplii and moina. Total 6 breeding trials were conducted and on an average 300 spawn were collected from each trial. The spawn attained selling size, ~ 4 cm in 6-8 weeks' time (Fig. 57). First batch of 200 young ones of 3-4 cm size were marketed to an ornamental fish entrepreneur.

Fig. 55. *Pethia setnai* brooders (Male & Female)

Fig. 56. Young one of *Pethia setnai*

Fig. 57. Young ones of *Pethia setnai* produced in captivity

Captive breeding and rearing protocol of *Pethia nigripinna*

The experiment demonstrated the possibility of natural spawning of *P. nigripinna* without hormonal interventions (Fig. 58). Spawning occurred within 24-48 h and the eggs were allowed to hatch in the tub only. After one week, the spawn were transferred to the aerated tanks (Fig. 59) and were fed with artemia nauplii and green water. After that they were transferred to aquarium tanks and fed with artemia nauplii, moina and pelleted feed for a period of two weeks. Later, young ones were maintained in 500 L FRP tanks provided with filtration system and aquatic plants. Total 7 breeding trials were conducted and on an average 250 spawn were collected from each trial. The spawn attained marketable size (~4 cm) in 6-8 weeks' time. This is the first report of a successful spawning of *P. nigripinna* in captivity.

Fig. 58. *Pethia nigripinna* brooders (Male & Female)

Fig. 59. Young one of *Pethia nigripinna*

Breeding up-scaling of *Dawkinsia rubrotinctus*

Up-scaling of breeding of *Dawkinsia rubrotinctus*, was done using F1 stock and produced more than 1000 young ones (Fig. 60). The young ones were reared in aquarium tanks with live and artificial feed and reached marketable size (~1.5 - 2 inch) in 8 weeks. A total of 500 young ones (>2 inches) were sold to an ornamental fish entrepreneur (Fig. 61).

Fig. 60. Young ones of *Dawkinsia rubrotinctus* produced in captivity

Fig. 61. Sale of *Dawkinsia rubrotinctus* and *Pethia setnai* to ornamental entrepreneur

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 best means to conserve biodiversity and species is to ensure participation of local stakeholders in its management. The project envisages setting up a marine ornamental fish village in Maharashtra to promote livelihood to mangrove dwellers. The captive production of *Amphiprion percula* and *A. ocellaris* was scaled up. Juveniles of these species are continuously being produced for supplying to the beneficiaries. Other clownfish *viz. A. frenatus, A. clarkii, A. ephippium, A. sebae, A. nigripes, A. akallopisos, A. perideraion* and *Premnas biaculeatus* are also being maintained in the hatchery. Larval rearing and juvenile production are also being attempted for four of them. First cluster mode beneficiaries rearing unit was established in Dive Kevani village at Thane district where hatchery bred clownfishes were stocked (Fig. 62) and retail sale was also launched. Second unit was established at Gandhinagar, Vengurla of Sindhudurg district and first batch of young-ones were stocked for further rearing.

Fig. 62. Stocking the hatchery bred clownfishes in the beneficiary rearing unit at Dive Kevani village, Thane district

Project: Establishing germplasm resource center for marine ornamental invertebrates: Harmonizing biodiversity conservation and promoting livelihood to the islanders of Lakshadweep

Period: August, 2018 - July, 2021

Coordinator: Kuldeep K. Lal

Personnel: T.T. Ajith Kumar (PI), Charan Ravi and T. Jaffer Hisham

Funding Support: Department of Biotechnology (DBT)

The project aims to conserve ornamental marine invertebrate germplasm and ensure sustainable livelihood to islanders of Lakshadweep. Exploratory surveys were carried out in five islands of Lakshadweep - Agatti, Bangaram, Thinnakara, Parali I and Parali II (Fig. 63). A total of 115 individual ornamental shrimps and 25 sea anemones were collected. These shrimps belonged to 6 families, 7 genera and 8 species namely, *Gnathophyllum americanum, Saron neglectus, Ancylocaris brevicarpalis, Stenopus hispidus, Lysmata hochi, Urocaridella arabianensis, Actinimenes* sp., and *Cuapetes* sp. In addition to shrimps, sea anemone, *Heteractis magnifica* and *Entacmaea quadricolor* were also collected. Captive propagation technology has been standardized for *Thor hainanensis* and *A. brevicarpalis*. Juveniles were successfully raised for the same, besides F2 generation was also produced for both the species. Scaled up production is in progress for *G. americanum, S. marmoratus, Periclimenella agattii* and *Cuapetes* sp. Sexual and asexual propagation methods were experimented for sea anemone, *H. magnifica*. Asexual propagation (dissection method) was attempted in 55 individuals of *H. magnifica* and within

Fig. 63. Project personnel in exploration

Fig. 64. Captive raised *Entacmaea quadricolor*

Fig. 65. Women beneficiaries under training

4.5 months complete development of individuals was observed, however, 20% mortality was noticed. But there was no progress in the animals maintained for sexual reproduction. Captive spawning and juvenile production were successful with *E. quadricolor* (Fig. 64).

In view of the transfer of technology for sustainable livelihood, organized a series of trainings and workshops to women beneficiaries of the Agatti Island (Fig. 65.)

Project: **National Repository of Fish Cell Lines in NBFGR (Phase II) and Access Center in C. Abdul Hakeem College and research on application of cell lines in virology, toxicology and gene expression studies**

Period: **May, 2017 - May, 2020**

Personnel: **Basdeo Kushwaha (PI), Ravindra Kumar, Murali S. and Akhilesh Kumar Mishra**

Funding Support: **Department of Biotechnology (DBT)**

Use of fish cell lines are increasing day by day for various applications to mitigate problems associated with fish and fisheries. Establishing fish cell lines, on other hand, requires time, infrastructure facilities and skill, but established cell lines save both time and cost of the users. National Repository of Fish Cell Lines (NRFC) is engaged in collection and maintenance of fish cell lines developed in the country and to fulfil the demand of fish cell lines for research and development works.

During the reporting period, five new fish cell lines, namely CMgM-1 (*Clarias magur*, muscle), CMgB-1 (*Clarias magur*, barbels), DDaF-1 (*Dario dario*, fin), ZFiM-1 (*Danio rerio*, muscle) and LRoF-1 (*Labeo rohita*, fin) developed under the project were included in the repository after proper authentication (Fig. 66). Three new cell lines, namely CyCKG (*Cyprinus carpio*, gill), PSF (*Etroplus suratensis*, fin) developed at PMFGR Division, Kochi and OnH (*Oreochromis nioloticus*, heart) developed by FHME Division, ICAR-NBFGR, were included in the repository after proper authentication. With these, the NRFC accession increased to 71 fish cell lines. Three new cell lines of parrotfish (brain, spleen and heart) have been received from FHME Division for inclusion in NRFC.

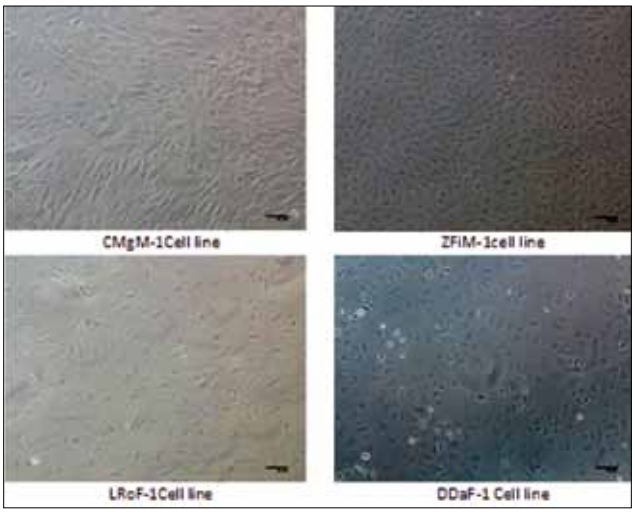


Fig. 66. Microphotographs of some of the new cell lines included in the repository

Besides the cell line development and authentication, general activities related to maintenance and distribution of cell lines were also carried out. Twenty-four fish cell lines were revived, passaged and cryopreserved. Fourteen cell lines were distributed to 6 researchers belonging to 5 institutions *viz*. Jawaharlal Nehru University, New Delhi; ICAR-CIFE, Mumbai; CUSAT, Kochi; College of Fisheries, Mangaluru; MS University, Baroda and GN Khalsa College, Mumbai, for research purposes.

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

Period: **December, 2017 - December, 2020**

Personnel: **Sullip Kumar Majhi (PI) and Santosh Kumar**

Funding Support: **Department of Biotechnology (DBT)**

Project aims to produce *Clarias magur* spermatozoa without sacrificing males, so that this endangered species can be cultured in commercial aquaculture by ensuring seed availability to farmers. Various biotechnological approaches have been employed to produce *C. magur* spermatozoa. Surrogacy technique was used to produce *C. magur spermatozoa in Pangasianodon hypophthalmus* (Fig. 67). Stripped milt from a few of the individuals was watery and appeared like milt of *C. magur*. This needs to be further verified with fertility trials of *C. magur* eggs with presumptive *C. magur* milt.

Project: **Indian major carp milt cryobank for improving genetic exchange between farms and commercial level quality seed production**

Period: **December, 2018 - November, 2020**

Co-ordinator: **Kuldeep K. Lal**

Personnel: **Santosh Kumar (PI), Sullip Kumar Majhi, Aditya Kumar, Ajay Kumar Singh and Rama Shankar Sah**

Funding Support: **National Fisheries Development Board (NFDB)**

The project envisages establishing milt cryobank of Indian major carps for effective genetic exchange between hatcheries through training and demonstration on use of cryopreserved milt for commercial seed production.

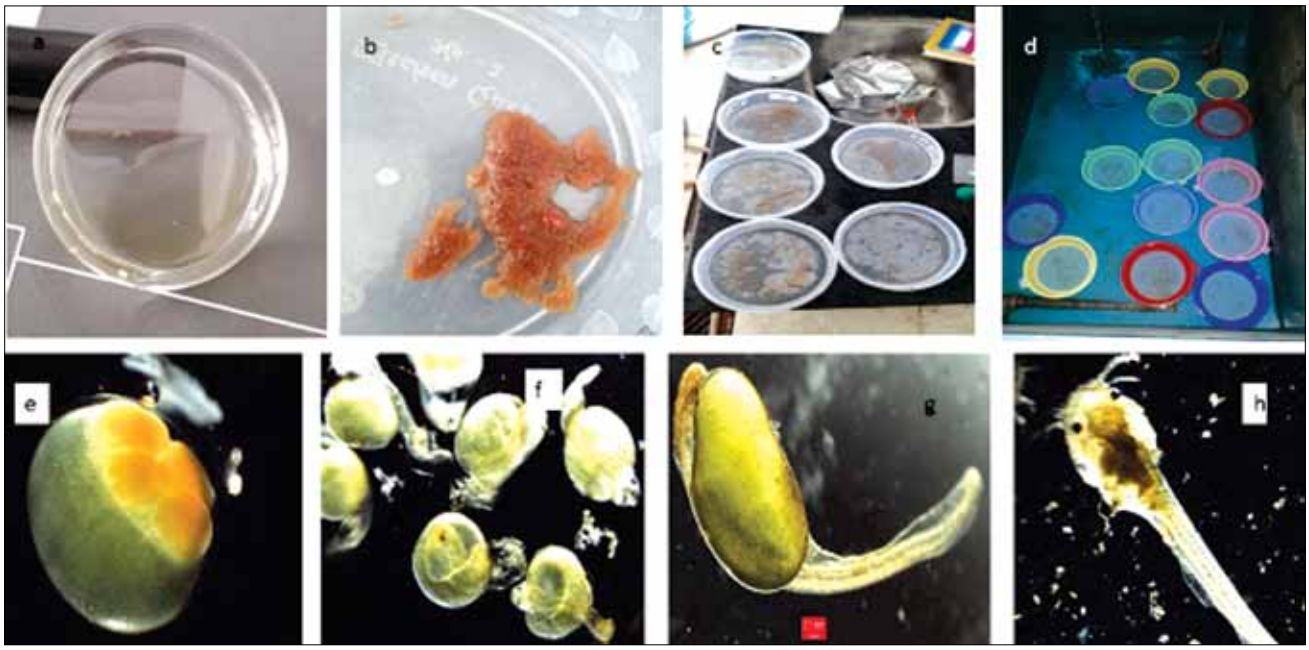


Fig. 67. (a) Sixteen months after the cell transplantation, milt was collected from surrogate *P. hypophthalmus* (note, morphologically the milt appears similar to *C. magur* type; transparent). (b) Eggs derived from *C. magur* female by hand stripping method. (c) Artificial fertilization of eggs and milt. (d) Incubation in flow-through system. (e) Embryo at 4-cell stage. (f) Generation of viable hatchlings. (g) View of a hatchling with yolk-sac. (h) View of a freely-swimming spawn

Training programmes

Under capacity building objectives, four training programmes on fish milt cryopreservation and seed production were conducted for state fisheries officials, hatchery managers, entrepreneurs, research scholars and post-graduate fishery students. Of these, three trainings were conducted at ICAR-NBFGR, Lucknow in February 2020, where 72 participants attended the training. One training was conducted at PMFGR Centre, Kochi, ICAR-NBFGR in March, 2020 wherein, 22 participants from Kerala and Karnataka participated. Total 207 hatchery operators/prospective farmers from 19 states of the country were trained in a total of 10 training programme during the project period (Table 7).

Table 7. State-wise list of participants of milt cryopreservation training

States	No. of participants
West Bengal	18
Orissa	25
Telangana	14
Andhra Pradesh	01
Karnataka	08
Gujarat	09
Maharashtra	06
Kerala	16
Tripura	17
Assam	06
Uttar Pradesh	34
Uttarakhand	01
Bihar	08
Punjab	01
Haryana	10
Jharkhand	11
Chhattisgarh	01
Madhya Pradesh	16
Rajasthan	05
Total	**207**

Up-scaling of milt cryopreservation in cryovials

Experiments were also conducted to check viability of cryopreserved milt using different cryovials for benefit of hatchery owners. Vials of 2 ml and 5 ml capacity were successfully tested. Thawing protocols for 2 ml and 5 ml vials were standardized for bulk fertilization and hatching percentage above 70 was obtained. Using 5 ml vials, bulk fertilization could be done. Species specific extenders were validated for all the species. Extender 7 for rohu and extender 9C for mrigal & catla were validated (Table 8).

Table 8. Composition of extenders used in milt cryopreservation

Chemical	Stock Solution	Extender (100 ml)
Extender 7		
NaCl	2.0 g/10 ml	3750 µl
KCl	1.6 g/10 ml	125 µl
$CaCl_2$	0.6 g/10 ml	334 µl
$NaHCO_3$	1.0 g/10 ml	200 µl
Double Distilled Water		95.591 ml
Extender 9C		
NaCl	2.0 g/10 ml	3250 µl
KCl	1.6 g/10 ml	885.6 µl
$CaCl_2$	0.6 g/10 ml	500 µl
$MgSO_4.7\ H_2O$	1.0 g/10 ml	197 µl
Glucose	1.0 g/10 ml	540 µl
Double Distilled Water		94.627 ml

Milt cryopreservation and supply to selected hatcheries

In early breeding season (June), milt from evaluated stocks of Indian major carp were cryopreserved using available protocol. Approximately 3000 vials of 2 ml capacity were stored in cryobank. In July, stored cryomilt was supplied to different partner hatcheries situated in Bihar, Haryana, Madhya Pradesh, Rajasthan & Uttar Pradesh and commercial seed production was done. At every hatchery, 13 lakhs eggs were fertilized and spawn were produced. In 2020 breeding season, 25 lakhs spawn were produced (Fig. 68). In two breeding seasons, approximately 62 lakhs spawn were produced in 20 hatcheries situated in 7 states (Table 9).

Table 9. Indian major carp cryopreserved milt supplied to hatcheries during 2020 and spawn produced using cryopreserved milt

States	Amount of IMC cryomilt supplied	No. of IMC eggs fertilized (in lakh)	No. of IMC spawn produced by cryomilt (in lakh)
Uttar Pradesh (2)	350 ml	26.74	4.92
Madhya Pradesh (4)	246 ml	19.79	1.40
Bihar (3)	360 ml	58.60	8.77
Rajasthan (1)	224 ml	27.90	6.00
Haryana (1)	268 ml	30.20	4.00
Total	**1,448 ml**	**163.23**	**25.09**

Fig. 68. Fertility trial at selected hatcheries using cryopreserved milt

Program 4.5: Documentation of fish genetic resources of India

India has four biodiversity hotspots and the country is blessed with a diverse range of aquatic fauna. Global climate change and anthropogenic activities have placed a lot of pressure on the biodiversity of fishes in the aquatic ecosystem. It is important to collect information and document the fish genetic resources of India and provide the information to the stakeholders. This will help the scientists and conservationists for their research and to evaluate the status of the different fish species. The documentation can also reduce taxonomic ambiguities of fish species among researchers. Moreover, it shall help the policymakers to make strategies for the sustainable exploitation of fisheries resources and to protect the Threatened/ Vulnerable/ Endangered fish species. ICAR-NBFGR has taken up various initiatives for the proper scientific documentation of fish genetic resources of India. Furthermore, the efforts made by the institute in the form of databases and repositories will form the foundation for future research that help in the sustainable utilization and conservation of fish genetic resources of the country.

Project: Developing and testing a model of fisheries-based entrepreneurship for socio-economic development of tribals and sustainable utilization of fisheries resources

Period: August, 2020 – March, 2023

Personnel: Lalit Kumar Tyagi (PI), Kripal Datt Joshi, Sharad Kumar Singh, Achal Singh, Raghvendra Singh, Aditya Kumar, Amit Singh Bisht and Sanjay Kumar Singh

Funding Support: Institutional under TSP (STC) component fund

Socio-economic upliftment of tribal population is important to fill the gaps in the human development indices between Scheduled Tribes and general population. Fisheries-based entrepreneurship can serve as a valuable intervention to improve the economic status of the scheduled tribes.

Project envisages collection of basic information from secondary sources about the resources, geographical and demographic details of tribal farmers of the selected area so as to select potential beneficiaries. Another activity is to communicate, discuss and finalize the collaborative component with ICAR-CIFE, Mumbai on the preparation and demonstration of fish feed using locally available resources in the study area. Discussion proposed with the existing tribal entrepreneur and other tribal farmers from the Sonebhadra district regarding collection of brood stock of locally available minor carps, which will boost breeding and species diversification in the region.

Project: Digital phenotyping tools for assessment of shape morphometric diversity in finfish genetic resources

Period: July, 2020 – March, 2022

Personnel: Achal Singh (PI), Rejani Chandran, G. Kantharajan and Rajesh Dayal

Funding Support: Institutional, ICAR-NBFGR

Increase in the global average temperature is believed to negatively impact the agriculture sector, which also includes the fisheries sector. Rapid increase in human population together with climate change are likely to impact the fisheries sector. The best utilization of fish genetic resources will be sustainable use along with other conservation and management initiatives. This project aims to develop an inventory of digital images of species with landmarks, for studying different aspects of ecological analysis, morphometrics and landmark-based shape analysis for identification of fish stocks from different rivers/locations across India. The proposed digitization of the landmarked fish specimens will help to create an inventory of fish stocks for thin plate spline-based identification. Truss morphometrics approach is an effective method for computing information about the shape of an organism and the quantification method of thin plate spline is increasingly used for discrimination of within population allometry and between population shape differences. Morphometric information of different fish species is of great importance for biologists and ichthyologists. In the reporting year, a preliminary literature survey of studies/application of geometric morphometric (GM) shape analysis in various aspects like determining growth potential in aquaculture, freshness of fish, fish oil quality etc. among many others were documented.

Project: Information system of selected commercially important shellfish resources from prioritised Indian aquatic ecosystem

Period: July, 2020 – March, 2024

Personnel: Ajey Kumar Pathak (PI), Teena Jayakumar T.K. and Ravi Kumar

Funding Support: Institutional, ICAR-NBFGR

Development of a database for the commercially important shellfish of India is crucial to understand spatial patterns of species and for the sustainable utilization of the resource. Furthermore, it will aid in the biodiversity assessment of the species in a specific geographical location. In the crustacean fisheries, mollusc reported from Indian waters was initially identified as the target organism for collecting the data on the different parameters as mentioned in table 10.

Literature survey was done to collect the data on the above listed parameters. Literatures on mollusc

species reported from Indian waters were screened and downloaded from authentic published sources only and a database structure using MS-ACCESS relational database management system under the Windows operating environment was designed to populate the data on these parameters. Further to strengthen the data on the museum specimens of mollusc species, the following parameters were finalised.

Specimen details

- Specimen code (System generated):
- Specimen name (To be filled by user):
- Taxonomic group (To be selected by user): Mussels/ Oysters/ Clams/ Pearl-oysters/ Window-pane oysters/ Ark-shells/ Whelks/ Chanks/ Cowries/ Squids/ Cuttlefish/ Other
- If other (Specify group: To be filled by user):

Taxonomy

- Phylum (To be filled by user):
- Subphylum (To be filled by user):
- Class (To be filled by user):
- Subclass (To be filled by user):
- Order (To be filled by user):
- Suborder (To be filled by user):
- Superfamily (To be filled by user):
- Family (To be filled by user):
- Genus (To be filled by user):
- Subgenus (To be filled by user):
- Specimen type (To be selected by user): Holotype/ Syntype/ Neotype/ Topotype/ Lectotype/Parratype/ Allotype/ Cotype/ Nontype/ Paralectotype/ Isotype
- habitat type (To be selected by user): Land/ Water
- If water (To be selected by user): Freshwater/ Brackish water/ Marine
- Type of preservation (To be selected by user): Wet specimen in Ethanol/ Wet specimen in Formalin/ Culture/ Silica gel/ Slide/ Dried/ SEM stub/ Fossil/ Herbarium/
- Museum name (Default value: ICAR- NBFGR, Lucknow):

Collection details

- Date of collection (To be filled by user):
- Time of collection (To be filled by user):

Geographical details of collection:

- Longitude (To be filled by user):
- Latitude (To be filled by user):
- Name of location (To be filled by user):
- Name of coast (To be filled by user):
- Name of district and state (To be filled by user):

Collector details

- Name of collector (To be filled by user):
- Designation (To be filled by user):
- Associated organisation (To be filled by user):
- Email (To be filled by user):
- Phone number (To be filled by user):

Identifier details

- Name of identifier (To be filled by user):
- Designation (To be filled by user):
- Date on which specimen identified (To be filled by user):
- Associated organisation (To be filled by user):
- Email (To be filled by user):
- Phone number (To be filled by user):

Submitter details

- Name of submitter (To be filled by user):
- Date of submission of specimen in museum (To be filled by user):
- Designation (To be filled by user):
- Associated organisation (To be filled by user):
- Email (To be filled by user):
- Phone number (To be filled by user):

A database structure to record the information on the above listed parameters for the museum specimen of mollusc species was designed using SQL Server relational database management system under the Windows operating environment. A data entry panel for entering the data on museum specimen of mollusc species is on the way.

In the reporting period, database structure of the mollusc species from the marine waters and museum specimens of mollusc species has been designed. Trade oriented crabs and shrimp species were identified

Table 10. Depicting mollusc species with related attributes

Attributes			
Taxonomic group	Mussels, oysters, clams, pearl-oysters, window-pane oysters, ark-shells, whelks, chanks, cowries, squids, cuttlefish		
Taxonomy	Phylum		
	Subphylum		
	Class		
	Subclass		
	Order		
	Suborder		
	Superfamily		
	Family		
	Genus		
	Subgenus		
	Species		
Inhabitation type	Land/ Water	If Water	Marine
			Brackish water
			Freshwater
General characteristics/ features			
Shell types	Univalve (Dextral/ Sinistral) / Bivalve (Equivalve/ Inequivalve)		
Sex type	Hermaphroditic (Monoaluic/ Dialuic/ Triaulic)/ Gonochoristic		
Accepted/ Valid name			
Synonyms			
Common name			
Local name			
Ecological group and Ecology/ Habitat			
Environmental position			
Functional group			
Paraphyletic group			
Habit			
Type locality			
Geographical distribution and distributional range			
Food and feeding			
Feeding type			
Reproduction	Mechanism of reproduction, breeding season and survival percentage		
Reproductive frequency			
Life cycle			
Life span			
Host/ parasite relationship			
Blooming/ Bio mineralisation			
Body shape (Thallus and Qualitative)			
Body size			
Brooding			

Attributes	
Calcification	
Dispersion mode	
Generation time	
Larval and juvenile development	
Mobility	
Seasonality	
Sociability	
Spawning	
Tolerance to pollutants	
Wave exposure	
Zonation	
Importance and utility to the society	Edible/ Ornamental
Conservation status according to IUCN Red List categories	
Reference of original description and other relevant literature sources	
Images	

for collecting the data on the various parameters, developing the database and the information system.

Project: **Intellectual property management and transfer/ commercialization of agricultural technology scheme (Up-scaling existing components i.e. Intellectual Property Right)**

Period: **June, 2020 – June, 2023**

Personnel: **Anutosh Paria**

Funding Support: **National Agriculture Innovation Fund (NAIF), ICAR**

Protection of intellectual property is one of the key factors in research and development following the Agreement on Trade Related aspects of Intellectual Property Rights (TRIPS) in the World Trade Organization (WTO). Most of the countries are generally adhered to certain minimum standards for rewarding different stakeholders associated with any intellectual property. Such intellectual property rights (IPRs) aid the development of different sectors including agriculture and are particularly important for a developing nation like India. Research in fish genetic resources has a plethora of potential to generate a number of technologies that can attract protection in the form of IPR.

There are several programmes of the institute that have potential to generate new technologies that may have massive impact on solving the age-old issues in fisheries sector of India. The technology of standardization of captive breeding of marine high-value ornamentals is one of the key areas which will give dividend to the organization and the fisher-folks of the respective region in the years to come. Inbreeding depression is becoming an area of concern in different carp hatcheries and the technology of sperm cryobanking standardized by the institute will address this issue by increasing genetic variability in the progeny. Oomycete infection in finfish is one of the major setbacks for the global aquaculture industry in the past years and even in the present days. In this direction, a formulation developed by the institute may become effective in treating oomycete infection such as *Aphanomyces invadans* and *Saprolegnia parasitica* as evidenced from the recent field trials. The institute house the largest collection of fish cell lines in the world with over 70 fish cell lines. These cell lines can have the commercial value in R&D for evaluation of drugs, toxicological and virological studies. Moreover, different on-going activities of the institute may help in developing entrepreneurship in establishing fish disease diagnostic laboratories and re-circulatory aquaculture system. In the front of technology commercialization, an application for a design developed by the institute related to surgical

platform for fish has been received in the reporting year and necessary process for IP protection has been initiated.

For capacity building in IP management, the ICAR-NBFGR staffs including Dr. Achal Singh, Dr. Rajiv Kumar Singh, Dr. Murali S., and Dr. Anutosh Paria have participated in two training programmes namely, MDP on Implementation of Access and Benefit Sharing Regulations in Agriculture Research and EDP for Master Trainers on Access and Benefit Sharing (ABS) Regulations in India and Nagoya Protocol organized by ICAR-NAARM, Hyderabad. Further, Dr. Achal Singh and Dr. Anutosh Paria has undergone a 14 days virtual workshop cum training programme on Intellectual Property Rights in Agricultural Research & Education in India jointly organized by NAHEP, ICAR and IPTM Unit, ICAR.

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

Emerging diseases in aquaculture systems are one of the major areas of concern which are hindering the steady growth of the fish farming and threatens the existence of indigenous germplasms. Moreover, the concern of introduction of exotic germplasms and evaluation of their risk or benefit is of paramount importance. This is also desired to understand their compatibility with the major cultivable indigenous species for diversification in Indian aquaculture. The advent of globalization led to the cross-border movement of different fish and fisheries products, thereby increasing the likelihood of spread of emerging fish pathogens to the new geographical area and in the due course of time further expansion of the host range. ICAR-NBFGR has been instrumental in addressing these important aspects of aquaculture through undertaking several programmes which includes management strategies for commercially-important fish pathogens through development of rapid diagnostic tools, therapeutic and prophylactic measures and implementation of nation-wide surveillance of aquatic animal diseases. Furthermore, evaluation of antimicrobial resistance in fisheries and risk-benefit assessment modelling of already introduced exotics fish species in Indian aquaculture are other thrust areas perceived by the institute in this direction.

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

Period: February, 2013 - June, 2021

Coordinator: Joykrushna 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 Kumar Pradhan, T. Raja Swaminathan and Gaurav Rathore

The National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) was operational through 31 collaborating centres in the country. In the reporting year, an expert consultation was held on April 17, 2020 to discuss the status and preparedness on Decapod Iridescent Virus-1 (DIV-1) in India. The meeting was attended by selected subject experts from different ICAR fisheries research institutes; officials from Department of Fisheries, Government of India; NFDB, scientists from Rajiv Gandhi Centre for Aquaculture, Marine Products Export Development Authority; and a few eminent experts from other organizations. The major objective of the consultation was to bring a consensus approach on status, risks and preparedness for DIV-1, and developing advisory regarding the disease for communication to the stakeholders for following a precautionary approach. In addition, there was discussion for undertaking surveillance under NSPAAD, and also requirement for screening the shrimp broodstock and other inputs imported into the country for DIV-1. A draft advisory for preventing the risk of DIV-1 was prepared and submitted to Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India.

Further, documents were prepared and submitted to the Expert Committee constituted to undertake third party evaluation of 1st Phase of NSPAAD. Based on the queries of the third party, information was provided and a presentation was made before the Expert Committee. Technical inputs on export rejection of frozen shrimps by China due to presence of White Spot Syndrome Virus (WSSV) and Infectious Hypodermal and Haematopoietic Necrosis Virus (IHHNV) were provided. Meetings of the Technical Committee constituted by Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying were held on November 18 and 23, 2020 to study the situation of occurrence of WSSV and IHHNV in shrimps in India. Subsequently, action points were prepared and submitted to Department of Fisheries. An updated note on NSPAAD being implemented in India along with reports on the status of various diseases and strength of the programme for the confidence of importing countries, was provided for Virtual Meeting with China's GACC. Besides, information on international publications and appreciation of the programme were also submitted. Inputs were also given to the Department of Fisheries for exclusion of IHHNV from OIE-listed diseases of crustaceans in consultation with members of scientific core committee of NSPAAD following request of Government of Ecuador.

QAAD Reports for the quarters January-March 2020, April-June 2020 and July-September 2020 were compiled on the basis of reports received from NSPAAD collaborating centres and submitted to DoF, Ministry of Fisheries, Animal Husbandry and Dairying. An online meeting was held on September 12, 2020 involving College of Fisheries, Nellore to discuss the problem of whitish/reddening of the tail region in farmed shrimp in Nellore, Andhra Pradesh following request from Society of Aquaculture Professionals and Industry. An attempt was made to collect the samples from suspected farms, however, the shrimps had been harvested in the meantime.

Positive control for Decapod Iridescent Virus 1 was procured from Dr. Hyoung Jun Kim, OIE Reference Laboratory for Viral Haemorrhagic Septicaemia, People's Republic of Korea. Shrimp samples received from ICAR-CIBA for NABL accreditation were screened for the desired pathogens.

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

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

Carried out disease surveillance in aquaculture farms located in the states of Uttar Pradesh and

Haryana under the sub-project ICAR-NBFGR component of NSPAAD. A total of 414 farmers were contacted over phone to know disease incidence. Subsequently, a WhatsApp group was created comprising of 187 farmers culturing pangasius to report the disease problems faced by them. Following report of disease cases in pangasius and pacu in Azamgarh and Sidharthnagar districts of Uttar Pradesh, disease investigation was undertaken and scientific advice provided to 45 farmers. Furthermore, fourteen disease cases were reported and cause of mortality was ascertained. The causative agent was identified to be *Dactylogyrus* spp., *Ichthyophthirius multifiliis*, *Zoothamnium* spp., *Trichodina* spp., *Myxobolus* spp., *Argulus* and *Lernaea* spp.; *Saprolegnia parasitica* and *Aphanomyces invadans*, and *Flavobacteriun columnare* (Fig. 69). As per the identified causative agent, appropriate management measures were suggested to the farmers.

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

Personnel: **T. Raja Swaminathan (PI)**

Culture of ornamental fishes has the potential to augment the livelihood of small and marginal farmers. In order to intensify the culture practices with proper health management protocols and safe exports, assessing the diseases is paramount. Hence, several ornamental fish species have been screened for presence of any disease. During this year, isolated the infectious spleen and kidney necrosis virus (ISKNV) from diseased giant gourami, *Osphronemus goramy* from India. The histopathological analysis of liver, spleen and kidney sections showed widespread necrosis, and intranuclear and cytoplasmic inclusions in liver of affected gourami. Transmission electron microscopy of ultra-thin sections of kidney and spleen revealed the presence of numerous polygonal viral particles within the cytoplasm of enlarged cells.

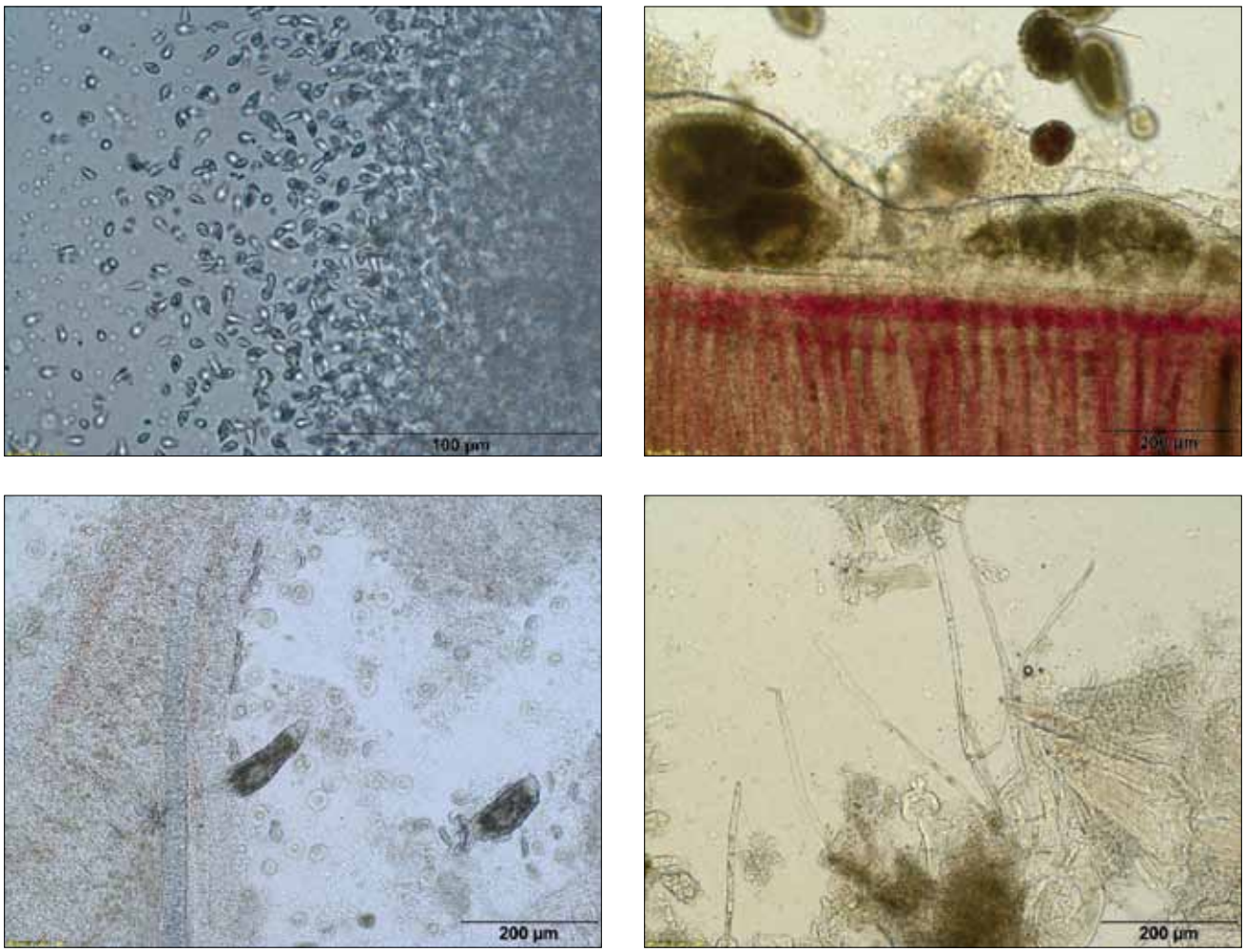


Fig. 69. Wet mount preparations from diseased fish tissues showing parasitic and fungal infection

Molecular and phylogenetic analyses confirmed the presence of ISKNV (570 bp) and major capsid protein (MCP) (324 bp) genes in the infected fish with significant similarity to the other ISKNV isolates. ISKNV was propagated in *Astronotus ocellatus* fin (AOF) cell line and further confirmed genotypically. High mortality rate (60%) was observed in gourami injected with ISKNV positive tissue homogenate through challenge studies. Tilapia seeds (n=500; seventeen consignment) received from six farms and hatchery, Kerala State Fishery Department were screened for tilapia lake virus (TiLV) during October to December, 2020 and no TiLV was detected from these samples.

Project: Network programme on antimicrobial resistance in fisheries and aquaculture

Period: October, 2016 - March, 2021

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

A total of 154 fish farms in the districts of Lucknow (n=85), Varanasi (n=16) and Barabanki (n=53) were sampled during the reporting period for isolation of *Escherichia coli*, *Aeromonas* spp., and *Staphylococcus* spp.

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

The collected fish samples comprising of IMCs and other species; from Lucknow (27 and 58), Varanasi (5 and 11) and Barabanki (26 and 27) were analyzed for the isolation and antimicrobial susceptibility testing (AST) of the targeted bacteria, *Aeromonas* spp., *E. coli* and *Staphylococcus* spp. A total of 437 isolates of 154 (35%) *Aeromonas* spp., 132 (30%) *E. coli* and 151 (35%) *Staphylococcus* spp. were recovered from the samples. The isolates were phenotypically identified and stored at -80 °C as glycerol stock.

AST was done by disc diffusion method following CLSI guidelines and data was analysed by WHONET software. AST of 142 isolates; 48 of *Aeromonas* spp., 47 of *E. coli* and 48 of *Staphylococcus* spp. was done in the reporting period. Among the 47 isolates of *E. coli*, highest resistance of 26.1% was seen against nalidixic acid, 17.4% isolates were resistant to cefotaxime and 15.2% to ceftriaxone. A total of 4.3% of isolates were found to be resistant to tetracycline (Table 11 and Fig. 70).

Table 11. Antibiotic resistance in *Escherichia coli* (n= 47) isolated from freshwater fish of Uttar Pradesh

Antibiotic name	Breakpoints	%R	%I	%S	%R 95% C.I.
Ampicillin	14 - 16	14.9	0	85.1	6.7-28.9
Amoxicillin/Clavulanic acid	14 - 17	2.1	2.1	95.7	0.1-12.7
Ceftazidime	18 - 20	2.1	6.4	91.5	0.1-12.7
Ceftriaxone	20 - 22	14.9	2.1	83	6.7-28.9
Cefotaxime	23 - 25	17	4.3	78.7	8.1-31.3
Cefoxitin	15 - 17	2.1	0	97.9	0.1-12.7
Cefpodoxime	18 - 20	4.3	2.1	93.6	0.8-15.8
Aztreonam	18 - 20	8.5	4.3	87.2	2.8-21.3
Imipenem	20 - 22	4.3	2.1	93.6	0.8-15.8
Amikacin	15 - 16	2.1	2.1	95.7	0.1-12.7
Nalidixic acid	14 - 18	27.7	2.1	70.2	16.1-42.9
Enrofloxacin	17 - 22	4.3	4.3	91.3	0.7-16.0
Trimethoprim/Sulfamethoxazole	11 - 15	4.3	2.1	93.6	0.8-15.8
Chloramphenicol	13 - 17	2.2	0	97.8	0.1-13.0
Tetracycline	12 - 14	4.3	2.1	93.6	0.8-15.8

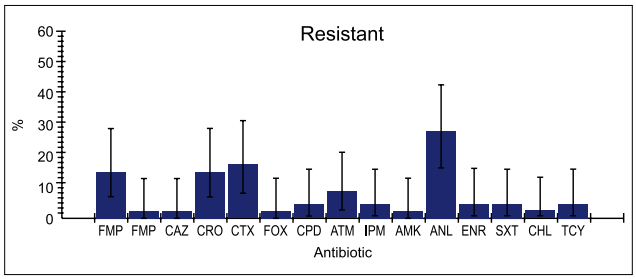


Fig. 70. Antibiotic resistance in *Escherichia coli* (n= 47) isolated from freshwater fish of Uttar Pradesh

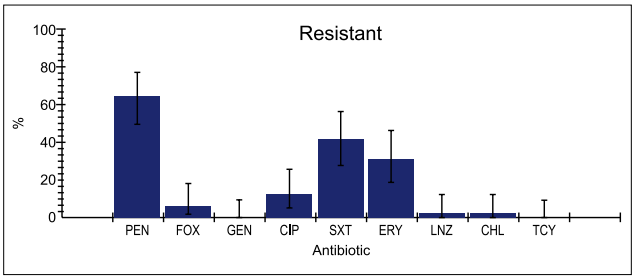


Fig. 71. Antibiotic resistance in *Staphylococcus* spp. (n= 48) isolated from freshwater fish of Uttar Pradesh

A total of 48 isolates of *Staphylococcus* spp. were analyzed for AMR for 9 listed antibiotics (Table 12). Out of these, 64% isolates were resistant to penicillin, and 41% isolates were resistant to trimethoprim/ sulfamethoxazole. A total of 31% of isolates were resistant to erythromycin. Cefoxitin resistance was seen in 6% of the isolates (Fig. 71).

A total of 48 isolates of *Aeromonas* spp. were analyzed for AMR of 11 listed antibiotics (Table 13). Out of these, 16% isolates were resistant to Cefoxitin and 8% to Cefotaxime. In other antibiotics, resistance was observed in less than 4% isolates. (Fig. 72).

Table 12. Antibiotic resistance in *Staphylococcus* spp. (n=48) isolated from freshwater fish of Uttar Pradesh

Antibiotic name	Breakpoints	%R	%I	%S	%R 95%C.I.
Penicillin G	S >= 29	64.6	0	35.4	49.4-77.5
Cefoxitin	S >= 25	6.2	0	93.8	1.6-18.1
Gentamicin	13 - 14	0	0	100	0.0-9.2
Ciprofloxacin	16 - 20	12.5	2.1	85.4	5.2-25.9
Trimethoprim/Sulfamethoxazole	11 - 15	41.7	2.1	56.2	28.0-56.8
Erythromycin	14 - 22	31.2	14.6	54.2	19.0-46.3
Linezolid	S >= 21	2.1	0	97.9	0.1-12.5
Chloramphenicol	13 - 17	2.1	0	97.9	0.1-12.5
Tetracycline	15 - 18	0	4.2	95.8	0.0-9.2

Table 13. Antibiotic resistance in *Aeromonas* spp. (n= 48) isolated from freshwater fish of Uttar Pradesh

Antibiotic name	Breakpoints	%R	%I	%S	%R 95%C.I.
Amikacin	15 - 16	2.1	0	97.9	0.1-12.5
Amoxicillin/Clavulanic acid	14 - 17	0	0	100	0.0-9.2
Ceftazidime	18 - 20	2.1	4.2	93.8	0.1-12.5
Ceftriaxone	20 - 22	4.2	2.1	93.8	0.7-15.5
Cefotaxime	23 - 25	8.3	4.2	87.5	2.7-20.8
Cefepime	15 - 17	2.1	0	97.9	0.1-12.5
Cefoxitin	15 - 17	16.7	0	83.3	8.0-30.8
Chloramphenicol	13 - 17	2.1	0	97.9	0.1-12.5
Ciprofloxacin	16 - 20	0	0	100	0.0-9.2
Imipenem	20 - 22	4.2	0	95.8	0.7-15.5
Trimethoprim/Sulfamethoxazole	11 - 15	4.2	0	95.8	0.7-15.5
Tetracycline	12 - 14	2.1	0	97.9	0.1-12.5

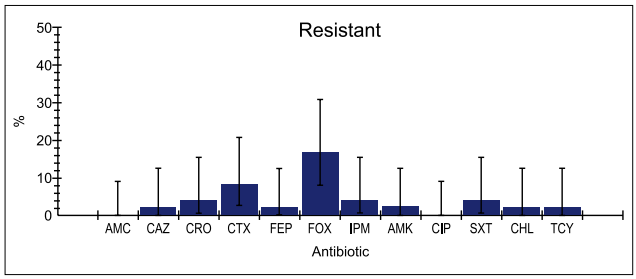


Fig. 72. Antibiotic resistance in *Aeromonas* spp. (n= 48) isolated from freshwater fish of Uttar Pradesh

Project: Support mitigation of antimicrobial resistance (AMR) risk associated with aquaculture in Asia

Period: October, 2020 – July, 2021

Personnel: Gaurav Rathore (PI), Chandra Bhushan Kumar and Vikash Sahu

Funding Support: FAO-ICAR-TCP

The project has been initiated in the reporting year to assess the AMR risk associated with Asian aquaculture having specific objective focusing on Indian aquaculture farms. An inception workshop was organized under this project jointly by ICAR-NBFGR and ICAR-CIFT virtually on December 10, 2020 to formally launch the FAO-ICAR-TCP program in India. Dr. Trilochan Mohapatra, Secretary, DARE & DG, ICAR was the Chief Guest. Mr. Tomio Shichiri, FAO, India and Shri Sagar Mehra, Joint Secretary (Inland Fisheries), Ministry of Fisheries, Animal Husbandry & Dairying were the Guests of Honor. Work plan of the project was presented and discussed with National and International experts. It was agreed that SOP developed in INFAAR would be followed for sample collection and analysis in the FAO-TCP. Samples from 80 farms i.e 40 each from Lucknow and Barabanki districts of Uttar Pradesh were collected. Bacterial isolation and their antimicrobial susceptibility testing are under progress. Questionnaire for AMU was developed and used to collect data from the farmers on farming practices and antimicrobial usage.

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

To assess the water quality and occurrence, expansion, composition and biological attributes of alien fishes, exploratory surveys were conducted in selected rivers, wetland and open-water resources in different parts of the country.

Explorations on the selected sites of river Ganga at Varanasi and Prayagraj; Yamuna and Tons around Prayagraj were conducted to assess appearance, expansion and establishment of alien fish species in the rivers. Also surveyed the fish markets of Varanasi,

Table 14. Occurrence, dominance and percent composition of alien fishes in different water resources

S.N.	River/ wetland	Total alien species observed	Sampling site	Geographical coordinates (Lat. (N); Long. (E))	Percent composition (Aliens)	Dominant species (Among aliens)
1.	Ganga	*Cyprinus carpio* *Oreochromis niloticus* *Pterygloplichthys pardalis**	Varanasi	25°19'45.42"N 83° 9'15.26"E	35	*O. niloticus*
			Prayagraj	25°30'8.59"N 81°51'20.12"E	38	*C. carpio*
2.	Yamuna	*C. carpio* *O. niloticus* *Clarias gariepinus** *Pterygloplichthys pardalis**	Prayagraj	25°25'24.18"N 81°52'30.24"E	41	*C. carpio*
3.	Tons/ Tamsa	*C. carpio* *O. niloticus* *H. molitrix**	Chakghat, Prayagraj	25° 2'10.22"N 81°43'48.61"E	26	*C. carpio*
4.	Gomti	*C. carpio* *O. niloticus* *Clarias gariepinus** *H. molitrix**	Lalpul, Lucknow	26°52'23.58"N 80°54'53.95"E	31	*C. carpio*

*Collected stray specimens occasionally

Prayagraj and Chakghat to record availability of alien fishes. Further the samples collected from the river Yamuna at Etawah, Agra and Mathura sites during previous explorations were also analyzed and compiled the data (14 and Fig. 73). The study revealed occurrence of 5 alien fish species from selected stretches of Ganga river system comprising common carp (*Cyprinus carpio*), Nile tilapia (*Oreochromis niloticus*), African magur (*Clarias gariepinus*), Amazon sailfin catfish, sucker-mouth catfish (*Pterygloplichthys pardalis*) and silver carp (*Hypophthalmichthys molitrix*). Among these, 4 species were observed from the river Yamuna and Gomti, which are extremely impaired due to multiple perturbations along its course. *O. niloticus* and *C. carpio* formed sizeable fishery in the rivers Ganga, Yamuna, Tons and Gomti round the year. Due to comparatively larger volume and depth, the river Yamuna holds higher composition and larger specimens in comparison to river Ganga at Prayagraj.

Fig. 73. Experimental fishing in the river Tons at Chakghat, near Prayagraj

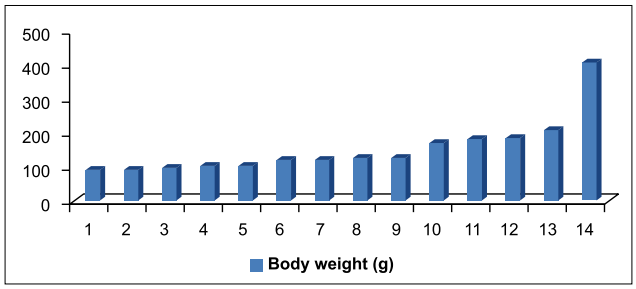


Fig. 74. Body weight (g) profile of Nile tilapia in the river Ganga, near Varanasi

water was alkaline in all the rivers (pH 7.9 - 8.4) and dissolved oxygen content 5.4 to 10.6 mgl^{-1}. Values of total dissolved solids (TDS), and conductance were between 137.0 to 238.0 mgl^{-1} and 272.0-483.0 µmhos, respectively.

The size range of common carp from the river Ganga at all the sampling sites comprised 248 to 660 mm with corresponding weight of 230.0 to 4876.0 g, respectively and tilapia from 165 to 345 mm with corresponding weight of 94.0 to 622.0 g, respectively. The size range of common carp from catches of river Yamuna at Prayagraj comprised 236 to 590 mm with corresponding weight of 160.0 to 3378.0 g, respectively and tilapia from 169 to 350 mm with corresponding weight of 92.0 to 892.0 g, respectively. The size range of tilapia in the river Tons at Chakghat ranged from 146 to 310 mm with corresponding weight of 59.0 to 491.0 g, respectively. Analysis of different length classes of *C. carpio* and *O. niloticus* reveals availability of all sized samples and fully established populations of both the species (Fig. 74 and 75) in these river sites.

The water temperature of the rivers during November 2020 varied between 23.9 °C (in river Ganga at Prayagraj) and 26.8 °C (river Tons, Chakghat). The

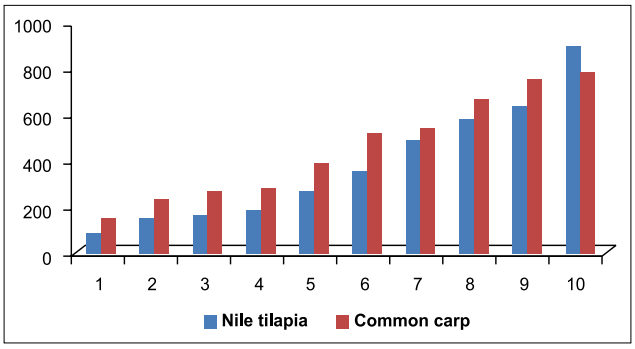


Fig. 75. Body weight (g) profile of Nile tilapia and common carp from the river Yamuna, caught by drag net near Prayagraj

Experimental fishing conducted in the river Yamuna near Prayagraj (Fig. 76 and 77) on November 7, 2020 using drag net (200 x 3 m, mesh size 65 x 25 mm) yielded record catch of 47.3 kg fish in one operation. The netted biomass comprised maximum catch of Nile tilapia (50.81%), followed by common carp (25.47%), the rest were *Sperata seenghala* (16.84%) and *Cirrhinus mrigala* (6.84%), the total biomass of exotic fishes was 76.29%. All the three rivers are observed under invasion of Nile tilapia (*O. niloticus*) and common carp (*C. carpio*) of different magnitudes. Besides these two species, no evidence of establishment of any other alien fish was observed from the sampled stretches of the rivers. However rare occasional sighting of a few specimens of *O. mossambicus, C. gariepinus, P. pardalis, P. anisitsi, H. molitrix, H. nobilis* and *Ctenopharyngodon idella* was recorded from the sampling sites of the rivers Ganga,

Yamuna, Gomti and their tributaries. The reasons for spread could be from aquaculture ponds situated on the catchments during flood or deliberately released by hobbyists.

Fig. 76. Fishing in river Yamuna at Prayagraj using drag net

Fig. 77. Fishes caught from river Yamuna at Prayagraj

Conducted explorations to certain open water resources of Peninsular region to assess various aspects of alien fishes. Explored Meenkara dam, in Bharathapuzha river basin, which is having total area of 2.60 sq. km, situated in Palakkad district of Kerala. Fishery of the dam is dominated by Indian major carps and tilapia (Fig. 78). One male African catfish (*C. gariepinus*) having body weight of 5.0 kg size with fully developed testis was caught during the survey. The occurrence of alien fishes from Karapuzha Dam in Karapuzha River, and Banasura Sagar Dam in Kabini River, Wayanad was studied. Karapuzha dam comprised of four alien fish species namely, *C. carpio, O. niloticus, C. idella* and *C. gariepinus*.

Fig. 78. African magur caught from Meenkara Dam, in Bharathapuzha River basin with mature testis

An invasive mussel, *Mytilla strigata* was reported from coastal waters of Kerala since last two years. Survey of Ashtamudi Lake and back waters of Kochi was conducted to assess the status of mussel. Observed more than 2000 individual mussels of 2-3 cm in size per square feet area (Fig. 79), while they were more abundant on the bottom. The intrusion of the mussel was observed upto 2 km for the coastal water towards lake, in saline water zone. The salinity of the back water was 25-30 ppt in different places. Mussel population declines with decrease in salinity during monsoon.

Fig. 79. *Mytilla strigata* collected from Ashtamudi Lake

A mobile app named as "Exotic Fish Survey" has been developed (Fig. 80) with the objective to monitor occurrence, spread and establishment of alien fishes across the country. The app is useful in recording the relevant information on alien species observed from any corner of the country and its easy retrieval to assess the alien fish diversity, invasion in different open water bodies, expansion and establishment of the species.

Fig. 80. Glimpses of the "Exotic Fish Survey" mobile app

Project: All India network project on fish health

Period: July, 2017 - March, 2021

Personnel: Pravata Kumar Pradhan (PI), Gaurav Rathore, Neeraj Sood and Anutosh Paria

Funding Support: ICAR, New Delhi

The economic loss due to disease outbreaks in aquaculture is one of the hindrances in the steady growth of the sector (Fig. 81). To collect information on economic losses due to fish diseases in Uttar Pradesh during the year, 126 fish farmers were contacted over phone. Among the farmers, 28 reported water quality management problems in their farms, whereas disease problems were reported by 38 farmers (Fig. 82). No incidences of any diseases were encountered by 60 farmers in their farms.

A formulation developed by ICAR-NBFGR was applied in 52 farms culturing pangasius, IMCs and pacu in Uttar Pradesh having active infection with oomycete pathogens. The effect of the formulation is being evaluated.

Fig. 81. Mass mortality in *Pangasianodon hypophthalmus* farm

Fig. 82. *Saprolegnia parasitica* infection in *Pangasianodon hypophthalmus*

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), New Delhi

Whole cell CyHV-2 was inactivated by incubating in 0.1% formalin for 2 days at room temperature

(formalin-inactivated CyHV-2) and at 80 °C for 1 hr (heat-inactivated CyHV-2), thus preparing an inactivated viral vaccine for CyHV-2 (Fig. 83). For both the formalin and heat-inactivated CyHV-2, a significant up-regulation was noticed for the genes CD8, GINF, IL-12 by 6 h itself, whereas for the genes IL-10 and CD4, a significant up-regulation was observed in 6 h for the heat-inactivated virus (Fig. 84).

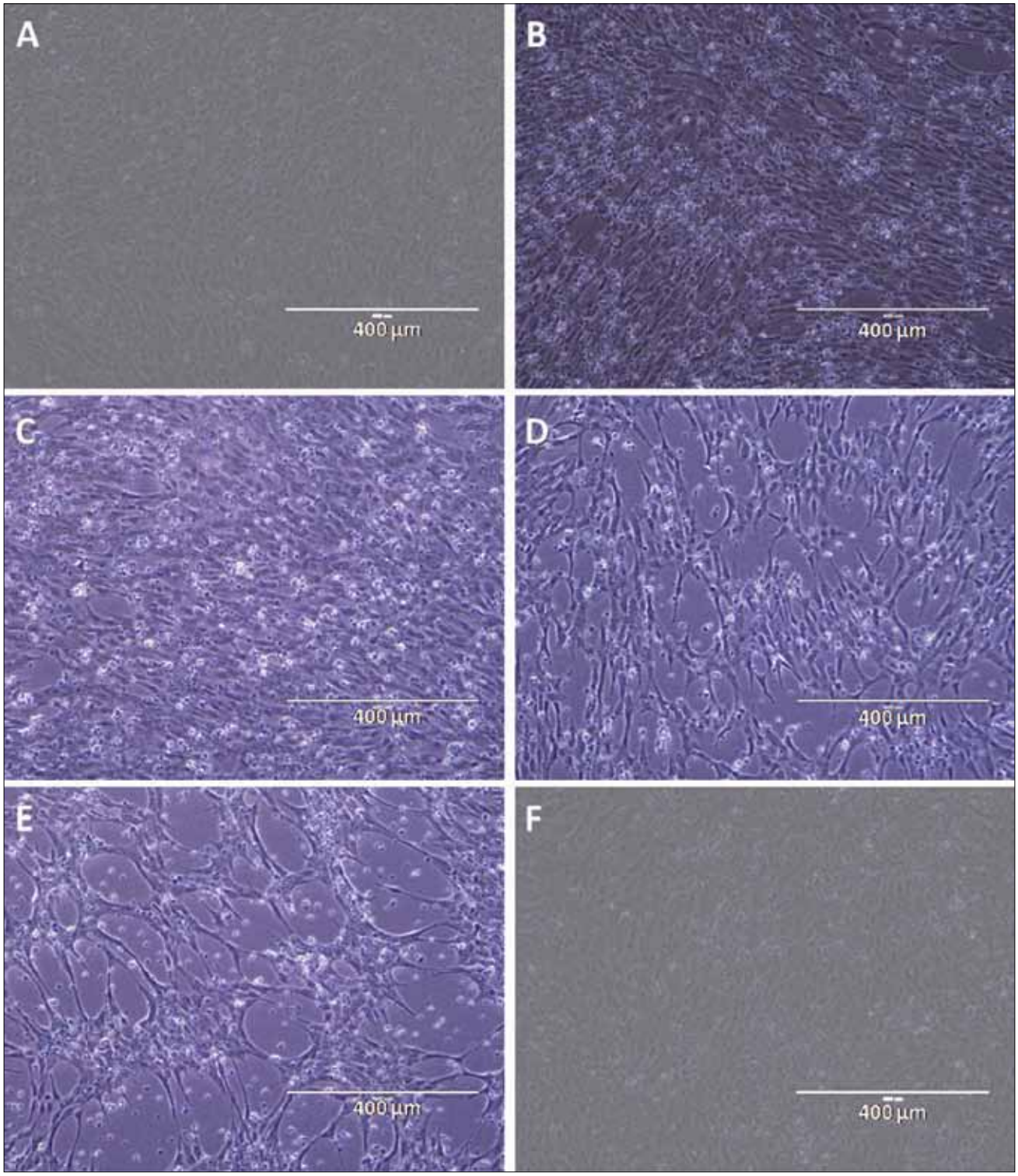


Fig. 83. The effect of morphological changes observed in FtGF cells after inoculating with differing concentrations of formalin-inactivated CyHV-2. (A) Cell treated with 0.1% formalin-inactivated vaccine with healthy cells with no morphological changes; (B) Cells incubated with 0.3% formalin-inactivated vaccine showing rounding and vacuolation of cells; (C) Similar rounding and vacuolation of cells were also observed in the cells treated with 0.5% formalin-inactivated vaccine leading to cluster formation in FtGF cells. Elongation of the cells and leading to detachment of cells was observed in the FtGF cell lines inoculated with 0.7% (D) and 1% (E) formalin-inactivated CyHV-2; (F) Control cells with no incubation with vaccine showing healthy cells

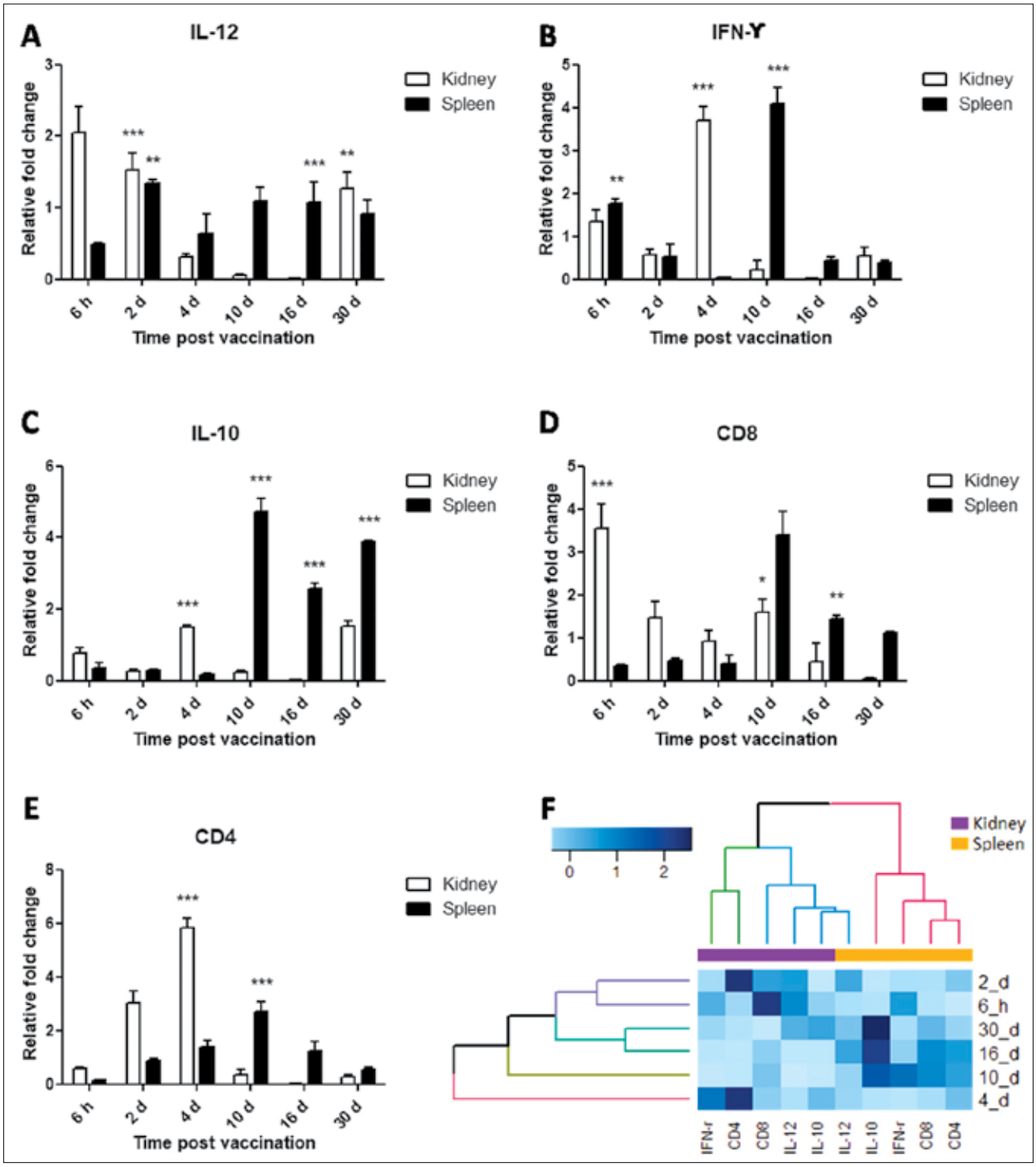


Fig. 84. Immune gene expression pattern in the kidney and spleen of goldfish immunized with the formalin-inactivated vaccine for CyHV-2 at various time points. Gene expression of (A) IL-12, (B) IL-10, (C) IFN-β, (D) CD8 and (E) CD4 in the kidney and spleen tissues; (F) Heatmap of the gene expression profile of immune genes with hierarchal clustering. The expression of target genes was normalized to that of the β-actin as a reference gene. For each gene, the relative expression level of the control animal is 1. Asterisks (*), (**), and (***) indicate significant differences with $p < 0.05$, $p < 0.01$, and $p < 0.001$, respectively to the corresponding control at each time point

The experimental fish were challenged intraperitonially with CyHV-2 virus of concentration $10^{5.2}$ TCID50/mL after 30 days post-vaccination. The results prove that the vaccines were able to elicit an innate and adaptive immune response by modulating the antiviral genes. The efficacy of the vaccine determined by challenging the immunized fishes with the CyHV-2 virus sited a high protection rate of 81.3% for formalin-inactivated CyHV-2 and 86.7% for heat-inactivated CyHV-2 (Fig. 85).

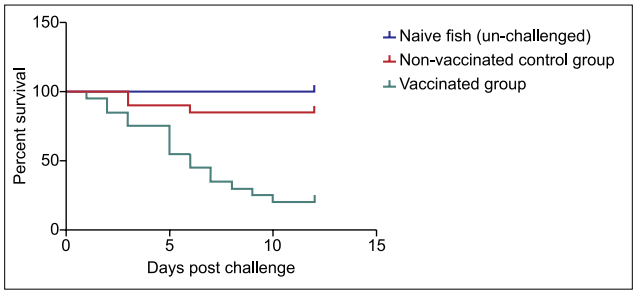


Fig. 85. Kaplan–Meier curve showing the percent survival of *Carassius auratus* challenged with CyHV-2 at 30 days post-vaccination. The vaccinated group and the non-vaccinated control group received an intraperitoneal injection of CyHV-2 ($10^{7.8}$TCID50/mL). A significant difference was noted for the formalin-inactivated vaccine with a p-value of 0.0023.

In order to develop recombinant protein for immunization of goldfish against CyHV-2 and to produce antibodies against CyHV-2 for use in serological tests, we identified and designed primers for ORFs encoding 5 structural proteins, *viz*. ORF66, ORF115, ORF131, ORF132, and ORF136 and also the full-length major capsid protein (MCP) gene of CyHV-2 (3,789 Kb). Those ORFs and MCP gene were cloned into TA cloning vector (pGEMT-Easy vector) and transformed into *E. coli* JM109 cells and pET32a (+) vector was chosen for the expression of protein in *E. coli* cells.

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**

Isolation of bacteriophages

A total of 57 pond water samples collected from different locations of Lucknow district were processed for bacteriophage isolation. Bacteriophage was isolated against *Aeromonas hydrophila* bacterial strain Mhg06. In the diffusion method, Mhg06 phage had titre >10^9 pfu/mL Mhg06 phage was found to have an efficient lytic activity, hence taken up for phenotypic characterization. Phage Mhg06 was purified by collecting a single and well separated plaque in SM buffer, then prepared its serial dilutions and finally mixed with culture and poured on TSA plates same as diffusion method. Further, it was concentrated using PEG precipitation method and stored at 4 °C for further characterization. Purified and concentrated bacteriophage Mhg06 had a titre of 2.85 × 10^{10} pfu/mL. A working stock of 5×10^7 pfu/mL was made from concentrated phage stock. Bacterial count of Mhg06 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.

Phenotypic characterization of *A. hydrophila* Phage Mhg06

One Step growth experiment: *A. hydrophila* Mhg06 strain was grown to mid-exponential phase (OD_{550} 0.2- about 2×10^7cfu/mL) and infected with purified phage to give a MOI of 1. Phages were allowed to absorb for 10 min and after that pellet was suspended in SM buffer, diluted in nutrient broth and incubated at 30 °C with shaking at 180 rpm. At selected time intervals, representative sample was taken, and phage titre was estimated by double-layer agar method. Purified phage Mhg06 showed a latent period of 10 min and a rise period of 230 min (Fig. 86).

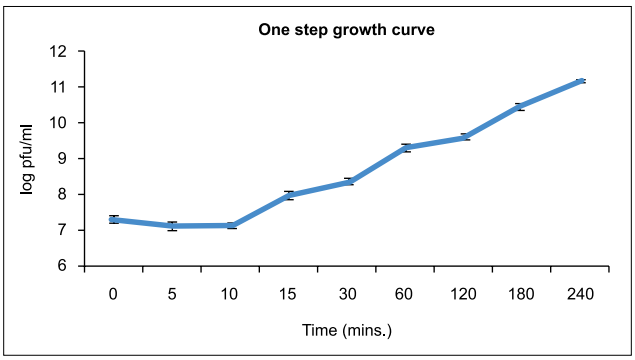


Fig. 86. One step growth curve of *Aeromonas hydrophila* Phage Mhg06

Adsorption curve: Pellet of 2 mL Mhg06 (10^7 CFU/mL) was suspended in equal volume of SM buffer and infected with phage lysate to give an MOI of 1.0. During incubation at 30 °C, aliquots of 100 µL were mixed with 900 µL SM buffer at different time intervals, immediately followed by centrifugation (10000 rpm for 3 minutes) and filtration (0.22 µm). The phage titre was determined using plaque assay after appropriate dilutions. Immediately after addition of phage to the bacterial host strain (time zero), a sample was taken which was considered as 100% non-adsorbed phages. The percentage of phage adsorption was calculated as follows: [(control titre - residual titre)/control titre] x 100%. Adsorption rate of phage

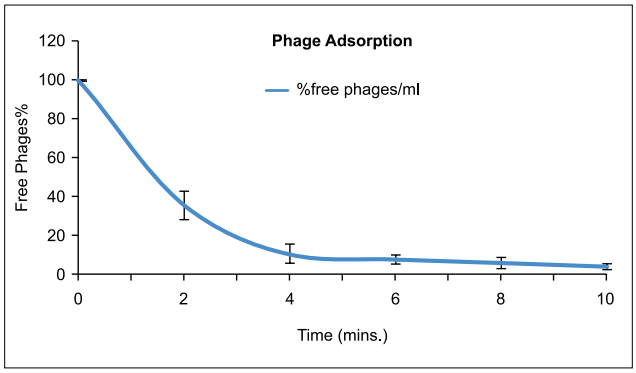


Fig. 87. Adsorption curve of *Aeromonas hydrophila* Phage Mhg06

on host bacteria was found to be very quick. After 10 min, 96% phages were adsorbed on the host cells (Fig. 87).

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, Mhg06 mid-exponential phase culture was infected with purified phage to give a MOI of 1, then incubated at at 30 °C with shaking at 180 rpm and optical density (OD_{600}) was measured at different time intervals. TOD of the purified Mhg06 phage was found to be 2 hours post-infection (Fig. 88).

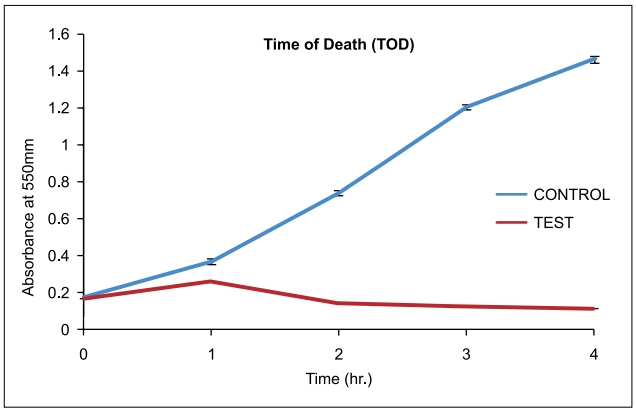


Fig. 88. Determination of Time of Death (TOD) of *Aeromonas hydrophila* Phage Mhg06

Lysogenization frequency: Exponential bacterial culture pellet of Mhg06 was dissolved in SM buffer and infected with phage at MOI of 1. After incubation at 30 °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 centers. The phage Mhg06 had a lysogenic frequency of 0.10%.

Influence of pH on phage viability: Phage Mhg06 was suspended in SM buffer, previously adjusted with 1M NaOH or 1M HCl, to yield a pH range of 3.0 to 11.0. After 60 min of incubation at 30 °C and serial dilution, each treated sample was tested against *A. hydrophila* Mhg06 strain in a double-layer agar assay to check the viability of phage. Phage viability was checked at pH 3, 5, 7, 9 and 11. Hundred percentage survival was seen at pH 7.0. The survivability did not decrease significantly even at pH 5.0 and 9.0. Hence, the phage was found to be stable at pH two points below and above the optimum pH. The survival rate decreased drastically at pH 3.0 and 11.0 by 53.9% and 74.6%, respectively (Fig. 89).

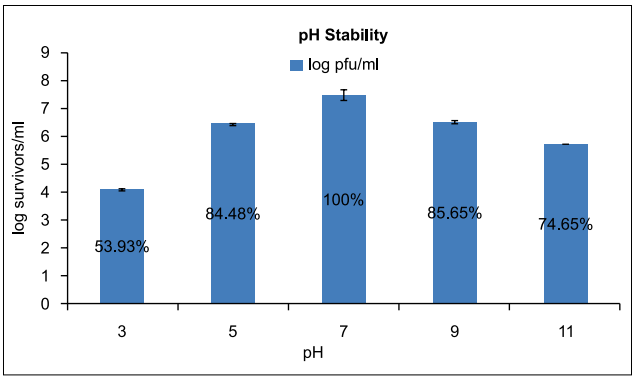


Fig. 89. pH stability of *Aeromonas hydrophila* Phage Mhg06

Effect of temperature on phage viability: Phage were suspended in SM buffer and incubated at temperature range of 4, 37, 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 Mhg06. The result showed that at 4 and 37 °C, bacteriophage had 100% viability, however, at higher temperature gradients *i.e.* 45, 55, 65 and 75 °C, although the phage remained active but percentage of survivability was decreased by 88.78%, 73.98%, 48.91% and 48.25%, respectively (Fig. 90).

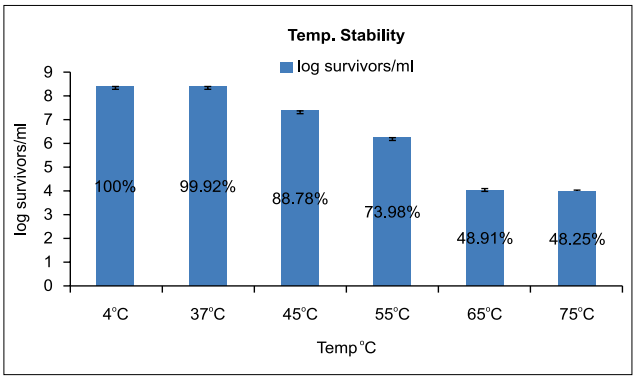


Fig. 90. Temperature stability of *Aeromonas hydrophila* Phage Mhg06

Phage stability in the presence of chloroform: Phage stability was evaluated by incubating phage lysate with 5%, 10%, 20% and 30% of chloroform separately, for 1 hour at room temperature followed by phage titer assay using double-layer agar method. Result showed percentage decrease of log survivors in the following percentage- 97.98, 85.90, 73.68 and 62.08, respectively (Fig. 91).

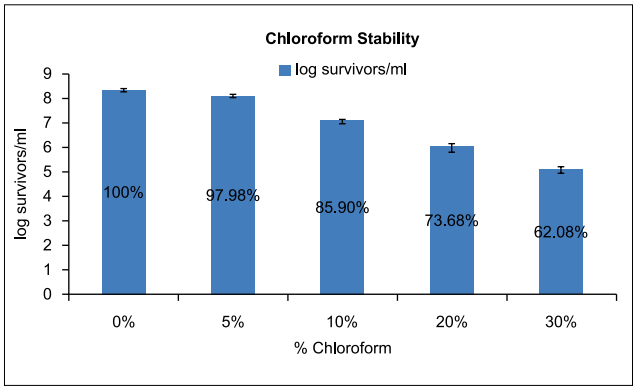


Fig. 91. Chloroform stability of *Aeromonas hydrophila* Phage Mhg06

Host range: A suitable phage in terms of therapeutic potential is the one which is potent in its activity against a wide range of host species and therefore, to isolate a phage that will act against varied strains of *A. hydrophila*, is imperative. Phage Mhg06 was tested on lawns of five different strains of *A. hydrophila* by spotting method. However, no plaques were obtained on any strain other than Mhg06 of target bacteria indicating strain-specific host range of isolated phage.

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

Period: **October, 2019 - October, 2022**

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

Funding Support: **NASF-ICAR, New Delhi**

Nile tilapia (*Oreochromis niloticus*) is one of the most important aquaculture species farmed worldwide. However, the recent emergence of tilapia lake virus (TiLV) disease, also known as syncytial hepatitis of tilapia, has threatened the global tilapia industry. Under the project, a cell line developed from heart of *Oreochromis niloticus* (OnH) was found

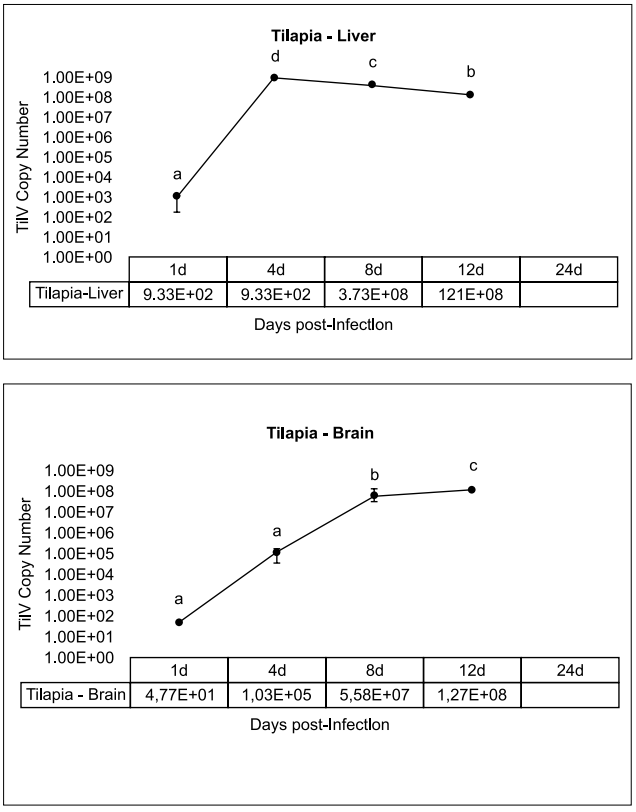


Fig. 92. Temporal disease progression of TiLV in different tissues of *Oreochromis niloticus*

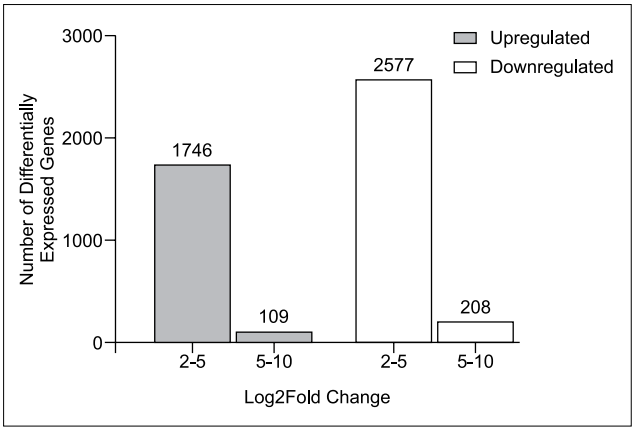


Fig. 93. Number of differentially expressed genes following TiLV infection in *Oreochromis niloticus*

to be susceptible to TiLV. The optimum temperature for virus replication was found to be 28 °C and the virus titre was determined to be $10^{5.3}$/mL. TEM of infected cells revealed electron dense virus particles in the cytoplasmic vesicles. Using the cell culture supernatant from TiLV-infected OnH cell line, a reproducible experimental infection model for TiLV was developed.

For assessing the transcriptome profile of TiLV-infected tilapia, naïve tilapia were infected with cell culture supernatant and tissue samples were collected at different time-points. Based on the maximum copy number of TiLV in liver samples (Fig. 92) at 6 days post-infection, RNA was isolated from liver of three control and three infected tilapia and were sequenced. Analysis of RNA-Seq data identified 4640 differentially expressed genes (DEGs) (Fig. 93), which were involved among others in antigen processing and presentation, MAPK, apoptosis, necroptosis, chemokine signaling, interferon, NF-kB, acute phase response and JAK-STAT pathways (Fig. 94). Besides, for knowing the relative susceptibility/ resistance of species co-cultured with tilapia, experimental infection was carried out in some of the important cultured fishes including silver carp, catla, tilapia, grass carp, mrigal and pacu. However, except tilapia, none of the fish species were found to be susceptible to TiLV (Fig. 95).

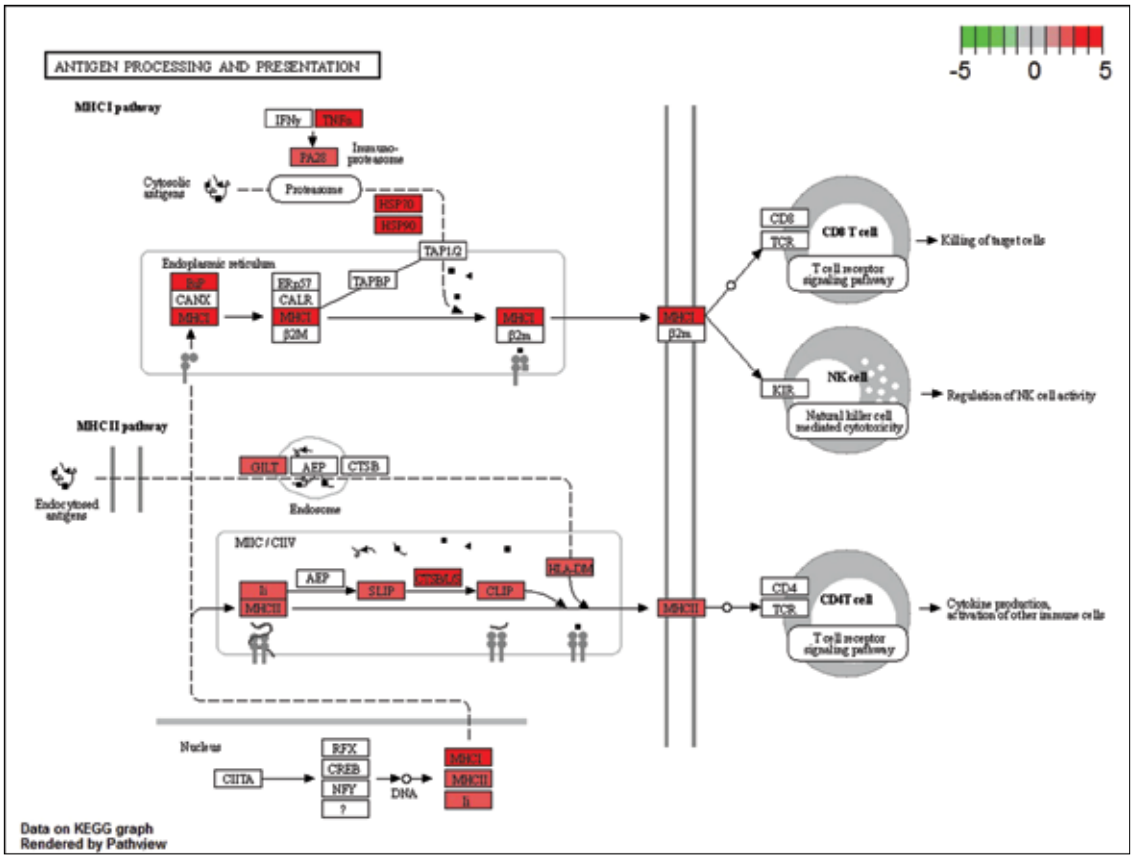


Fig. 94. Antigen processing and presentation signalling pathway in *Oreochromis niloticus* following TiLV infection

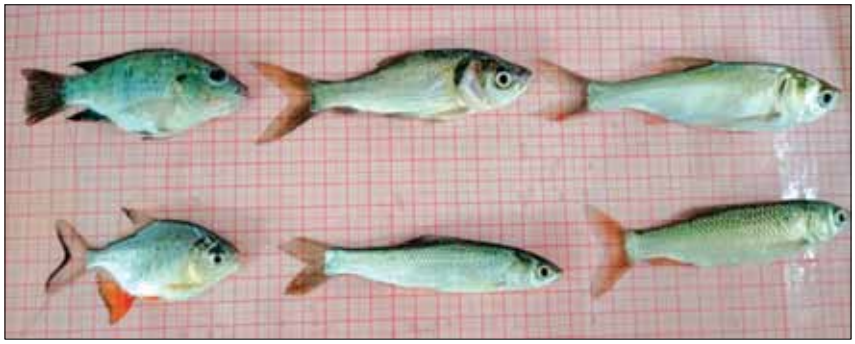


Fig. 95. Susceptibility of important freshwater aquaculture species to TiLV infection

WORKSHOPS / SYMPOSIA / TRAINING / MEETINGS ORGANIZED

Training on eOffice

An eOffice training for the administrative staff of ICAR-NBFGR was conducted during January 27-28, 2020. The training consisted of briefing sessions on overview of eOffice followed by demonstration sessions. Hands on sessions was conducted in computer labs to provide experiential learning on eOffice and eFile.

eOffice training in progress

Training Programme on Awareness for Utilization of Natural Resources under Constitutional frame

A three day training programme on "Awareness for Utilization of Natural Resources under Constitutional frame" was organized at ICAR-NBFGR, Lucknow during January 30 - February 1, 2020. The participants were from ICAR-NBFGR, Lucknow (Scientists, Technicals, Administration and Supporting staff) and one staff each from ICAR-CISH and ICAR-IISR, Lucknow.

Snapshots of 'Awareness for Utilization of Natural Resources under Constitutional Frame'

Hands-on Training programme on Determination of Viral Load Quantification by Real Time PCR in Aquatic Animals

A hands-on training programme on "Determination of Viral Load by Quantitative Real Time PCR in Aquatic Animals" for officials of NFDB-Aquatic Animal Health & Quality Testing Laboratory

Inaugural function of training programme

was organised during February 24-28, 2020. The topics covered during the training programme included cloning of viral gene fragment, preparation of standards for qRT-PCR analysis and determining viral load in samples.

International Conference on "Recent Biotechnological Innovation in Aquaculture (Live Aqua 2020)"

ICAR-NBFGR in collaboration with Bharathiar University organized an International Conference on "Recent Biotechnological Innovation in Aquaculture (Live Aqua 2020)" at Bharathiar University, Coimbatore during February 27-28, 2020. The conference was aimed to provide platform for sharing biotechnological innovations, discoveries and updates in the field of aquaculture for developing action plans and strategies for sustainable development in the field. The conference was inaugurated by Dr. Kuldeep K. Lal, Director, ICAR-NBFGR. The distinct guests present were Prof. Dr. P. Kaliraj, Vice-Chancellor, Bharathiar University, Dr. K. Murugan, Registrar, Bharathiar University, Dr. N. Saravanane, Scientist F, Centre for Marine Living Resources and Ecology, Prof. N. Munuswamy, CSIR-Emeritus Scientist, University of Madras, Dr. T. Thangaradjou, Scientist E, DST-SERB and Dr. P. Padmanaban, Deputy Director, Lee Kong Chain School of Medicine, Nanyang Technological University, Singapore. The technical sessions were held under 11 thematic areas where a total of 625 national and international delegates from research and development institutions, including senior experts in the topic, scientists, university professors, researchers, students, representatives of government and other organizations participated. About 103 oral presentations were included under different sessions and around 108 posters were presented by the delegates.

Images of 'Live Aqua 2020'

Opening Ceremony of Germplasm Resource Centre at Agatti Island, Lakshadweep

ICAR-NBFGR & DBT germplasm resource centre for marine ornamental invertebrates has been inaugurated at Agatti Island, Lakshadweep on March 8, 2020. The centre was inaugurated in august presence of Dr. A.K. Rawat, Scientist G and Senior Advisor, DBT, Dr. A.G. Ponniah, Former Director, ICAR - NBFGR & CIBA, Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, Dr. Vindhya Mohindra, Head, Fish Conservation Division, ICAR-NBFGR, Dr. T.T. Ajith Kumar, SIC-PMFGR Centre, Kochi, Smt. A. Sajidha, Chairperson, V.D.P., Agatti, and Dr. Mohammad Koya, Deputy Collector (I/c), Agatti, Lakshadweep. This facility is located on the premises of the CMLRE, MoES field station, approximately 1.5 km away from Agatti Airport. The infrastructure facilities developed at the centre included water pumping setup with filtration units, quarantine, broodstock development, larval rearing and juvenile rearing units. A total of 15 species of ornamental shrimps and 2 species of sea anemone are being maintained in the facility. Technology standardization for the captive propagation of high value marine ornamental shrimps and sea anemones are being attempted in the facility.

Glimpses of opening ceremony of germplasm resource centre at Agatti Island, Lakshadweep

Training Programme on Fish Milt Cryopreservation of IMC Broodstock

PMFGR Centre, Kochi of ICAR-NBFGR conducted a training programme on "Fish milt cryopreservation for genetic improvement of IMC broodstock" at Peechi, Thrissur, Kerala during March 10-12, 2020. The training programme was attended by 25 participants comprising of 12 fisheries department officials from Kerala, 8 fishermen from Karnataka and 5 research assistants from Kerala. Mr. Benny Kurian, Assistant Director (Fisheries), Palakkad was the Chief Guest of the program and in inaugural address, he stressed the need of cryopreserving milt of superior quality male fishes and outbreeding with the stocks available in different farms for improving the fish seed quality. The participants were exposed to both theoretical and practical aspects. Hands-on practical training was provided to the beneficiaries on inducing fish using synthetic hormone, milt collection, motility of the sperm quality assessment, cryopreservation, thawing of cryopreserved milt, motility check of thawed milt, fertility trials and tagging of fish. In addition, lectures were delivered regarding maintaining the genetic diversity of broodstock and its importance for quality seed production, and fish health management in broodstock. The valedictory function was presided over by Shri. Saju M.S., Joint Director of Fisheries, Central Zone, Kerala. In valedictory address, he reiterated the importance of milt cryopreservation for producing the quality seed of IMCs.

Glimpses of training programme on fish milt cryopreservation of IMC broodstock

Expert Consultation on Status and Preparedness on Decapod Iridescent Virus-1

An expert consultation was held under National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) on April 17, 2020 to discuss the status and

preparedness on decapod iridescent virus-1 (DIV1) in India. The meeting was attended by selected subject experts from different ICAR Fisheries Research Institutes, officials from Department of Fisheries, Government of India, NFDB, RGCA, MPEDA, and a few eminent experts from different organizations. The major objective of the consultation was to bring a consensus approach on status, risks and preparedness needs regarding DIV-1, and developing advisory regarding the disease for communication to the stakeholders for following a precautionary approach. In addition, there was discussion for undertaking surveillance under NSPAAD, and also requirement for screening the shrimp broodstock and other inputs imported into the country for DIV-1.

NSPAAD Review Committee Meeting

A meeting was held with members of NSPAAD Review Committee constituted by Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India comprising of Prof. Iddya Karunasagar, Senior International Food Safety Consultant and Former Senior Fisheries Officer, FAO of UN; Dr. A.G. Ponniah, Ex-Director, ICAR-NBFGR and ICAR-CIBA; Dr. C.V. Mohan, Principal Scientist, WorldFish, Malaysia; Dr. M. Gajendragad, Emeritus Scientist, ICAR-NIVEDI, Bengaluru and Dr. Nagendra R. Hegde, Scientist G, NIAB, Hyderabad on August 5, 2020 to discuss the queries of the members. The National Coordinator, NSPAAD and Deputy Director General (Fy.Sc.), ICAR, Dr. J.K. Jena; Co-coordinator, NSPAAD and Director, ICAR-NBFGR, Lucknow, Dr. Kuldeep K. Lal; Dr. Neeraj Sood, Consortium Principal Investigator, NSPAAD and Dr. P.K. Pradhan, Principal Scientist, ICAR-NBFGR participated in the meeting. During the meeting, a presentation was made to address the points of the members of Review Committee.

INFAAR-Fisheries Component SOP validation Meeting

An online meeting was organized by ICAR-NBFGR for validation of SOP developed for operation of INFAAR-Fisheries Component on November 10, 2020. The meeting was attended by the personnel from ICAR-NBFGR, ICAR-CIFT and FAO-India.

Training Program on Effective Health Management for Enhancing Work Efficiency

HRD cell of ICAR-NBFGR, organized a short training program on "Effective health management for enhancing work efficiency of employees" in physical mode, at ICAR-NBFGR, Lucknow during November 26-28, 2020 in which 16 skilled supporting staff participated.

Regional Capacity Building Program on Aquatic Genetic Resources for Asia-Pacific Nations

ICAR-NBFGR and Asia Pacific Associations of Agricultural Research Institutions (APAARI), Bangkok, Thailand, organized a virtual International training programme on "Regional capacity building on biotechnological tools in aquatic genetic resource management and *ex-situ* conservation for Asia-Pacific countries" during December 07-18, 2020. This collaboration was part of the mission to achieve the United Nations- Sustainable Development Goals (SDG-17 on Partnerships for the Goals). A total of 35 participants from 14 countries (Asia & Pacific region including India) participated in the program. The aim of the program was to enhance the skill of researchers working in aquaculture production and fisheries sectors. The important part was that 11 countries nominated women participants (22) working in fisheries sector and, thus, extending help for mission of women empowerment and also to achieve the SDG-5 (Gender Equality) and SDG-4 (Quality Education). International eminent experts those who made deliberations in the training programme were: Dr. Graham Mair, Senior Aquaculture Officer, FAO; Dr. Daniela Lucente, Consultant, FAO; Mr. Simon Wilkinson, Coordinator Communication Programmes, NACA; Dr. Ruth Garcia Gomez, Aquaculture Stewardship Council and Dr. Catherin Lebbe, Deputy Director of Fish Physiology and Genomics Department of INRAE (former INRA), France. The scientists from ICAR-NBFGR also made their deliberations on different biotechnological tools followed by demonstration film on laboratory techniques, created by shooting and editing of laboratory techniques, followed by interaction session for making the training effective. The inaugural session was Chaired by Dr. J.K. Jena, Deputy Director General (Fy.Sc.), and along with Dr. Rishi K. Tyagi, Coordinator, APCoABB, APAARI. Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, Lucknow welcomed the delegates and participants. The opening expert lecture was delivered by Dr. Devin Bartley, Former Head, Aquaculture Services, FAO. The valedictory function was Chaired by Dr. Trilochan Mohapatra,

Secretary, DARE & Director General, ICAR who also distributed certificates to the participants. The other dignitaries present were Dr. J.K. Jena, Deputy Director General (Fy.Sc.), ICAR; Dr. Matthias Halwart, Head, Aquaculture Division, FAO; Dr. Ravi Khetarpal, Executive Secretary, APAARI; Dr. Rishi K. Tyagi, Coordinator, APCoAB, APAARI; and Dr. A.G. Ponniah, Former Director, ICAR-NBFGR & ICAR-CIBA; Directors of ICAR-CIFT and ICAR-DCFR.

Glimpses of Regional Capacity Building Program

Launch Workshop for FAO-ICAR-TCP programme

An inception workshop was organized jointly by ICAR-NBFGR & ICAR-CIFT virtually on December 10, 2020 to formally launch the FAO-ICAR-TCP entitled "Support mitigation of Antimicrobial Resistance (AMR) risk associated with aquaculture in Asia" in India. Dr. Trilochan Mohapatra, Secretary, DARE & DG, ICAR was the Chief Guest. Mr. Tomio Shichiri, FAO, India and Shri Sagar Mehra, Joint Secretary (Inland Fisheries), Ministry of Fisheries, Animal Husbandry & Dairying were the Guests of Honor. The workshop was attended by 30 scientists/ experts from ICAR Fisheries Institutes, ICAR-Animal Science Institutes, WorldFish, Network of Aquaculture Centres in the Asia-Pacific (NACA), FAO Regional Office for Asia and the Pacific (RAP), FAO India and FAO Headquarters.

Project Advisory Committee (PAC) Meeting of Project on Host-Pathogen-Environment Interaction of Tilapia Lake Virus Disease

The first Project Advisory Committee (PAC) meeting of the NASF project entitled "Understanding molecular basis of host-pathogen-environment interaction of Tilapia Lake Virus Disease" was held online on December 22, 2020. Dr. K.K. Vass, Ex-Director, ICAR-CIFRI and Chairman, PAC; Dr. S. Raizada, Ex-ADG (Inland Fisheries), ICAR and Member, PAC; Dr. Kuldeep K. Lal, Director, ICAR-NBFGR; Dr. C.V. Mohan, Principal Scientist and Research Lead for India, WorldFish; Dr. P.K. Pradhan, CPI, ICAR-NBFGR; Dr. Neeraj Sood, Dr. T. Raja Swaminathan, Dr. Anutosh Paria from ICAR-NBFGR, Lucknow and Dr. K.V. Rajendran, CCPI, ICAR-CIFE, Mumbai; Dr. Megha K. Bedekar and Dr. Saurav Kumar from ICAR-CIFE participated in the meeting. Dr. Pradhan and Dr. Rajendran made detailed presentations on the progress of the project achieved by the two collaborating centres. In the concluding remarks, the Chairman appreciated the team for making significant progress in the project during this period, in spite of the difficulties due to COVID-19 pandemic.

Important Institutional Meetings

Research Advisory Committee Meeting

The 24th Research Advisory Committee (RAC) meeting of ICAR-NBFGR, Lucknow was held online under the Chairmanship of Dr. A.G. Ponniah during April 15-27, 2020. The RAC members, Dr. S.C. Mukherjee, Dr. K.V. Bhat, Dr. Anup Mandal and Dr. Pravin Puthra attended the meeting in the presence of Dr. J.K. Jena, DDG (Fy.Sc.), ICAR. Dr. Kuldeep K. Lal, Director, ICAR-NBFGR welcomed the Chairman, and Members of the newly constituted committee. Chairman thanked all the members for participation in the meeting. Chairman and members of the committee expressed their happiness to be associated with the RAC of ICAR-NBFGR. Director, ICAR-NBFGR presented the overview of the institute. Dr. P.K. Pradhan, Member Secretary, RAC presented the action taken report (ATR) on the recommendations of previous RAC. 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 critically reviewed progress of all the ongoing research programmes of the institute and provided significant inputs to improve the research programmes. Committee provided valuable suggestion and recommendations to improve the research output and visibility of the institute. In concluding remarks, the Director thanked the RAC for the valuable guidance and assured that the institute would strive hard to meet the expectations of all the stakeholders.

Annual Institute Research Committee (IRC) Meeting

The 33rd Institute Research Committee (IRC) meeting of the institute was held online, during July 27, 28 and 30, 2020. Dr. Rajeev K. Singh, Member Secretary, IRC welcomed the Chairman, Dr. Kuldeep K. Lal, Director ICAR-NBFGR, Dr. P. Pravin, ADG (Marine Fisheries), Head of the Divisions; Dr. Ravindra Kumar (MBBD), Dr. Vindhya Mohindra, (FCD), Dr. Gaurav Rathore (FHM&ED), SICs; Dr. T.T. Ajith Kumar (PMFGR, Kochi) and Dr. Sharad Kumar Singh (ARTU, Chinhat, Lucknow). Member Secretary also welcomed Dr. Kripal Datt Joshi (Chairman, PME), scientists and technical staff from headquarters, PMFGR Centre, ARTU, Administrative Officer and Assistant Finance & Accounts Officer. A total of 41 research projects and 8 new project proposals were discussed in the meeting.

Mid-term Institute Research Committee (IRC) Meeting

The mid-term Institute Research Committee (IRC) meeting was held online on December 28, 2020. Dr. Rajeev K. Singh, Member Secretary, IRC welcomed the Chairman, Dr. Kuldeep K. Lal; Head of the Divisions; SICs; Chairman, PME; scientists and technical staff from headquarters, PMFGR, Kochi and ARTU, Chinhat, Lucknow.

Institute Management Committee Meeting

The 34th Institute Management Committee (IMC) meeting of ICAR-NBFGR was held on March 13, 2020. The meeting was attended by Dr. P. Pravin, Dr. Aparna Chaudhari, Dr. P.K. Sahoo, Dr. Suseela Mathew, Dr. V.R. Suresh, Shri Prem Singh Kashyap and Shri Mahendra Kumar Bind.

Institutional Animal Ethics Committee Meeting

Institutional Animal Ethics Committee meeting of ICAR-NBFGR was held on December 22, 2020 to discuss various proposals received from the Principal Investigators.

IMPORTANT DAYS AND CELEBRATIONS

Republic Day Celebrations

Institute celebrated Republic Day 2020 with great zest and enthusiasm. Dr. Kuldeep K. Lal, Director hoisted the National Flag in the presence of staff members of the institute. In his remarks, he appreciated the efforts of all staff members and highlighted the achievements of ICAR-NBFGR. Dr. Lal also informed the staff that the institute has undertaken several initiatives, to comply with the recent efforts of the Government of India. The programme was followed by a sports event in which children and staff of the ICAR-NBFGR family actively participated.

Celebration of Republic Day 2020

International Women's Day Celebration

ICAR-NBFGR celebrated International Women's Day 2020 on March 6, 2020. The programme was based on International theme for the year 2020, #Each for Equal. Mrs. Shashwati Mukherjee, LLM (Criminal Law & Law of Tort), Chief Guest of the event delivered a talk on "Rights of women in reference to constitutional & legal rights in India". She briefed about chronology of women's struggle for their rights from USSR-Russia in 1917 and how it has changed over the decades. The highlight of lecture was importance of Article 21 in Indian constitution and right to privacy of women. Equal pay for equal work for women, awareness about sexual harassment at workplaces and several other constitutional and legal rights in different articles for safeguarding dignity and recognizing the strength of the women at workplace were also addressed.

#Each for Equal

Celebration of Independence Day 2020

Mrs. Shashwati Mukherjee, Chief Guest of the function, delivering her talk

Independence Day Celebration

The institute celebrated the Independence Day on August 15, 2020 following COVID-19 guidelines. Dr. Kuldeep K. Lal, Director hoisted the National Flag in the presence of staff of the Bureau. Director appreciated the achievements made by the institute and thanked the staff members and residents for cooperating amid the pandemic.

Vigilance Awareness Week

Vigilance Awareness Week was observed from October 27 to November 02, 2020. Dr. Kuldeep K. Lal, Director, ICAR-NBFGR virtually administered the Integrity Pledge for Citizens & Organizations in bilingual mode on October 27, 2020 to all the staff, students and research scholars at ICAR-NBFGR Headquarters and its centre/units.

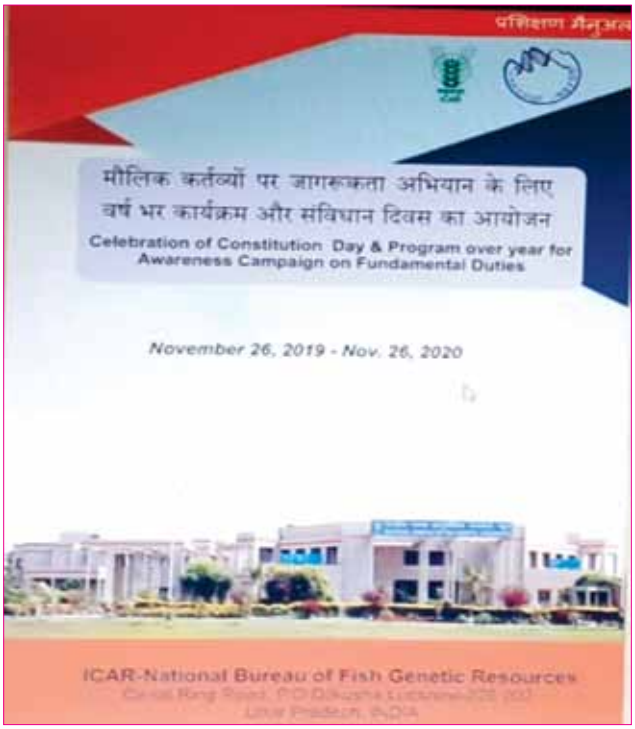
Pledge taken by Institute Staff

In his address, Dr. Lal urged all the staff members of the institute to be vigilant towards their responsibilities. All the employees were also sensitized to take e-pledge through CVC website (https://pledge.cvc.nic.in). Trainees of Skill India training programme from different districts of Uttar Pradesh were also sensitized about vigilance awareness at ARTU, Chinhat.

Online vigilance awareness programme sensitization by vigilance officer

Constitution Day

ICAR-NBFGR, Lucknow celebrated year-long celebration (November 26, 2019 to November 26, 2020) and concluded on November 26, 2020. Released a manual, highlighting the importance of fundamental duties on valedictory function organised through virtual mode. Dr. Achal Singh, Nodal Officer, HRD welcomed Director, ICAR-NBFGR and all the staff of NBFGR HQ, ARTU Chinhat and PMFGR Kochi. In the opening remarks, he highlighted the activities conducted during the year (November 26, 2019 - November 26, 2020). Dr. Kuldeep K. Lal, Director, ICAR-NBFGR reminded all those present to inculcate discipline, follow guidelines, wear a mask whenever we step out, respect the law, not to damage national property, practice fundamental duties and ensure societal welfare.



Releasing of Awareness Manual

Agriculture Education Day

Celebrated Agriculture Education Day on December 3, 2020 through online mode, at ICAR-NBFGR. On the occasion, three events were organised: Drawing & Painting (junior & senior) and Essay competition. A total of 90 students from schools such as CMS, Kanpur Road; CMS, Gomti Nagar extenstion; Army Public School, Nehru Road; Kendriya Vidyalaya, Gomti Nagar; Pioneer Montessori School, Eldeco Udyan-I and Mount Litera Zee School, Lucknow participated in different events. The prize money was transferred to the bank account of all winners and digital certificates were distributed.

Award winning drawing & paintings

Kisan Diwas

ICAR-NBFGR, Lucknow celebrated Kisan Diwas with great enthusiasm on December 23, 2020 to mark the birth anniversary of Former Prime Minister, Shri Chaudhary Charan Singh. The program was organized at Nabipanah Village, Maal block, Malihabad, Lucknow in the presence of Dr. Kuldeep

Kisan Diwas celebrations

K. Lal, Director, ICAR-NBFGR, scientists from ICAR-NBFGR and local social workers. On this occasion, approximately 500 farmers from the Malihabad region of Lucknow participated. Farmers were made aware of various aspects of aquaculture practices like fish breeding and rearing, feed preparation, and fish health. They were also briefed about PMMSY scheme of Government of India. Besides, ARTU, Chinhat, also organized another program to celebrate Kisan Diwas in which 40 farmers participated. The farmers were made aware about PMMSY through audio-visual aid and also scientist-farmer interaction programme was conducted on aquaculture.

EXTENSION ACTIVITIES

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 coordinated by a team of scientists and technical officers. A training programme on fish culture and breeding was organised for tribal farmers of Baksa at Guwahati, Assam in collaboration with the Aquaculture & Biodiversity Center, Dept. of Zoology, Gauhati University, Guwahati in which 30 tribal farmers were trained.

Technological and Infrastructure Support for Tribal Farmers

Two programmes on technological and infrastructure support were conducted in collaboration with Dept. of Zoology, Gauhati University, Guwahati and Haflong Government College, Haflong, Assam for selected tribal farmers. The programmes aimed at strengthening fisheries-based enterprises towards enhancing their livelihood. Ten tribal beneficiaries from Dimali, Salbari and Batakuchi villages, Kamrup (Rural) district of Assam; six from Majdia, Kahibari and Kallipar villages of Baksa district of Assam, and four from Naben and Longmailai villages of Halflong district of Assam were selected. They were provided

Aquaculture support to tribal farmers in Assam

technological guidance, infrastructure support in the form of pond renovation, supply of inputs such as fish seed, supplementary fish feed, one vermicompost unit, one poultry shed and indigenous poultry birds of the NE region. Regular monitoring and technical support were provided by the collaborating partner to the selected tribal farmers.

Awareness Programme on Biodiversity Conservation in Western Ghats

The ICAR-NBFGR, Lucknow, in collaboration with Department of Zoology, Bharathiar University, Coimbatore organized an awareness programme on Biodiversity Conservation in Western Ghats under Scheduled Tribe Component (STC) at Coimbatore on February 28, 2020. Dr. Gopal Krishna, Vice-Chancellor, ICAR-CIFE, Mumbai inaugurated the programme and Dr. A.G. Ponniah, Former Director, ICAR-NBFGR, Lucknow & ICAR-CIBA, Chennai presided over the programme. The Chief Guest of the programme Mr. I. Anwardeen, IFS Additional PCCF and Director, Tamil Nadu Forest Academy explained the endemic diversity of Western Ghats and the role of ecosystem services to maintain the ecological integrity. Dr. Kuldeep K. Lal, Director, ICAR-NBFGR explained the role of the institute in conservation of aquatic genetic resources of our country and livelihood promotion. Dr. Kandan, Director, Rajiv Gandhi Centre for Aquaculture shared opportunities for livelihood generation through sustainable biodiversity utilization. Dr. L.K. Tyagi, Nodal Officer, STC scheme, ICAR-NBFGR, Lucknow presented an overview of

various activities undertaken by ICAR-NBFGR for tribal development under the STC scheme and ways through which tribal farmers can be benefitted from this scheme. Over 100 beneficiaries including Self-Help Group members attached with Krishi Vigyan Kendra and tribal community from Palakkad (Kerala), Nilgiri and Coimbatore (Tamil Nadu) districts of Western Ghats region participated in the programme. Various case studies/ success stories were presented about fish culture, conservation and sustainable utilization, livelihood promotion and breeding techniques of indigenous freshwater and ornamental fishes. The tribal farmers actively involved in the discussions and showed their interest in adopting the indigenous fish culture techniques for their livelihood.

Glimpses of awareness programme at Coimbatore

Outreach Programme on Marine Biodiversity Conservation and Opportunities for Ornamental Aquaculture at Lakshadweep

ICAR-NBFGR, Lucknow in collaboration with Centre for Marine Living Resources and Ecology (Ministry of Earth Sciences) and Department of Fisheries, Union Territory of Lakshadweep, organized a two-day outreach programme on "Awareness about Marine Biodiversity Conservation at Agatti Island, Lakshadweep" during March 8-9, 2020 as part of Scheduled Tribe Component (STC). The programme was inaugurated by the Chief Guest, Dr. A.K. Rawat, Advisor/ Scientist G, Department of Biotechnology, Government of India. Dr. A.G. Ponniah, Former Director, ICAR-NBFGR, Lucknow and ICAR-CIBA, Chennai presided over the programme. Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, Dr. Mohammed Koya, Deputy Collector (I/c), Agatti, Lakshadweep, Smt. A. Sajidha, VDP Chairperson, Agatti and Dr. Vindhya Mohindra, Head, Fish Conservation Division, ICAR-NBFGR, Lucknow also attended the programme. Representatives from Bombay Natural History Society (BNHS), National Centre for Sustainable Coastal Management (NCSCM) and local NGOs were also present in the programme. Over 100 women of various Self-Help Groups based at Agatti, actively participated in the two-day event. A booklet on marine biodiversity conservation at Lakshadweep and opportunities for ornamental aquaculture prepared by the ICAR-NBFGR team in Malayalam was also released and distributed to all the participants and stakeholders.

Lectures on various topics were delivered including, biodiversity of Lakshadweep; values and threats, need to conserve aquatic resources and breeding & rearing of marine ornamental organisms for alternate/additional livelihood option for tribal people, etc. The participants interacted with the experts and had a lively discussion on protection of natural biodiversity of the island and to create sustainable alternate livelihood through natural aquatic resource management. Participants were keen on collaborating with the ICAR-NBFGR about germplasm conservation of marine ornamentals and improving their livelihood.

Hands on Marine Ornamental Shrimp Rearing for Tribal Farmers at Lakshadweep

Hands-on learning on high value marine

Awareness programme at Lakshadweep

ornamental shrimps (*Thor hainanensis* and *Ancylocaris brevicarpalis)* rearing were provided to the tribal farmers, including women of Agatti Island at Lakshadweep. These shrimps are native to Lakshadweep and have very good demand in international aquarium trade. This opportunity will contribute towards enhancement of the livelihoods of tribal farmers, as well as, will reduce pressure on exploitation of these precious resources from the wild. A total of 40 farmers selected and recommended by

Hands-on marine ornamental shrimp rearing for tribal women at Lakshadweep

the Lakshadweep administration underwent Hands-on learning of one month each, at ICAR-NBFGR facility at Agatti Island.

Training-cum-demonstration on Broodstock Development of Indigenous Carps

ICAR-NBFGR in collaboration with Fish For All Research and Training Centre, M.S. Swaminathan Research Foundation, Tsunami Nagar, Nagapattinam district, Tamil Nadu carried out a training-cum-demonstration on broodstock development of indigenous carps for seed production as potential livelihood option of the tribal villagers at Thenpathi village, Nagapattinam district, Tamil Nadu.

A village level meeting was conducted on June 4, 2020 in Thenpathi village. A total of 45 villagers (male - 15 and female - 30) participated in the meeting. The project activities were explained to the community and the concept of brood stock development of indigenous carps for seeds production planned in the community ponds was introduced to them. The villagers accepted to participate in the activities and two women group were selected for the actively involving the SHGs members.

A webinar on vegetable cultivation in the bunds of the fish pond was organised by the Fish For All Research and Training Centre, M.S. Swaminathan Research Foundation, Tsunami Nagar, Nagapattinam district, Tamil Nadu on October 23, 2020 in which 10 farmers participated. Similarly, an orientation programme on vegetable cultivation in the bunds of the community fish ponds was also organised on November 5, 2020 in which 15 farmers participated.

The community fish pond renovation was planned and executed by the community with guidance from

the SHGs members. During a focus group discussion, a common understanding of how the community pond renovation, the constraints and needs for pond renovation work were discussed. Community fish pond-1 (0.50 acre, size 30-meter length, 33-meter width and 4-meter depth) and community fish pond -2 (0.33 acre, size 20-meter length, 24-meter width and 4-meter depth) were renovated.

Training Programme on "Clownfish Aquaculture"

ICAR-NBFGR in association with Mangrove Cell and Mangrove Foundation, Department of Forest, Government of Maharashtra conducted a training programme on "Clownfish Aquaculture" as a part of NBFGR's ongoing program on "Establishment of marine ornamental fish village at Maharashtra".

A three-day training program was organized during January 20 - 22, 2020 at ICAR-NBFGR hatchery facility at the premises of the Coastal and Marine Biodiversity Centre, Mangrove foundation Government of Maharashtra, Airoli, Thane, Mumbai. About 40 beneficiaries from Raigad and Palgarh districts of Maharashtra participated in the programme. The training was inaugurated by Dr. Gopal Krishna, Director and Vice Chancellor, ICAR-CIFE, Mumbai. Mr. N.G. Kokre, Range Forest Officer of Mangrove Foundation was also present in the programme. The participants were trained about the identification of different clownfish species, clownfish rearing technologies, water quality monitoring and management, different feeding strategies and clownfish diseases. The hands-on exposure was given on water quality management, disease diagnosis and treatment, handling of hatchery equipments, setting up of filtration units, packing, and transportation. Mr. V. Tiwari, IFS, Additional PCCF and Executive Director, Mangrove Foundation delivered valedictory address and distributed certificates to the participants.

Training on clownfish aquaculture

Training of Trainers (ToT) on Re-Circulatory Aquaculture System (RAS)

ICAR-NBFGR organized a residential training programme of 5 days duration at ARTU, Chinhat for officials from various states, entrepreneur and progressive fish farmers under NFDB sponsored ToT on Re-Circulatory Aquaculture System (RAS) for 25 participants during January 27-31, 2020.

ToT activities at ARTU, Chinhat

Skill Development Programme (SDP) on RAS for Farmers

ICAR-NBFGR organized a three-day residential training programme for farmers across India under NFDB sponsored SDP on Re-Circulatory Aquaculture System (RAS) for 35 participants during February 5-7, 2020 at ARTU, Chinhat.

Skill Development Programme on RAS for farmers

Activities under RKVY scheme

Skill Development Training under Rashtriya Krishi Vikas Yojana (RKVY)

One skill development training programme for beneficiaries under RKVY in collaboration with ICAR-ATARI, Kanpur and Agricultural Skill Council of India (ASCI) on freshwater aquaculture farmer was successfully conducted for 20 young participants during February 27 to March 23, 2020. Out of 20 participants, 19 got certification from Ministry of Agriculture & Farmers' Welfare, Government of India.

Awareness-cum-training Programme on Pradhan Mantri Matsya Sampada Yojana (PMMSY)

The PMFGR centre, Kochi of ICAR-NBFGR conducted awareness-cum-training programme on Pradhan Mantri Matsya Sampada Yojana (PMMSY) for the benefit of fish farmers via video conferencing on December 12, 2020 in Kodungallur, Thrissur District, Kerala. Thirty fish farmers attended the programme and they were appraised about the framework of PMMSY scheme as well as the goals and outcomes envisaged for the scheme. This was followed by a training programme on indigenous ornamental fish culture, biofloc fish culture, re-circulatory aquaculture systems (RAS) and an interactive discussion about diseases in ornamental fish aquaculture and its treatment.

Awareness-cum-training programme on Pradhan Mantri Matsya Sampada Yojana

Foundation for Advancement of Agriculture and Rural Development Sponsored SDP on Fish Production

ICAR-NBFGR conducted a four-day SDP programme on fish production for farmers of Chandauli, Varanasi, Ghazipur and Sonbhadra districts of U.P. under Foundation for Advancement of Agriculture and Rural Development (FAARD), Varanasi for 23 participants during December 28-31, 2020.

Activities under FAARD sponsored SDP on fish production

Mera Gaon Mera Gaurav Programme

ICAR-NBFGR organized a COVID-19 awareness-cum-sensitization programme along with scientist-farmer interaction under Mera Gaon Mera Gaurav programme at Rajauli Village, Bakshi Ka Talab, Lucknow on December 29, 2020. Villagers were sensitized about COVID-19 protocols and stressed on prevention measures. More than 100 farmers/villagers attended the programme. COVID-19 sanitation/ safety kit (mask, sanitizers, soap) and relevant leaflet were also distributed to all the participants on the occasion.

Mera Gaon Mera Gaurav programme activities

Promotion of Indigenous Barbs for Ornamental Aquaculture

Three spot barb, *Dawkinsia rubrotinctus,* a beautiful coloured ornamental barb endemic to the Cauvery River basin in Kerala, Karnataka and Tamil Nadu and Narayan barb, *Pethia setnai,* endemic to west flowing rivers of Goa and Karnataka are having good demand in ornamental trade. ICAR-NBFGR developed breeding protocol for these species and sold fingerlings of *D. rubrotinctus* and *P. setnai* to M/S. Jisinto Aquarium, Chalakudy, Thrissur, Kerala.

Sale of indigenous barbs fingerlings

Distribution of Captive Bred Indigenous Fish Seeds

Three endemic fishes of Kerala, Malabar labeo (*Labeo dussumieri*), yellow catfish (*Horabagrus brachysoma*) and Naadan mushi (*Clarias dussumieri*) were bred in hatchery conditions and after nursery rearing, the seeds were distributed to the Department of Fisheries, Government of Kerala and interested fish farmers. Dr. J.K. Jena, DDG (Fy. Sc.), ICAR, virtually attended fish seed distribution programme as Chief Guest. Dr. Riji John, Dean, KUFOS was the Guest of Honour in the programme. The fish seeds were provided to the fisheries department officials of National Seed Centre, Pannivelichira, Pathanamthitta, Malampuzha, Palakkad, Neyyar, Trivandrum and National Fish Seed Farm, Ullalam, Malappuram.

Distribution of captive bred indigenous fish seeds

Fish Seed Production

Quality fish seed production is one of the important activities of the institute. The institute has been supplying quality IMC seeds to fish farmers, hatchery owners and state fisheries departments of Uttar Pradesh. Institute produced 1017 lakhs seed in the form of spawn, fry and fingerling of IMC, minor and exotic carps during the year.

Adoption of Re-Circulatory Aquaculture System (RAS) Facility by Trainee

Mr. Hammad, S/O Abdullah, trained by ICAR-NBFGR at ARTU, Chinhat (2018-19 1st batch) under RKVY/ASCI- Skill India, has established Re-Circulatory Aquaculture System (RAS) in the vicinity of Chinhat, Lucknow. This facility is also currently being utilized as demonstration unit for other farmer trainees of ICAR-NBFGR.

Re-Circulatory Aquaculture System (RAS) facility established by ICAR-NBFGR trainee

Media Programme (TV, Radio etc.)

Experts from the institute have participated in the following media programmes for reaching out to the stakeholders and providing them technological inputs and advisory services.

S.No.	Date/Month	Telecast/Broadcast Agency	Programme
1	March 6, 2020	Lucknow Doordarshan	Matsya Palan Kaise Karey
2	May 3, 2020	Lucknow Doordarshan	Covid-19 me Matsya Palan me Samayaik Karya
3	May 27, 2020	IFFCO Kisan CSR	Income generation through carp culture
4	July 17, 2020	DD Kisan	Fish Culture
5	June-August, 2020	All India Radio (Akashvani), Lucknow	Samekit Matsya Palan Se Doguni Amdani/Composite Fish Culture

AWARDS AND RECOGNITIONS

- ICAR-NBFGR received prestigious first prize under "Rajashri Tandan Rajbhasha Puraskar Yojna" (small institute category) of ICAR for the year 2018-2019
- Dr. T.T. Ajith Kumar, SIC, PMFGR Centre of ICAR-NBFGR received Dr. M. Devaraj Memorial Award for the best oral presentation in the International conference on Marine ecosystems: Opportunities and challenges organised by the Marine Biological Association of India held at the ICAR-CMFRI during January 7-10, 2020.

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, 2021
2	Systematic review and evolutionary study of Indian Clupeiform fishes	Mahender Singh (PI), T.T. Ajith Kumar, Teena Jayakumar, T.K. and Akhilesh Kumar Mishra	April, 2017 - March, 2021
3	Capacity building and feasibility studies on new area of research on AqGR management **Sub Project I:** Culture of tissue specific cells **Sub Project II:** Genetic tagging of brooders of *Labeo rohita* using low depth sequencing	 Basdeo Kushwaha (PI) and Murali S. Mahender Singh (PI)	April, 2020 - 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, Rama Shankar Sah and Rajesh Kumar (Personnel HQ) P.R. Divya (PI), V.S. Basheer, and Charan Ravi (Personnel PMFGR Center)	April, 2014 - March, 2020
5	Fish diversity pattern of fish communities from river basins of Thar Desert, India	Ajey Kumar Pathak (PI), Rajesh Dayal, Ravi Kumar and Kantharajan G.	April, 2018 - March, 2021
6	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, 2021
7	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 & 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), Labrechai Mog Chowdhury and Murali S.	April, 2018 - March, 2021

S. No	Project Title	Personnel	Period
8	Digital phenotyping tools for assessment of shape morphometric diversity in finfish genetic resources	Achal Singh (PI), Rejani Chandran, Kantharajan G. and Rajesh Dayal	July, 2020 - March, 2022
9	Information system of selected commercially important shellfish resources from prioritized Indian aquatic ecosystem	Ajey Kumar Pathak (PI), Teena Jayakumar T.K. and Ravi Kumar	July, 2020 - June, 2023
10	Establishment of standardised genomic markers for cataloguing diversity below species level	Sangeeta Mandal (PI), Vindhya Mohindra, Rajeev Kumar Singh, Divya P.R.	August, 2020 -March, 2023
11	Up-scaling of fish milt cryopreservation tools for sustainability of aquaculture seed production	Santosh Kumar (PI), Aditya Kumar, Raghvendra Singh, Ajay Kumar Singh, Rama Shankar Sah, V.S. Basheer, Charan R.	November, 2020 - March, 2023
Fish Health Management & Exotics Division			
12	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, 2021
13	Risk and benefit assessment modelling for exotic species	Kripal Datt Joshi (PI), V.S. Basheer, Aditya Kumar, Satyendra Mohan Srivastava and Vikash Sahu	April, 2017 - March, 2021
14	Network project on assessment of anti - microbial resistance in fisheries and aquaculture	Gaurav Rathore (PI), Chandra Bhushan Kumar, Anutosh Paria, Chinmayee Muduli, Satyendra Mohan Srivastava and Vikash Sahu	December, 2017 - March, 2021
Peninsular & Marine Fish Genetic Resources Centre, Kochi			
15	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) and Teena Jayakumar T.K.	 April, 2016 - March, 2021 April, 2016 - March, 2021
16	Genetic approach and evaluation to aid conservation and sustainable propagation of near threatened catfish *Clarias dussumieri*	Divya P.R. (PI) and V.S. Basheer	June, 2020 - July, 2023
17	Network project on ornamental fish breeding and culture (NPOFBC)	V.S. Basheer (PI) and Charan Ravi	October, 2018 - March, 2022
Aquaculture Research and Training Unit			
18	Livelihood improvement through freshwater aquaculture human resource development for the Scheduled Caste of the Government of India prioritised selected district of Uttar Pradesh	Sharad Kumar Singh (PI), Lalit Kumar Tyagi, Achal Singh, Aditya Kumar, Raghvendra Singh, Amit Singh Bisht and Sanjay Kumar Singh	April, 2020 - March, 2024

ICAR Plan Fund

S. No	Project Title	Personnel	Scheme	Period
1	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 - June, 2020

S. No	Project Title	Personnel	Scheme	Period
2	Network project on agricultural bioinformatics and computational biology: **Sub Project** Understanding genomic factors responsible for growth performance in *Clarias magur*	Ravindra Kumar (PI), Basdeo Kushwaha, Mahender Singh, Murali S. and Reeta Chaturvedi	ICAR-CABIN	July, 2020 - March, 2026
3	ICAR-CRP Genomics: *De-novo* genome sequencing of anadromous Indian shad, *Tenualosa ilisha* (Hamilton, 1822) and Indian major carp, *Catla catla*	Vindhya Mohindra (PI), Basdeo Kushwaha, Rajeev Kumar Singh and Labrechai Mog Chowdhury	ICAR-CRP	July, 2015 - March, 2021
4	CRP-Agro Biodiversity: On farm evaluation of prioritized fish genetic resources for conservation aquaculture	Kuldeep K. Lal (PI), T.T. Ajith Kumar, V.S. Basheer, Santosh Kumar, Charan Ravi, Aditya Kumar and Ajay Kumar Singh	ICAR-CRP	August, 2017 - March, 2021
5	All India network project on fish health	Pravata Kumar Pradhan (PI), Gaurav Rathore, Neeraj Sood and Anutosh Paria	ICAR	April, 2017 - March, 2020
6	Developing and testing a model of fisheries-based entrepreneurship for socio-economic development of tribals and sustainable utilization of fisheries resources	Lalit Kumar Tyagi (PI), Kripal Datt Joshi, Sharad Kumar Singh, Achal Singh, Raghvendra Singh, Aditya Kumar, Amit Kumar Bisht and Sanjay Kumar Singh	ICAR-TSP (STC) component fund	August, 2020 - March, 2023
7	Intellectual property management and transfer/ commercialization of agricultural technology scheme (Up-scaling existing components *i.e.* Intellectual Property Right)	Anutosh Paria (PI)	NAIF (ICAR)	June, 2020 - June, 2023

External Funded Projects

S. No	Project Title	Personnel	Scheme	Period
1	National repository of fish cell lines in NBFGR (Phase II) and access center 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	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	December, 2017 - December, 2020

S. No	Project Title	Personnel	Scheme	Period
3	National surveillance programme for aquatic animal diseases	Joykrushna Jena (Coordinator), Kuldeep K. Lal (Co-coordinator), Neeraj Sood, Pravata Kumar Pradhan, T. Raja Swaminathan, Chandra Bhushan Kumar and Gaurav Rathore	NFDB	February, 2013 -June, 2021
	Sub project I: Nodal Centre for national surveillance programme for aquatic animal diseases	Neeraj Sood (PI), Pravata Kumar Pradhan, T. Raja Swaminathan and Gaurav Rathore		
	Sub project II: Surveillance of freshwater fish and shellfish diseases in Uttar Pradesh and Haryana	Pravata Kumar Pradhan (PI), Neeraj Sood, Chandra Bhushan Kumar and Gaurav Rathore		
	Sub project III: Surveillance of ornamental fish diseases	T. Raja Swaminathan (PI)		
4	Biocontrol of *Aeromonas hydophila* and *Flavobacterium columnare* infection in *Labeo rohita* through phage therapy and paraprobiotics	Gaurav Rathore (PI) and Anutosh Paria	DBT-Twin	May, 2018 - May, 2021
5	Support mitigation of antimicrobial resistance (AMR) risk associated with aquaculture in Asia	Gaurav Rathore (PI), Chandra Bhushan Kumar and Vikash Sahu	FAO-ICAR-TCP	October, 2020 - June, 2021
6	Development of vaccines and diagnostic kit for the management of goldfish herpesviral hematopoietic necrosis disease in India	T. Raja Swaminathan (PI & ICAR National Fellow)	ICAR Education Division	April, 2017 - April, 2022
7	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	August, 2020 - August, 2021
8	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), Lalit Kumar Tyagi and Charan Ravi	UNDP -Mangrove Cell, Maharashtra	July, 2018 - June, 2021
9	Establishing germplasm resource center for marine ornamental invertebrates: Harmonising bioversity conservation and promoting livelihood to the islanders of the Lakshadweep	Kuldeep K. Lal (Coordinator), T.T. Ajith Kumar (PI) and Charan Ravi	DBT	August, 2018 - July, 2021
10	Phylogenetic relationships of Indian species of goatfishes (Family: Mullidae) inferred from genetic and morphologic data	Jasmine Anand (PI) and T.T. Ajith Kumar	DST-SERB TARE	January, 2020 - December, 2022

S. No	Project Title	Personnel	Scheme	Period
11	Understanding genomic mechanism of thermal tolerance using golden mahsheer, *Tor putitora* as model	Vindhya Mohindra (PI) and Labrechai Mog Chowdhury	NICRA	August, 2018 - September 2021
12	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 Chowdhury	NASF	August, 2018 - March, 2021
13	Indian major carp milt cryobank for improving genetic exchange between farms and commercial level quality seed production	Kuldeep K. Lal, (Coordinator), Santosh Kumar (PI), Sullip Kumar Majhi, Aditya Kumar, Ajay Kumar Singh and Rama Shankar Sah	NFDB	November, 2018 - November, 2020
14	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
15	Population genomics and mapping signatures of natural selection in Asian seabass in India	Rajeev Kumar Singh (PI), Sangeeta Mandal, Rejani Chandran and Kantharajan G.	DBT	April, 2019 - April, 2022

PUBLICATIONS

Research Papers

International

1. Ajith Kumar, T.T., R. Charan, T. Jayakumar, L.K. Tyagi, N. Saravanane, V. Mohindra, T.J. Hisham and K.K. Lal, 2020. Framework of participatory linkage for marine ornamentals germplasm conservation to livelihood: Is community aquaculture an inclusive option? *Aquaculture Asia*, 24(4): 3-8.
2. Akash, S., P. Purushothaman, M. Madhavan, R. Charan, T.J. Hisham, M. Sudhakar, T.T. Ajith Kumar and K.K. Lal, 2020. *Urocaridella arabianensis* n. sp., a new Palaemonid shrimp (Crustacea, Decapoda, Palaemonidae) from Lakshadweep Islands, India with taxonomic comparison on the genus *Urocaridella borradaile*, 1915. *Zootaxa*, 4816(1): 49-66.
3. Alam, A., V. Gopinath, D.N. Jha, K.D. Joshi, J. Kumar, S.C. Sukla, V.R.R. Thakur, Monika Gupta and B.K. Das, 2020. Food and feeding biology of commercially important fresh water eel, *Mastacembelus armatus* (Lacepede, 1800) from the Ganga River, India. *Oceanography & Fisheries Open Access Journal*, 11(4): 5557818.
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9. Dharmaratnam, A., R. Kumar, V.S. Basheer, N. Sood, P.K. Pradhan, S. Das and T.R. Swaminathan, 2020. Establishment and characterisation of fantail goldfish fin (FtGF) cell line from goldfish, *Carassius auratus* for *in vitro* propagation of cyprinid herpes virus-2 (CyHV-2). *PeerJ*, 8: e937.
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11. Dutta, N., R.K. Singh, A. Pathak, V. Mohindra, S. Mandal, G. Kaur and K.K. Lal, 2020. Mitochondrial DNA markers reveal genetic connectivity among populations of Osteoglossiform fish *Chitala chitala*. *Molecular Biology Reports*, 47:8579–8592.
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river Ganga. *Indian Journal of Animal Sciences*, 90(1): 109-115.

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13. विश्वामित्र सिंह बैसवार, अखिलेश कुमार मिश्र, रविन्द्र कुमार एवं बासदेव कुशवाहा, 2020. मात्स्यिकी में जीनोमिक्स की उपयोगिता पर संक्षिप्त प्रकाश, In: मत्स्यलोक अंक (8), 2019–2020 रा.म.आ.स. ब्यूरो, लखनऊ. pp. 20-21.
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15. कृपाल दत्त जोशी, 2020. हिमालय क्षेत्र की ट्राउट प्रजातियाँः विभिन्न जैव वैज्ञानिक तथ्य, In: मत्स्यलोक अंक (8), 2019–2020 रा.म.आ.स. ब्यूरो, लखनऊ. pp. 24-29.
16. नेहा सिंह, बासदेव कुशवाहा, मुरली एस. कुमार, श्रेया श्रीवास्तव, पंकज सोनी, रविन्द्र कुमार एवं अखिलेश कुमार मिश्र, 2020. त्रिआयामी कोशिका संवर्धन (3–डी सेल कल्चर) : एक बहुउपयोगी तकनीक, In: मत्स्यलोक अंक (8), 2019–2020 रा.म.आ.स. ब्यूरो, लखनऊ. pp. 30-31.
17. छेदी लाल वर्मा एवं रोहित प्रताप ओझा, 2020. कम लागत वाले प्रोपेलर (नोदक) पम्प का मत्स्य पालन में प्रयोग, In: मत्स्यलोक अंक (8), 2019–2020 रा.म.आ.स. ब्यूरो, लखनऊ. pp. 32-35.
18. राहुल कुमार, रवीन्द्र एवं आकृति रस्तोगी, 2020. जलीयकृषि में बायोफ्लॉक तकनीकी की उपयोगिता, In: मत्स्यलोक अंक (8), 2019–2020 रा.म.आ.स. ब्यूरो, लखनऊ. pp. 36-38.
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20. शिवानन्द, चन्द्रभूषण कुमार, चिन्मयी मुदुली, अनुतोष पारिया, विकाश साहू, अनिल, एस.एम. श्रीवास्तव, एवं गौरव राठौर, 2020. एण्टीबायोटिक्स प्रतिरोधकता तथा उसकी आनुवंशिक क्रियाविधि, In: मत्स्यलोक अंक (8), 2019–2020 रा.म.आ.स. ब्यूरो, लखनऊ. pp. 42-45.
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22. आलोक चौरसिया, 2020. रास्पबेरी पाई का उपयोग कर जलीय जीव स्वास्थ्य निगरानी प्रणाली, In: मत्स्यलोक अंक (8), 2019–2020 रा.म.आ.स. ब्यूरो, लखनऊ. pp. 49-53.
23. रविंद्र, पूजा आर्या, राहुल कुमार, आकृति रस्तोगी एवं देव कुमार वर्मा, 2020. जलीय तंत्रो की निगरानी तथा संतुलन में मेटाजिनोमिक्स का महत्व, In: मत्स्यलोक अंक (8), 2019–2020 रा.म.आ.स. ब्यूरो, लखनऊ. pp. 54-57.
24. ललित कुमार त्यागी, अमित सिंह बिष्ट, संजय कुमार सिंह, संगीता मंडल, रजनी चन्द्रन एवं त्रिवेश सुरेश मायकर, 2020. भारत में नदियों की विविधता और उपयोगिता, In: मत्स्यलोक अंक (8), 2019–2020 रा.म. आ.स. ब्यूरो, लखनऊ. pp- 58-59.
25. आशीष कुमार मौर्या, प्रदीप कुमार मौर्या, अजय कुमार यादव एवं अरविन्द कुमार वर्मा, 2020. घर में पालें रंगीन मछलियां, In: मत्स्यलोक अंक (8), 2019–2020 रा.म. आ.स. ब्यूरो, लखनऊ. pp, 60-63.
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29. विनीता सिंह, बी.पी. शाही एवं विवेकानंद, 2020. जल संरक्षण–समग्र विकास की गंभीर आवश्यकता एवं उपाय, In: मत्स्यलोक अंक (8), 2019–2020 रा.म.आ.स. ब्यूरो, लखनऊ. pp. 74-77.

30. अचल सिंह, विन्ध्या मोहिन्द्रा, अमित सिंह बिष्ट, ममता चक्रवर्ती, रवि कुमार, एवं कुलदीप के. लाल, 2020. कृषि–शिक्षा–दिवस समारोह के प्रभाव का समय–श्रेणी द्वारा विश्लेषण, In: मत्स्यलोक अंक (8), 2019–2020 रा.म.आ.स. ब्यूरो, लखनऊ. pp. 86-89.

31. अचल सिंह एवं विन्ध्या मोहिन्द्रा, 2020. प्रोडक्टिव–वर्क–टाइम व नॉन–प्रोडक्टिव–वर्क–टाइम का सकारात्मक–इंटेलीजेंट प्रबंधन द्वारा संतुलित विकास, In: मत्स्यलोक अंक (8), 2019–2020 रा.म.आ.स. ब्यूरो, लखनऊ. pp. 90-95.

Booklets

1. Jose, S., R. Chandran, J. Hisham and T.T. Ajith Kumar, 2020. Marine biodiversity conservation at Lakshadweep (Malayalam), ICAR-NBFGR, Lucknow, 46 p.

2. Kantharajan, G., T.T. Ajith Kumar, V. Mohindra and K.K. Lal, 2020. Biodiversity of the Gulf of Mannar marine biosphere reserve and opportunities for alternate / additional livelihood measure towards conservation, ICAR-NBFGR, Lucknow, 40 p.

PARTICIPATION IN SEMINAR / SYMPOSIA / WORKSHOP / TRAINING / MEETINGS

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

- Academic Council meeting at ICAR-CIFE, Mumbai on January 4, 2020.
- Director's Conference, 2020 held at NASC Complex, New Delhi during January 21-22, 2020.
- 137th Meeting of the MPEDA held at Kochi on February 6, 2020.
- Visit to CIFNET, KUFOS, Lakshadweep Island & PMFGR Centre, ICAR-NBFGR, Kochi during February 14-15, 2020 to discuss future collaborative research programmes.
- International conference on Recent Biotechnological Innovation in Aquaculture (Live Aqua - 2020) during February 27-28, 2020 held at Bharathiar University, jointly organized by ICAR-NBFGR and Bharathiar University, Coimbatore, Tamil Nadu.
- Awareness programme on Marine Biodiversity Conservation at Agatti during March 8-9, 2020 organized by ICAR-NBFGR.
- On-field demonstration of fertility trial using cryopreserved Indian major carp milt in selected hatcheries of Haryana and Rajasthan during July 7-12, 2020.
- Demonstration of cryopreservation and seed production from cryopreserved fish milt to hatchery operators of Jaipur and Bhimpur during August 6-11, 2020.
- RAMC meeting of ZSI, at Kolkata on June 19, 2020.
- 138th Meeting of the MPEDA held at Kochi on June 29, 2020.
- ICAR Regional Committee-I meeting on June 30, 2020.
- Rapid Ruler Community Response meeting on July 3, 2020.
- Webinar on the Rapid Rural Community Response to COVID-19 on July 7, 2020.
- Vitrual Expert Committee Meeting – Agrobiodiversity on August 27, 2020
- Meeting organized by NFDB on certification, accreditation, traceability and labelling of aquaculture inputs held on August 28, 2020.
- Experts Meet on amendments in the draft Biodiversity Rules 2020 and Biodiversity Act 2002, held on September 1, 2020.
- 25th meeting of the National Committee on introduction of exotic aquatic species into Indian waters organized by the DOF, Ministry of Fisheries, Animal Husbandry and Dairying on September 3, 2020.
- Meeting for the National Consultation on broodstock, seed, feed for enhancing production and productivity in aquaculture and promotion of fisheries exports held on September 4, 2020, organized by the DOF, Ministry of Fisheries, Animal Husbandry and Dairying.
- Meeting to discuss the comprehensive strategy to ensure that the fisheries sector regains its momentum after being impacted by COVID-19 and achieves the envisaged target of doubling exports by 2024-25 held on September 7, 2020, organized by the Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying.
- Meeting of National mission on biodiversity and human well being: enhancing biodiversity held on September 14, 2020.
- Meeting for EFC presentation of ICAR-NBPGR, including CRP on Agrobiodiversity, organized by ICAR-NBPGR, New Delhi on September 16, 2020.
- 5th meeting of the Technical Expert Committee (TEC) of Aquaculture and Marine Biotechnology organized by DBT, Ministry of Science and Technology during September 23-24, 2020.
- Discussion on the prevention of Antimicrobial Resistance in the 11th meeting of the Standing Committee of the Southern Zonal Council, organized by the DOF, Ministry of Fisheries,

Animal Husbandry and Dairying on September 27, 2020.

- Stakeholder meeting for discussion with World Bank preparation mission for fisheries sector Covid-19 recovery project-new value chains & diversification (ornamental fisheries, cold water fisheries, seaweed mariculture), organized by the DOF, Ministry of Fisheries, Animal Husbandry and Dairying on October 15, 2020.
- Course Director of International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and Ex Situ Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok, Thailand, during December 7-18, 2020 held at Lucknow.
- Review meeting of CRPs, Incentivizing Research in Agriculture and NPFGGM organized by ICAR, New Delhi on December 19, 2020.

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

- 3rd International Symposium on Genomics in Aquaculture (ISGAIII-2020) organized by ICAR-CIFA during January 21-23, 2020 at Bhubaneswar in collaboration with Association of Aquaculturist and made a lead presentation on "Magur genomics: status and prospects".
- International conference on Recent Biotechnological Innovation in Aquaculture (Live Aqua-2020) at Bharathiar University, Coimbatore, Tamil Nadu, and delivered a lead lecture on "Fish Cell Line Repository" during February 27-28, 2020.
- Meeting on Interactive Dashboard on May 19, 2020 organized by Xanthus Institute.
- Meeting on Biobanking Automation on August 18, 2020.
- राजभाषा कार्यान्वयन समिति की तिमाही बैठक on September 25, 2020 organized by ICAR-IISR, Lucknow.
- हिन्दी कार्यशाला ई–फाइल on September 26, 2020.
- Webinar on Exploration, Discovery and Genetic Characterization of India's Biodiversity: Strategies for Addressing the Linnaean Shortfall in India on October 6, 2020 organized by Biodiversity Collaborators.
- Hindi workshop/ meeting on Relevance of Gandhian Ideologies in Today's Work jointly organized by ICAR-CIFE, Mumbai and ICAR-NBFGR, Lucknow on October 2, 2020.
- Delivered expert talk on "Repository of fish cell lines and FisOmics portal" in International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and *Ex Situ* Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok, Thailand, during December 7-18, 2020 held at Lucknow.

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

- Online MDP on Intellectual Property Valuation and Technology Management organized by ICAR-NAARM, Hyderabad during September 1-5, 2020.
- Webinar on Integrating Energy, Climate Change and Development organised by Mizoram University on September 8, 2020.
- Webinar on Biodiversity based Livelihood Programmes: Promises and Prospects in India organised by ATREE; Biodiversity Collaborative on September 18, 2020.
- Webinar on Relevance of Gandhian Ideologies in Today's World, organized by ICAR-CIFE, Mumbai in collaboration with ICAR-NBFGR, Lucknow to commemorate the 151th Birth Anniversary of Mahatma Gandhi on October 2, 2020.
- Course Coordinator of International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and *Ex Situ* Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok, Thailand, during December 7-18, 2020 held at Lucknow.
- Attended Quinquennial Review Team meeting of ICAR-CIBA, Chennai as member on December 17, 2020.

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

- Meeting convened by Dr. J.K. Jena, DDG (Fy. Sc), ICAR on April 27, 2020 to discuss on the modalities for inclusion of ongoing programme of INFAAR in the SFC for the 13th plan period (2020-21 to 2024-25).

- 2nd consultation meeting on Regional AMR Monitoring and Surveillance Guidelines Volume 3: Monitoring and Surveillance of AMR in Aquaculture from June 22-25, 2020.
- Meeting convened by Dr J.K. Jena, DDG (Fy.Sc.), ICAR through video conferencing to discuss on the modalities for timely implementation of the forthcoming FAO-TCP titled Support Mitigation of Antimicrobial Resistance (AMR) Risk Associated with Aquaculture in Asia by ICAR-NBFGR and ICAR-CIFT on September 8, 2020.
- Training on Quality Management System in AMR Laboratories for INFAAR on September 14, 2020 organised by FAO India.
- 5th Advisory Board meeting of INFAAR held on September 14, 2020 to review the operations of INFAAR and finalization of plans for 2020-2021.
- 3rd annual review meeting of INFAAR convened by FAO-ICAR on September 15, 2020.
- Webinar organised by ICAR-CIFE on Aquatic Animal Health on November 24, 2020, as panelist.
- Workshop on Implementation of ICAR-FAO-TCP Programme in India on Support Mitigation of Antimicrobial Resistance (AMR) Risk Associated with Aquaculture in Asia organized through virtual mode by ICAR-NBFGR on December 10, 2020.
- FAO meeting on AMU Farm Level Monitoring Guidelines held on December 16, 2020.

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

- 107th Indian Science Congress held at UAS, GKVK Campus, Bangalore from January 3-7, 2020 and delivered an invited lecture on "Time scale changes in fish assemblages, fishery and habitat parameters of Ganga River system" on January 6, 2020 in Animal Sciences, Veterinary and Fisheries Science Section. Also Co-chaired a session under main program area of Animal Sciences, Veterinary and Fisheries Science Section on January 5, 2020.
- Delivered a talk on "Role of exotics in Re-circulatory Aquaculture System" in 5-day National Training Programme funded by National Fisheries Development Board for Trainers at ICAR-NBFGR, Chinhat Centre on January 30, 2020.
- Meeting of the Expert Committee of NASI, Prayagraj for S&T intervention in various activities for the welfare of scheduled tribes under NASI-ST Plan on January 31, 2020 at Prayagraj.
- Exhibition held at Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand on the occasion of International Conference on Ecosystem Health and Fisheries of Indian Inland Waters: Multiple Stressors, Management and Conservation organized by the ICAR-CIFRI, Barrackpore, Kolkata during February 17-19, 2020.
- Mega event of National Academy of Sciences (NASI), Prayagraj on S&T Interventions for the Welfare of Tribal Population at Institute of Life Sciences, Bhubaneswar, organized by NASI, Prayagraj during February 24-25, 2020.
- Workshop on Promoting and Recognizing Agri-Innovation in Uttar Pradesh organised by Agri-Innovation Foundation, Lucknow and ICAR-IISR at ICAR-IISR, Lucknow on February 27, 2020.
- Meeting on Interactive Dashboard on May 19, 2020 organized by Xanthus Institute.
- Regional Committee Meeting No. I conducted by ICAR-CPRI, Shimla on June 30, 2020.
- Delivered invited lecture on "Himalayan fisheries and aquaculture; challenges and opportunities" on August 5, 2020 at CAS in Marine Biology, Faculty of Marine Sciences, Annamalai University, Parangipettai, Tamil Nadu.
- E-flow assessment meeting for Uttar Pradesh rivers organized by WWF-India from August 5-6, 2020.
- 25th Meeting of the National Committee on Introduction of Exotic Aquatic Species into India conducted by Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, New Delhi on September 3, 2020.
- Webinar on Healthy Wetlands-Resilient Cities organized by WWF-India on September 4, 2020.
- Interview with Third Party Review Team of ICAR, New Delhi on November 25, 2020.
- Meeting on proposed project Developing the guidelines for control blasting to safeguard fishes, cows, and poultry from blasting induced ground vibrations and noise in Indian Himalayan Region (IHR) and Mining areas with Dr. C. Swamliana, Head, CSIR-CIMFR, Dhanbad alongwith other project team members on December 3, 2020.

- 21st Institute Management Committee meeting of ICAR-DCFR, Bhimtal on December 23, 2020 as Member.

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

- 3rd International Symposium on Genomics in Aquaculture (ISGAIII-2020) organized by ICAR-CIFA during January 21-23, 2020 at Bhubaneswar in collaboration with Association of Aquaculturist and presentated a paper.
- Hindi workshop/ meeting on Relevance of Gandhian Ideologies in Today's Work jointly organized by ICAR-CIFE, Mumbai and ICAR-NBFGR, Lucknow on October 2, 2020.
- AFS talk 11 (online) entitled "How can museum science and collections benefit fisheries research partners" delivered by Michel Hammer on December 6, 2020.
- Delivered expert talk and practical demonstration in the International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and *Ex Situ* Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok, Thailand at ICAR-NBFGR, Lucknow during December 7-18, 2020.

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

- Made presentation on "Update on infection with Decapod Iridescent Virus-1" during Expert Consultation on Status and Preparedness on Decapod Iridescent Virus-1 on April 17, 2020.
- Webinar on Trade Barriers due to Presence of OIE-listed Pathogens conducted by MPEDA on July 21, 2020
- OIE/NACA regional virtual meeting on Infection with Decapod Iridescent Virus-1 (DIV-1) organised by OIE Regional Representation for Asia-Pacific, Tokyo on August 20, 2020.
- Regional webinar on Infection with Decapod Iridescent Virus-1 (DIV1) and Preparedness for Emerging Shrimp Diseases organised by NACA, Bangkok during September 10-11, 2020.
- Delivered an invited talk on "Aquatic animal disease surveillance in India" during the online national workshop on Fish Health and Disease Management in Tropics organized by College of Fishery Science, NDVSU, Jabalpur, Madhya Pradesh on September 14, 2020.
- 19th Meeting (online) of the Asia Regional Advisory Group on Aquatic Animal Health (AGM-19) organized by NACA, Bangkok during November 26-27, 2020.
- Technical Committee meetings to study the situation of occurrence of white spot syndrome virus (WSSV) and infectious hypodermal and hematopoietic necrosis virus (IHHNV) in shrimp in India on November 18 and 23, 2020.
- Webinar on Mysterious Diseases: The Failure of Disease Surveillance in India organized by Centre for Science and Environment (CSE), New Delhi on July 27, 2020.
- Made a presentation before NSPAAD Review Committee, constituted by Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India to address the queries regarding NSPAAD on August 5, 2020.
- Meeting to discuss the comprehensive strategy to ensure that the fisheries sector regains its momentum after being impacted by COVID-19 and achieves the envisaged targets of doubling exports by 2024-25 organised by Department of Fisheries on September 7, 2020.
- Interview with Third Party Review Team of ICAR, New Delhi on November 25, 2020.
- Course Coordinator and delivered expert talk on "Surveillance, disease diagnosis and cell culture" in International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and *Ex Situ* Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok, Thailand, during December 7-18, 2020 held at Lucknow.
- Project Advisory Committee meeting of NASF funded project Understanding molecular basis of host-pathogen-environment interaction of Tilapia Lake Virus Disease on December 22, 2020.

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

- International conference on Recent Biotechnological Innovation in Aquaculture (RBIA) and delivered an invited lecture on "Exotic fishes in India: An insight and preparedness for

mitigation" at Bharathiar University, Coimbatore, Tamil Nadu during February 27-28, 2020.

- National Seminar on Science and Technology: Rural Development, conducted by Kerala Science Congress during March 19-20, 2020.
- Delivered a special lecture on "Biodiversity conservation with special reference to fishes" on October 13, 2020, in a webinar, conducted by Forest Department, Kerala.
- Delivered a special lecture on "Fish genetic resources of India: Conservation and challenges" on August 8, 2020, in an International webinar conducted by Annamalai University.
- World Fisheries Day 2020 conducted by CIFA, Bhubaneswar on November 21, 2020.
- Webinar on the Scenario of Freshwater Aquaculture in India during COVID-19 Pandemic, conducted by CIFA, Bhubaneswar on December 15, 2020.
- Delivered a special lecture on "Exotic fishes in aquaculture", for the trainees sponsored by African Asian Rural Development Organisation (AARDO), Government of India, and conducted by CMFRI, Kochi on October 20, 2020.

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

- OIE/NACA regional virtual meeting on Infection with Decapod Iridescent Virus-1 (DIV-1) organised by OIE Regional Representation for Asia-Pacific, Tokyo on August 20, 2020.
- Regional webinar on Infection with Decapod Iridescent Virus 1 (DIV1) and Preparedness for Emerging Shrimp Diseases organised by NACA, Bangkok during September 10-11, 2020.
- Delivered an invited talk on "New insight into fish pathogenic oomycete *Aphanomyces invadans*" during the online national workshop on Fish Health and Disease Management in Tropics organized by College of Fishery Science, NDVSU, Jabalpur, Madhya Pradesh on September 10, 2020.
- Delivered an invited talk on "Role of surveillance programme in disease control in aquatic animals" during National Webinar on Aquatic Animal Health Management for Sustainability of Aquaculture Production organised by Kerala University of Fisheries & Ocean Studies on August 25, 2020.
- 19th Meeting (online) of the Asia Regional Advisory Group on Aquatic Animal Health (AGM-19) organized by NACA, Bangkok on November 26-27, 2020.
- Technical Committee meetings to study the situation of occurrence of white spot syndrome virus (WSSV) and infectious hypodermal and hematopoietic necrosis virus (IHHNV) in shrimp in India on November 18 and 23, 2020.
- Webinar on Mysterious Diseases: The Failure of Disease Surveillance in India organized by Centre for Science and Environment (CSE), New Delhi on July 27, 2020.
- Meeting to discuss the comprehensive strategy to ensure that the fisheries sector regains its momentum after being impacted by COVID-19 and achieves the envisaged targets of doubling exports by 2024-25 organised by Department of Fisheries on September 7, 2020.
- Made presentation regarding progress of the research work carried out under the project Understanding molecular basis of host-pathogen-environment interaction of Tilapia Lake Virus Disease before NASF Project Advisory Committee meeting on December 22, 2020.

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

- Recognized as third party assessor for Training of Trainers (ToT) in different aspects of aquaculture for ASCI agency at ATARI, Kanpur on February 15, 2020.
- Delivered lecture on "Fish feed and importance of supplementary feed for enhancement of fish productivity" on Februaury 24, 2020 at Eklavya Training Center, Department of Fisheries, Lucknow.
- Workshop for vigilance officers of ICAR institutes organized by ICAR-NAARM, Hyderabad during August 5-7, 2020.
- Pradhan Mantri Matsya Sampada Yojana (PMMSY) district level meeting at Vikas Bhawan, Lucknow on September 21, 2020.
- Scientific Advisory meeting of KVK, Lucknow at ICAR-IISR, Lucknow on December 17, 2020.
- Meeting on Interactive Dashboard on May 19, 2020 organized by Xanthus Institute.

- Technical Webinar on Aquaculture and Value Chains organized by Network for Development of Agricultural Cooperatives in Asia and the Pacific (NEDAC) Training Centre Bangkok on July 17, 2020.

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

- A virtual master class on Development Communication Design for Social Impact and CSR Partnerships organised by the Centre for Development Management and Communication (CDMC), MICA, Ahmedabad and the Impact Academy (by CSRBOX) during July 6, 8 & 10, 2020.
- Virtual Dialogue on the Impacts of COVID-19 on Fisheries and Aquaculture: Effects, Good Practices and Recommendations organised by the Fisheries and Aquaculture Department COVID-19 Task Force, FAO on July 17, 2020.
- 7th Massive Open Online Course (MOOC) on Designing E-Learning Content conducted by ICAR-NAARM, Hyderabad during July 1-31, 2020
- Orientation Webinar on Innovation Excellence Indicators Framework organised by the CII on behalf of the Office of the Principal Scientific Advisor (PSA) to the Government of India on September 17, 2020.
- Webinar on Engaging Business at a Landscape Level – Lessons from the Shared Resources, Joint Solutions (SRJS) Programme organised by the IUCN Business & Biodiversity Programme on September 24, 2020.
- Webinar on Carbon Revenues from Climate Impacts Mitigation in Agriculture and Agribusiness on October 14, 2020.
- CII Agro & Food Tech 2020 organised on virtual platform by the Confederation of India Industry, Northern region, Chandigarh during October 16-22, 2020.
- Virtual conference on Sustainable, Technology led and Responsible Development of Fisheries Sector - The Next Level of Growth organised by the Confederation of India Industry, Northern region, Chandigarh on October 19, 2020.
- Webinar series consisting of seven webinars on various themes under the Biodiversity Conversations: India's Opportunities and Challenges, jointly organised by the Office of the Principal Scientific Advisor to the Government of India, the National Biodiversity Authority, and the Biodiversity Collaborative on September 18, 21, 25 and October 3, 6, 9 & 12, 2020.
- FAO Webinar: Asia Pacific Aquaculture Review on October 26, 2020.
- 3rd Steering Committee meeting of the Department of Biotechnology, Government of India for the biotechnology-based programs for societal development during November 9-10, 2020 as Committee Member.

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

- Management Development Program (MDP) on Orientation-cum-Awareness and Implementation of ABS Guidelines, conducted by ICAR-NAARM, Hyderabad during July 7-10, 2020.
- Course Coordinator of International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and *Ex Situ* Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok, Thailand, during December 7-18, 2020 held at Lucknow.
- Delivered a lecture on "Genomic approaches for conservation of fish genetic resources: A perspective for India" in webinar organized by Jhunjhunwala P.G. College, Dr. R.M.L. Avadh University, Ayodhya on May 26, 2020.

Dr. Mahender Singh, Principal Scientist delivered expert lecture on "DNA sequencing" and practical demonstration on "Analysis of genetic diversity for species delineation", "Automated genotyping" and "DNA sequencing procedures, sequence quality check and processing for application" in the International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and *Ex Situ* Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok, Thailand at ICAR-NBFGR, Lucknow during December 7-18, 2020.

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

- Committee meeting on export rejection from China due to the detection of White Spot Syndrome Virus and IHHNV organized by MPEDA, Kochi on January 6, 2020.

- International conference on Recent Biotechnological Innovation in Aquaculture (RBIA) at Bharathiar University, Coimbatore, Tamil Nadu during February 27- 28, 2020.
- Expert Consultation on Status and Preparedness on Decapod Iridescent Virus-1 conducted by DDG (Fy. Sc.), ICAR, New Delhi, during April 17, 2020.
- Delivered a lecture on "Development and characterization of animal cell line" in the online faculty development program entitled Recent Trends in Molecular Biotechnology organized by Department of Biochemistry, Ethiraj College for Women, Chennai on June 3, 2020.
- Delivered a lecture on "Ornamental fish diseases and remedies" in the national webinar on Marine Ornamental Aquaculture: Opportunities and Challenges in India organized by Sathyabama Institute of Science and Technology, Chennai and Cochin University of Science and Technology, Kochi on July 12, 2020.
- OIE Regional Virtual Meeting on Decapod Iridescent Virus 1(DIV1), conducted by Department of Fisheries, Ministry of Fisheries Animal Husbandry and Dairying, Government of India, on August 20, 2020.
- Delivered a lecture on "Fish health" in the experimental learning programme on different aspects of fisheries sciences to the 4th year B.F.Sc students of CAS in Marine Biology, Faculty of Marine Sciences, Annamalai University on August 21, 2020.
- Technical Committee meeting to study the situation of occurrence of White Spot Syndrome Virus (WSSV) and Infectious Hematopetic Necrosis Virus (IHHNV) in shrimp in India in response to China's query on WSSV and IHHNV status in India on November 16, 2020.
- Video conference on inclusion of Aquatic Animal Health and Disease Management related subject in UG and PG held under chairmanship of Joint Secretary (Inland Fisheries), Department of Fisheries, Ministry of Fisheries, Animal Husbandry and dairying, Government of India on December 04, 2020.
- Delivered lectures on "Fish cell line research in India" and "Ornamental fish viral disease and their management" in the UGC-sponsored Refresher Course in Bio-Science to the faculty members, organized by Bharathidasan University, Tiruchirappalli on December 17, 2020.

Dr. T.T. Ajith Kumar, Principal Scientist & SIC (PMFGR) participated in the following activities:

- International conference on Marine Ecosystems: Opportunities and Challenges and presented a paper on "Captive breeding of ornamental shrimps, *Ancylocaris brevicarpalis* and *Thor hainanensis* at Lakshadweep: An addition to marine ornamental aquaculture" organised by the Marine Biological Association of India held at ICAR-CMFRI during January 7-10, 2020.
- Organizing Secretary of International conference on Recent Biotechnological Innovation in Aquaculture (Live Aqua-2020) at Bharathiar University, Coimbatore, Tamil Nadu during February 27-28, 2020.
- Methodology development workshop on Biodiversity and Agriculture, Nutritional Security and Livelihoods, organized by Ashoka Trust for Research in Ecology & Environment (ATREE) held at Bangalore during March 12-13, 2020.
- Delivered a lecture on "Opportunities and challenges in ornamental aquaculture" in the national webinar on Marine Ornamental Aquaculture: Opportunities and Challenges in India organized by Sathyabama Institute of Science and Technology, Chennai and Cochin University of Science and Technology (CUSAT), Kochi on July 10, 2020.
- International faculty development programme (online) on Research Breakthroughs and Technological Developments in Life Sciences organized by ICAR-CIFA, Ayyappa College, Nagercoil, Tamil Nadu and Maharshi Dayanand University, Haryana and delivered a talk on "Marine ornamental aquaculture: Measure towards biodiversity conservation & livelihood promotion" on August 14, 2020.
- Delivered a talk on "Ornamental aquaculture: Way forward to biodiversity conservation & livelihood promotion" in the webinar organized by Zoological Survey of India Regional Centre, Digha, West Bengal on August 24, 2020.
- 5th meeting of the Technical Expert Committee on Aquaculture and Marine Biotechnology conducted by DBT during

September 23-24, 2020 and presented the second-year progress of the ongoing project.

- International Ornamental Fish Webinar (SOFI 2000) organized by Cochin University of Ocean Science & Technology, Kochi during October 15-17, 2020.
- Delivered a talk on "Conservation strategies for marine ornamental germplasm" to the P.G. students, Dept. of Applied Zoology, Mangalore University on October 23, 2020.
- Meeting on sharing of data set by the ICAR bureaux to the alliance of biodiversity international and CIAT for fine tuning the agrobiodiversity index, convened by the DDG (Crop Science), ICAR on November 11, 2020.
- Board of Studies meeting for M.Sc. Interdisciplinary Programs in Allied Health Sciences conducted by the Chettinad University, Chennai on November 18, 2020.
- Delivered a talk on "Marine ornamental germplasm conservation for future perspective" in the national webinar on Next Generation Technology for Sustainable Fisheries organized by the Alagappa University, Tamil Nadu on November 21, 2020.
- Delivered a talk on "Marine ornamental fish breeding and culture" in the national webinar on Ornamental Fishes of India: Diversity and Prospects organized by the Zoological Survey of India on December 1, 2020.
- Delivered a lecture on "Ornamental marine genetic resources: Conservation & livelihood promotion" in the International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and Ex Situ Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok, Thailand, during December 7-18, 2020, held at Lucknow.

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

- Delivered lecture on "Benefit-cost ratio analysis for aquaculture in changing scenario" in ToT on RAS at ARTU Chinhat, Lucknow, during January 27-31, 2020.
- Delivered lecture on "Management of work & time for healthy-life" in the HRD training program on Awareness for Utilisation of Natural Resources under Constitutional Frame for all the ICAR-NBFGR staff and a few scientists from ICAR-CISH, and ICAR-IISR, organised at ICAR-NBFGR, Lucknow from January 30 to February 1, 2020.
- Workshop on Promoting and Recognising Agri-Innovation in Uttar Pradesh organised by Agri-Innovation Foundation, Lucknow and ICAR-IISR at ICAR-IISR, Lucknow on February 27, 2020.
- Workshop on Training Management Information System (TMIS) for HRD Nodal officers of ICAR organised by HRM ICAR, New Delhi on May 8, 2020.
- Meeting on Artificial Neural Network organized by STATCRAFT, Bangalore on May 18, 2020.
- Meeting on Interactive Dashboard organized by Xanthus, Goa on May 19, 2020.
- Meeting on Decision Trees organized by STATCRAFT, Bangalore on May 25, 2020.
- Meeting on Logistic Regression organized by STATCRAFT, Bangalore on June 1, 2020.
- Meeting on Hierarchical Cluster Analysis organized by STATCRAFT, Bangalore on June 08, 2020.
- Meeting on Factor Analysis organized by STATCRAFT, Bangalore on June 15, 2020.
- Training program on Demystifying Interactive Dashboards, conducted by Xanthus Institute, Goa during June 22-23, 2020.
- Meeting on Linear Discriminant Analysis organized by STATCRAFT, Bangalore on June 29, 2020.
- Management Development Program (MDP) on Orientation-cum-Awareness and Implementation of ABS Guidelines organised by ICAR-NAARM during July 7-10, 2020.
- National webinar on Mathematical Modelling and Determination of Sample size in Research on the occasion of "World Population Day" organized jointly by Department of Mathematics, Institute of Science and Directorate of Research & Consultancy, GITAM (Deemed to be University), Visakhapatnam, Andhra Pradesh, India on July 11, 2020.
- Survival Analysis organized by STATCRAFT, Bangalore on July 13, 2020.

- Online EDP for Master Trainers on Access and Benefit Sharing (ABS) Regulations in India and Nagoya Protocol organised as part of the UNDP-GEF Global ABS Project by ICAR-NAARM, Hyderabad during July, 15-17, 2020.
- Webinar on Towards Inclusive Innovations and Network-based Entrepreneurship organised by Department of Management, Mizoram University, Mizoram on August 10, 2020.
- Training program on IP Valuation and Technology Management organized by ICAR-NAARM, Hyderabad during September 1-5, 2020.
- Webinar on Integrating Energy, Climate Change and Development organised by Mizoram University on September 8, 2020.
- Workshop-cum-training on Intellectual Property Rights in Agricultural Research & Education in India organised by ICAR, New Delhi during September 12-28, 2020.
- Webinar on National Mission on Biodiversity and Human Well-Being: Enhancing Biodiversity, Augmenting Human Well-being organised by National Biodiversity Authority, ATREE and Biodiversity Collaborative on September 14, 2020.
- Delivered guest lecture on "Relevance of Gandhian ideologies in today's world" in webinar on Celebration of Commemoration of 151th Birth Anniversary of Father of Nation, Mahatma Gandhi jointly organised by ICAR-NBFGR, Lucknow and ICAR-CIFE, Mumbai on October 2, 2020.
- Delivered lecture on "Fish Morphometrics Analysis" in International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and *Ex Situ* conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok, Thailand during December 7-18, 2020, held at Lucknow.
- Five-day International training program on 3D Geometric Morphometrics on virtual mode by Transmitting Science, Spain during December 14-18, 2020.

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

- Two-day International e-Conference on Understanding and Managing Small Scale Fisheries organised by ICAR-CIFRI, Barrackpore during September 9-10, 2020.
- Delivered talk on "Role and application of disruptive technologies in the aquaculture" in international e-Conference on Technological Support to Fight Against COVID-19 jointly organised by University of Rewa, Madhya Pradesh during June 21-22, 2020.
- Webinar on Showcasing Demonstrated Waste-To-Value Technologies organised by Department of Biotechnology, New Delhi on October 2, 2020.
- Webinar on j-Gate@CeRA online Northern Regional Ambassador and User Orientation hosted by Informatics Publishing Limited on October 28, 2020.
- Virtual Conference on Skilling in Healthcare Beyond Covid organised by Confederation of Indian Industry on October 27, 2020.

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

- International conference - CLIMFISHCON 2020 on Impacts of Climate Change on Hydrological Cycle, Ecosystem, Fisheries and Food Security, jointly organized by CUSAT, School of Industrial Fisheries, Kochi and Department of Fisheries, Kerala at Kochi during February 12-14, 2020.
- Delivered a lecture on "Recent trends in molecular biotechnology" in Online Faculty Development Program organized by Department of Biochemistry, Ethiraj College for Women, Chennai during June 3-4, 2020.
- Delivered lectures on "Research breakthroughs and technological developments in life sciences" and "Marine ornamental aquaculture: Measure towards biodiversity conservation & livelihood promotion" in the International faculty development programme (online) on Research Breakthroughs and Technological Developments in Life Sciences organized by ICAR-CIFA, Ayyappa college, Nagercoil, Tamil Nadu and Maharshi Dayanand University, Haryana during August 10-16, 2020.

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

- Invited lecture on "Women and biodiversity" in breakthroughs and technological webinar on Women in Biodiversity: To Get Solutions from Nature organised by Telangana State Biodiversity Board on May 12, 2020.

- Invited online lecture on "Patent informatics for technological advancement in academia for boosting innovation and entrepreneurship: The race for genome editing technology; the CRISPR CAS case study" for Faculty Development Programme on Innovation Entrepreneurship and Patents in Academia organised by Amity Institute of Biotechnology, Lucknow Campus on June 27, 2020.
- Invited lecture on "IPR in biotechnology" during online short-term course on Intellectual Property Rights held at Dr. B.R. Ambedkar National Institute of Technology, Jalandhar, Punjab during August 18-22, 2020.
- Invited talk on "IPR in the field of science" during webinar on IPR for Entrepreneurial Growth organised by Consortium of Women Entrepreneurs of India (CWEI) on August 17, 2020.
- Invited lecture on "LC-MS based proteomics: Understanding basics" at Amity Institute of Biotechnology, Noida Campus on October 28, 2020.
- Presented online paper on "Systemic design thinking for creating sustainable products through women Self Help Groups: An experimental case study from the outskirts of Lucknow" in 9th Symposium of RSD9 on Relating Systems Thinking and Design, organised by The Oslo School of Architecture and Design, Ontario College of Art & Design, Design and Architecture, in collaboration with National Institute of Design during October 9-17, 2020.

Dr. Sangeeta Mandal, Scientist participated in the following activities:

- Training on Geospatial Analysis using QGIS & R at ICAR-NAARM, Hyderabad during February 27 - March 3, 2020.
- Online training programme on Advanced Bioinformatics Tools and its Applications in Agriculture organised by ICAR-NAARM, Hyderabad during September 14-19, 2020.
- Delivered lectures on "Taxonomy: Why and How?" and "Mitochondrial DNA and Polymerase Chain Reaction (PCR)" in International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and *Ex Situ* Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok, Thailand during December 7-18, 2020, held at Lucknow.

Dr. Rejani Chandran, Scientist participated in the following activities:

- Training on Geospatial Analysis using QGIS & R at ICAR-NAARM, Hyderabad during February 27 to March 3, 2020.
- Attended and delivered a talk on "Biodiversity of Lakshadweep and livelihood" at the awareness programme on Marine Biodiversity Conservation at Lakshadweep conducted by ICAR-NBFGR at Agatti Island, Lakshadweep on March 8-9, 2020.
- Delivered an online lecture on "Ecological diversity tools and application in fish genetic resource management" to B.F.Sc. and M.F.Sc. students of College of Fisheries, (CAU, Imphal), Tripura on May 12, 2020.
- Training program on Demystifying Interactive Dashboards, conducted by Xanthus Institute, Goa during June 22-23, 2020.
- Online course on Remote Sensing & GIS Technology and Applications for University Teachers & Government Officials conducted by ISRO-Indian Institute of Remote Sensing (IIRS), Dehradun during June 13 to July 1, 2020.
- Workshop on Scientific Writing and Research Ethics organized by DBT/Wellcome Trust India Alliance on August 14, 2020.
- Delivered an online lecture on "Tools in taxonomy" to B.F.Sc. students of Centre of Advanced Study in Marine Biology, Annamalai University on August 17, 2020.
- National webinar on Abiotic Stress in Agriculture: Geospatial Characterization and Management Options organized by ICAR-NIASM, Baramati on August 27, 2020.
- Webinar on National Mission on Biodiversity and Human Well-Being: Enhancing Biodiversity, Augmenting Human Well-being on September 15, 2020.
- Webinar on Biodiversity and Ecosystem Services: Understanding, Restoring and Conserving Biodiversity to Ensure our Future Confirmation by Bioversity Collaborative on September 25, 2020.

- Webinar on Women Empowerment: An Overview in the Light of Gandhian Philosophy organized by ICAR-CIFRI, Barrackpore, West Bengal, India on October 1, 2020.
- Webinar on Awareness Raising and Networking Event Horizon 2020 - European Green Deal Call co-funded by the Department of Biotechnology (DBT), Government of India on November 5, 2020.
- World Fisheries Day 2020 organized by ICAR-CIFA on November 21, 2020.
- Delivered a lecture and practical demonstration on "Biological traits and intraspecific variation" in International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and *Ex Situ* Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok, Thailand during December 7-18, 2020, held at Lucknow.
- Five-day International training program on 3D Geometric Morphometrics on virtual mode by Transmitting Science, Spain during December 14-18, 2020.

Dr. Santosh Kumar, Scientist participated in following activities

- International conference on Recent Biotechnological Innovation in Aquaculture (Live Aqua-2020) during February 27-28, 2020 at Bharathiar University, Coimbatore, Tamil Nadu.
- Webinar on Hierarchical Cluster Analysis using Statcraft organized by Veer Narmad South Gujarat University, Surat on June 8, 2020.
- Training program on Demystifying Interactive Dashboard organized by Xanthus Institute, Goa during June 22-23, 2020.
- Delivered a lecture on "Fish milt cryopreservation techniques for quality seed production: A methodological approach" in MARC Forum at Annamalai University, Chidambaram on October 1, 2020.
- International workshop-cum-training on Designing and Implementing Genomic Selection in Aquaculture organized by ICAR-CIFE, Mumbai during October 12-16, 2020.
- Practical demonstration on "Fish milt cryopreservation" in International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and *Ex Situ* Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok, Thailand during December 7-18, 2020, held at Lucknow.

Dr. Aditya Kumar, Scientist participated in the following activities:

- Invited lecture on "Entrepreneur opportunity through aquaculture technologies" in Fisheries Entrepreneurship Seminar and Expo-2020 held at ICAR-IISR, Lucknow organised by Centre for Agriculture and Rural Development on January 30, 2020.
- International conference on Recent Biotechnological Innovation in Aquaculture organised by Bharathiar University, Coimbatore, Tamil Nadu in collaboration with ICAR-NBFGR, Lucknow at Bharathiar University, Coimbatore during February 27-28, 2020.
- National webinar on Challenges, Opportunities and the Future of Indian Fisheries post COVID-19 Era, organized by College of Fisheries Science, JAU, Veraval during May 28-30, 2020.
- International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and *Ex Situ* Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok, Thailand during December 7-18, 2020, held at Lucknow.

Dr. Charan Ravi, Scientist participated in the following activities:

- Hands-on Training on Fish Milt Cryopreservation for Genetic Improvement of Broodstock organized by ICAR-NBFGR, Lucknow during February 4-7, 2020.
- Training program on Demystifying Interactive Dashboard organized by Xanthus Institute, Goa during June 22-23, 2020.

Dr. Labrechai Mog Chowdhury, Scientist :

Delivered lecture and practical demonstration on "DNA isolation and RNA isolation" in International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and *Ex Situ* Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok, Thailand during December 7-18, 2020, held at Lucknow.

Dr. Murali S., Scientist participated in the following meetings/programs:

- International conference on Recent Biotechnological Innovation in Aquaculture (Live Aqua-2020) at Bharathiar University, Coimbatore, Tamil Nadu, and delivered a talk on "FisOmics: A web portal for fish genomic research" during February 27-28, 2020.
- Training program on Demystifying Interactive Dashboard organized by Xanthus Institute, Goa during June 22-23, 2020.
- MDP on Implementation of ABS: Awareness and Sensitization workshop organised by ICAR-NAARM, Hyderabad during July 7-10, 2020.
- Online EDP for Master Trainers on ABS: Regulations in India and Nagoya Protocol organised by ICAR-NAARM, Hyderabad during July 15-17, 2020.
- CABin Scheme Progress Meeting organised by ICAR-IASRI, New Delhi on July 22, 2020.
- Workshop on Scientific Writing and Research Ethics organised by DBT/Wellcome Trust India Alliance on August 14, 2020.
- National Mission on Biodiversity and Human Well-Being: Enhancing Biodiversity, Augmenting Human Well-being organised by Biodiversity Collaborative on September 14, 2020.
- Webinar on Women Empowerment: An Overview in the Light of Gandhian Philosophy organized by ICAR- CIFRI, Barrackpore, West Bengal, India on October 1, 2020.
- Online course on Analysis of Breeding Experiments using ASReml-R by ICAR-CIFE, Mumbai during October 12-15, 2020.
- World Fisheries Day Lecture 2020 organised by ICAR-CIFA on November 21, 2020.
- Delivered a lecture on "Basic molecular biology" in International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and *Ex Situ* Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok during December 7-18, 2020.

Dr. Anutosh Paria, Scientist participated in the following activities:

- Delivered a lecture on "Entrepreneurship opportunities in Indian fisheries sector to mitigate COVID-19 impact: ICAR-NBFGR perspective" in webinar on Entrepreneurship Opportunities in Indian Fisheries Sector organized by ZTMC, Fisheries, ICAR-CIFT on June 12, 2020.
- Delivered an invited talk on "Role of pattern recognition receptors (PRRs) and interferons in fish vaccination" in National webinar on Advances in Aquatic Animal Health Management organized by College of Fisheries, CAU (lmphal), Lembucherra, Tripura during June 23-25, 2020.
- Training programme on Demystifying Interactive Dashboards organized by Xanthus Institute, Goa during June 22-23, 2020.
- MDP on Implementation of Access and Benefit Sharing Regulations in Agriculture Research organized by ICAR-NAARM, Hyderabad during July 7-10, 2020.
- Online EDP for Master Trainers on Access and Benefit Sharing (ABS) Regulations in India and Nagoya Protocol organized by ICAR-NAARM, Hyderabad during July 15-17, 2020.
- Annual Review Meeting of All India Network Project on Fish Health on September 11, 2020.
- Webinar on National Mission on Biodiversity and Human Well-Being: Enhancing Biodiversity, Augmenting Human Well-being organized by Biodiversity Collaborative on September 14, 2020.
- Webinar on Biodiversity and Health: One Health and Zoonoses in Vulnerable Communities in India organized by Biodiversity Collaborative on September 21, 2020.
- International webinar on Beauty and the Beast: Important Parasites of Fish organized by Fish Health Section of Asian Fisheries Society on December 9, 2020.
- Delivered a lecture on "Quantitative PCR for disease diagnosis with emphasis on fish viruses" in International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and *Ex Situ* Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok during December 7-18, 2020.

Shri Chandra Bhushan Kumar, Scientist participated in the following activities:

- Delivered an invited lecture on "Fish health management and entrepreneurship development"

in Fisheries Entrepreneurship Seminar organized by Centre for Agriculture and Rural Development (CARD) at ICAR-IISR, Lucknow on January 30, 2020.

- 13th meeting of Steering Committee at National Level to oversee and monitor the tilapia seed and grow-out production in India by Department of Fisheries, Ministry of Fisheries Animal Husbandry and Dairying at Krishi Bhawan, New Delhi on February 6, 2020.
- Training on Geospatial Analysis using QGIS & R, organized by ICAR-NAARM, Hyderabad during February 27 - March 3, 2020.
- Webinar on Updated BLAST rRNA Database: RefSeq Ribosomal RNA Sequences for Identification of Fungi, Bacteria and Archaea organized by NCBI Staff, National Library of Medicine on June 17, 2020.
- Training on Understanding Basics of Antibiotics in Context of Antimicrobial Resistance for INFAAR Members organized through virtual mode by FAO India during June 22-23, 2020.
- Workshop on Scientific Writing and Research Ethics organized by DBT/Wellcome Trust India Alliance on August 14, 2020.
- Meetings of the ICAR Partners of FAO-TCP titled Support Mitigation of Antimicrobial Resistance (AMR) Risk Associated with Aquaculture in Asia organized by ICAR-NBFGR on September 8 & December 3, 2020.
- Webinar on Aquatic Animal Health organized through virtual mode by ICAR-CIFE, Mumbai on November 24, 2020.
- Training on Aquatic Epidemiology Concepts Introduction Course organized through virtual mode by World Fish in collaboration with Norwegian Veterinary Institute during December 09-10, 2020.
- Workshop on Implementation of ICAR-FAO-TCP programme in India on Support Mitigation of Antimicrobial Resistance (AMR) Risk Associated with Aquaculture in Asia organized through virtual mode by ICAR-NBFGR on December 10, 2020.

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

- Delivered lecture on "Clownfish resources of India' during the training programme on Clownfish Aquaculture for the beneficiaries of Raigad and Palghar districts of Maharashtra at ICAR-NBFGR hatchery facility at Airoli, Thane, Mumbai during January 20-22, 2020.
- International Conference on Recent Biotechnological Innovation in Aquaculture (RBIA) at Bharathiar university, Coimbatore, Tamil Nadu during February 27-28, 2020.
- Delivered a lecture on "Marine finfish taxonomy" in the webinar organized by the Department of Fisheries Science, School of Marine Sciences, Alagappa University, Tamil Nadu on June 15, 2020.
- Training programme on Demystifying Interactive Dashboards organized by Xanthus Institute, Goa, during June 22-23, 2020.
- International virtual training on Regional Capacity Building Program on Biotechnological Tools in Aquatic Genetic Resource Management and *Ex Situ* Conservation jointly organized by ICAR-NBFGR, Lucknow and APAARI, Bangkok, Thailand during December 7-18, 2020, held at Lucknow.

Ms. Chinmayee Muduli, Scientist participated in the following activities:

- Aquaculture Health and Disease Management Webinar series organized by World Aquaculture Society-Asian Pacific Chapter and Aquaculture Innovation Centre, Singapore on September 30, 2020.
- CII Virtual Conference on Indian Fisheries Sector: The Next Level of Growth on October 19, 2020.
- Virtual Rally of Stewards for the Future: One Region, One Movement to Fight Antimicrobial Resistance organized by WHO, WPRO on November 27, 2020.
- International webinar on Beauty and the Beast: Important Parasites of Fish organized by Fish Health Section of Asian Fisheries Society on December 9, 2020.
- Webinar on Scenario of Freshwater Aquaculture in India during Covid-19 Pandemic organized by ICAR-CIFA on December 15, 2020.
- International web conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences 2020 organized during December 28-30, 2020.

- Virtual training on Breeding & Seed Production of Rainbow Trout and it's Best Management Practices organized by ICAR-DCFR, Bhimtal on December 29, 2020.

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

- International conference on Recent Biotechnological Innovation in Aquaculture (RBIA) (LIVE AQUA 2020) organized by ICAR-NBFGR and Bharathiar University at Coimbatore during February 27-28, 2020.
- Invited virtual guest lecture on "Limnology of riverine ecosystem" for UG students of Dr. MGR, Fisheries College and Research Institute, Thalainayeru, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam on May 27, 2020.
- Online course on Remote Sensing & GIS Technology and Applications for University Teachers & Government Officials conducted by ISRO-Indian Institute of Remote Sensing (IIRS), Dehradun during June 13- July 1, 2020.
- Webinar on Abiotic Stress in Agriculture: Geospatial Characterization and Management Options organized by ICAR-NIASM, Baramati on August 27, 2020.
- Online training programme on Understanding of Coastal Ocean Processes using Remote Sensing and Numerical Modelling conducted by ISRO-Indian Institute of Remote Sensing (IIRS), Dehradun during September 21-25, 2020.

Technical Personnel

Dr. A.K. Yadav, Chief Technical Officer and Shri Sanjay Kumar Singh, Assistant Chief Technical Officer participated in following activities:

- Meeting on Interactive Dashboard on May 19, 2020 organized by Xanthus Institute, Goa.
- Webinar lecture on Business Opportunities in Fish Post-Harvest by Dr. C.N. Ravishankar, Director CIFT on June 5, 2020.
- Technical webinar on Aquaculture and Value Chains organized by Network for Development of Agricultural Cooperatives in Asia and the Pacific (NEDAC) Training Centre Bangkok on July 17, 2020.

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

- Training program on Demystifying Interactive Dashboards, conducted by Xanthus Institute, Goa during June 22-23, 2020.
- Webinar on Women Empowerment: An Overview in the Light of Gandhian Philosophy organized by ICAR- CIFRI, Barrackpore, West Bengal, India on October 1, 2020.
- Hindi meeting on Relevance of Gandhian Ideologies in Today's World organized by ICAR-CIFE and ICAR-NBFGR on October 2, 2020.

Shri Satyavir Chaudhary, Senior Technical Officer participated in the following activities:

- National webinar on Reinventing Library and Information Services to Meet the Emergencies & Exigencies organized by Association of Agricultural Librarians and Documentarists of India (AALDI) during May 13-17, 2020.
- National webinar on Transforming the Agriculture Knowledge Resource Centers to meet the post COVID-19 Challenges organized by Navsari Agriculture University, Navsari (Gujarat) and Association of Agricultural Librarians and Documentarists of India (AALDI) during May 26-30, 2020.
- National webinar on Digital Transformation of Libraries during COVID-19 Pandemic: How to Overcome Challenges organized by Faculty of Library Science, Netaji Subhash Chandra Bose Govt. P.G. College, Lucknow on June 8, 2020.
- National webinar on Use of E-Resources in Agriculture Libraries organized by University of Agriculture Science, Dharwad and NAHEP-ICAR, New Delhi on June 12, 2020.
- National Level Faculty Development Programme: SOWSEEKNOW- Sowing Seeds of Knowledge to Library & Information Professionals organized by Navsari Agriculture University, Navsari (Gujarat), V.N.M. Krishi Vidyapeeth, Parbhani, Maharashtra and Association of Agricultural Librarians and Documentalists of India (AALDI) during June 18-22, 2020.
- National webinar on Emerging Trends in Scholarly Publishing organized by University Library & Information Center, Karnataka Veterinary, Animal

& Fisheries Sciences University, Nandinagar, Bidar on June 23, 2020.

- National webinar on Awareness & Use of CeRA Resources through J-Gate Discovery Platform organized by Nehru Library, CCS Haryana Agricultural University, Hisar in Collaboration with Consortium for E-Resources in Agriculture (CeRA) ICAR-DKMA, New Delhi and Informatics Publishing Limited, Bangalore on June 25, 2020.
- Workshop-cum-webinar on Agricultural Knowledge Management in the Networked Digital Environment organized by NAHEP-ICAR, New Delhi, ICAR-IVRI, Izatnagar, U.P. and Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan on July 15, 2020.
- National webinar on Accessibility of Knowledge Resources & e-Learning Management During COVID-19 organized by University Library, Chhattisgarh KamdhenuVishwavidyalaya, Durg in Association with Informatics Publishing Limited, Bangalore on July 17, 2020.
- Sensitization workshop-cum-webinar on Agricultural Knowledge Management in the Networked Digital Environment organized by NAHEP-ICAR, New Delhi & ICAR-IVRI, Izatnagar, U.P. and Banda University of Agriculture & Technology, Banda (U.P.) on July 24, 2020.
- Sensitization workshop-cum-webinar on Agricultural Knowledge Management in the Networked Digital Environment organized by NAHEP-ICAR, New Delhi, ICAR-IVRI, Izatnagar, U.P. and Bihar Animal Sciences University, Patna, Bihar on August 5, 2020.
- Sensitization programme on Knowledge Management in the Networked Digital Environment organized by NAHEP-ICAR, New Delhi, Tamil Nadu Veterinary and Animal Science University Library, Chennai and Kerala Veterinary and Animal Science University, Pookode, Wayanad, Kerala on August 27, 2020.
- Session on Accessing Taylor & Francis Journals organized by Taylor & Francis Group an Informa Business on September 15, 2020.
- International webinar on YouTube as an Informal Learning Platform for Library Professionals organized by Nehru Institute of Engineering & Technology, P.K. Das Knowledge Fort, Coimbatore and Aga Khan University, Karachi, Pakistan on September 26, 2020.
- International virtual symposium on Digital Scholarship organized by NAHEP-ICAR, New Delhi & Tamil Nadu Veterinary and Animal Science University Library, Chennai during October 14-15, 2020.
- Sensitization programme on Knowledge Management in the networked Digital Environment organized by NAHEP-ICAR, New Delhi, ICAR-IVRI, Izatnagar, U.P. and Acharya Narendra Deva University of Agriculture and Technology, Kumargang, Ayodhya, U.P. on October 29, 2020.
- Act as expert/ advisor in the interview board of UPSSSC, Lucknow during December 14-18 and 22-24, 2020.

Shri Vijay Kumar Singh, Technical Officer attended A Comprehensive and Advanced Workshop on ABC of Scientific Writing organized by ICAR-NRRI, Cuttack from August 18 to September 2, 2020.

Dr. Vikash Sahu, Technical Officer participated in the following activities:

- National webinar on Role of Agriculture and Allied Sciences towards Global Food Security jointly organized by Society of Biological Sciences & Rural Development, Prayagraj, U.P. and R.S.S.M. College, Sitamarhi, Bihar during June 13-15, 2020.
- National webinar on Impact of COVID-19 on the Environment: with Special Emphasis on Economically Important Fauna organized by Department of Zoology, Dr. R.P.M. Degree College, Lucknow on June 20, 2020.
- Virtual symposium on the Recent Trends in the Aquaculture Industries jointly organized by Col. Dr. Jeppiaar Research Park, Centre for Ocean Research (COR) and Sathyabama University Technology Bussiness Incubator (SU-TBI) in association with Ministry of Earth Sciences, Earth Science Technology Cell (MoES-ESTC) during July 20-25, 2020.
- Virtual International seminar on New Normal in Fisheries Sector Amidst and Post COVID19 in India organized by TNJFU Business School (Fisheries) OMR Campus, Chennai during July 31 - August 2, 2020.

- E-workshop on ABC of Scientific Writing organized by Krishi Vigyan Kendra Cuttack, Santhapur, ICAR-NRRI, Cuttack during August 18 - September 2, 2020.
- Webinar on Integrating Energy, Climate Change and Development organized by Department of Management, Mizoram University on September 8, 2020.
- The FAO-TCP (AMR)- Partner's Meet for India component organized by ICAR-NBFGR and ICAR-CIFT on December 3, 2020.
- Workshop on Implementation of ICAR-FAO-TCP Programme in India on Support Mitigation of Antimicrobial Resistance (AMR) Risk Associated with Aquaculture in Asia organized through virtual mode by ICAR-NBFGR on December 10, 2020.

Administrative Personnel

Mamta Chakraborty, Private Secretary participated in the following activities:

- Training program on Demystifying Interactive Dashboards, conducted by Xanthus Institute, Goa during June 22-23, 2020.
- Webinar on Women Empowerment: An Overview in the Light of Gandhian Philosophy organized by ICAR-CIFRI, Barrackpore, West Bengal, India on October 1, 2020.
- Hindi meeting on Relevance of Gandhian Ideologies in Today's World organized by ICAR-CIFE and ICAR-NBFGR on October 2, 2020.

Ram Sakal Chaurasia, Personal Secretary participated in Hindi meeting on Relevance of Gandhian Ideologies in Today's World organized by ICAR-CIFE and ICAR-NBFGR on October 2, 2020.

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 7589 books, 15 e-books and 3348 bound volumes of journals and other reference materials. In addition to these, many journals were received on gratis/exchange basis.

Library Automation

The Library is operating in fully automated mode. The various activities of library have been computerized using KOHA: Open-Source Library System, 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 through 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 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. 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 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

Promotion/Joining/Relieving/MACP/Superannuation/Voluntary Retirement during January to December, 2020.

Promotion

S.No.	Name of employee	Date of Promotion
1.	Shri Babu Ram promoted from ACTO to CTO Level-11 to Level-12	24.02.2018
2.	Shri Surendra Pratap Singh promoted from ACTO to CTO Level-11 to Level-12	24.02.2018
3.	Shri Prem Chandra promoted from STO to ACTO Level-10 to Level-11	06.01.2016
4.	Shri Sandeep promoted from Junior Stenographer to Personal Assistant from Level-4 to Level-6	24.10.2020 (A.N.)

Joining

S.No.	Name of employee	Date of Joining
1.	Dr. Raghvendra Singh, Scientist	31.07.2020 (F.N.)

Relieving

S.No.	Name of employee	Date of relieving
2.	Shri Ravi Bhadra, Finance & Accounts Officer relieved from ICAR-NBFGR, Lucknow to join ICAR-CISH, Rehmankhera, Kakori, Lucknow for the post of Finance & Accounts Officer	11.12.2020 (A.N.)

MACP

S.No.	Name of employee	Effective date
	Administrative	
1.	Shri Sandeep, Junior Stenographer granted 1st financial up-gradation benefits from Level-4 to Level-5	23.06.2020
2.	Shri Phool Chandra Verma granted 3rd financial up-gradation benefits from Level-5 to Level-6	01.08.2020
	Supporting Staff	
3.	Shri Anil Kumar, Skilled Support Staff granted the 3rd financial up-gradation benefits from Level-3 to Level-4	19.12.2019
4.	Shri Dukhi Shyam Deo, Skilled Support Staff granted 3rd financial up-gradation benefits from Level-3 to Level-4	22.09.2019
5.	Shri Laxchman Prasad, Skilled Support Staff granted 3rd financial up-gradation benefits from Level-3 to Level-4	01.09.2018
6.	Shri Indrajit Singh, Skilled Support Staff granted 3rd financial up-gradation benefits from Level-3 to Level-4	14.02.2020

Superannuation/Voluntary Retirement

S.No.	Name of employee	Date of Superannuation/Retirement
1.	Shri Raj Bahadur, Senior Technical Assistant	31.07.2020
2.	Shri Laxman Prasad, Skilled Support Staff	31.07.2020 (Voluntary Retirement)
3.	Shri Babu Ram, Chief Technical Officer	31.12.2020

Staff Position

	Research Management/ Director	Scientist	Administrative	Technical	SSS
Sanctioned	01	44	21	38	20
In position	01	33	17	27	18

INSTITUTE MANAGEMENT COMMITTEE

34th IMC meeting was held on March 13, 2020 with the following newly constituted committee:	
1.	**Dr. P. Pravin** Assistant Director General (Marine Fisheries) Indian Council of Agricultural Research Krishi Anusandhan Bhawan-II, Pusa New Delhi-110012
2.	**Dr. Aparna Chaudhari** Principal Scientist & Head ICAR-Central Institute of Fisheries Education Panch Marg, Off Yari Road, Versova, Andheri West, Mumbai, Maharashtra-400061
3.	**Dr. P.K. Sahoo** Principal Scientist & National Fellow ICAR-Central Institute of Freshwater Aquaculture Kausalyaganga, Bhubaneswar, Odisha-751002
4.	**Dr. Suseela Mathew** Principal Scientist & Head ICAR-Central Institute of Fisheries Technology CIFT Junction, CIFT Road Matsyapuri, Willingdon Island Kochi, Kerala-682029
5.	**Dr. V.R. Suresh** Principal Scientist ICAR-Central Marine Fisheries Research Institute Ernakulam, North P.O, Kochi, Kerala-68201
6.	**Shri Prem Singh Kashyap** Machona, Sahaswaan P.O. Badaun, Uttar Pradesh-243638
7.	**Shri Mahendra Kumar Bind** R/o 8/118 HIG Avas Vikas Colony, Yojna III, Jhusi, Prayagraj Uttar Pradesh-211019

RESEARCH ADVISORY COMMITTEE

24th RAC online meeting of the Institute was held on April 15-27, 2020. The composition of the RAC is as under:		
1	**Dr. A.G. Ponniah** Former Emeritus Scientist, ICAR-CMFRI Former Director, ICAR-CIBA & ICAR-NBFGR, Former Discipline Leader, WorldFish Centre, Malaysia 933, Ground Floor, Snowdrops, 10th Street H Block, Anna Nagar West Chennai, Tamil Nadu-600040	**Chairman**
2	**Dr. Anup Mandal** Manager (Central Genetics Lab) Rajiv Gandhi Centre for Aquaculture (RGCA) (MPEDA, Ministry of Commerce & Industry, Government of India) 3/197, Poompuhar Road, Karaimedu Village, Sattanathapuram PO, Sirkazhi Taluk, Nagapattinum Dist., Tamil Nadu-609109	**Member**
3	**Dr. K.V. Bhat** Formar Principal Scientist, Emeritus Scientist ICAR- National Bureau of Plant Genetic Resources New Delhi-110012	**Member**
4	**Dr. S.C. Mukherjee** Former Joint Director, ICAR-CIFE, Mumbai 187A, Sahid Nagar P.O., Bhubaneswar, Odisha-751007	**Member**
5	**Dr. (Prof.) Bechan Lal** Professor Department of Zoology Banaras Hindu University, Varanasi-221005	**Member**
6	**Dr. P. Pravin** Assistant Director General (M.Fy.) Indian Council of Agricultural Research Krishi Anusandhan Bhawan-II Pusa, New Delhi-110012	**Member**
7	**Dr. Kuldeep K. Lal** Director ICAR-National Bureau of Fish Genetic Resources Canal Ring Road, P.O. Dilkusha Near Telibagh, Lucknow, Uttar Pradesh-226002	**Member**
8	**Dr. Parvata Kumar Pradhan** Principal Scientist, FHM&E Division ICAR-National Bureau of Fish Genetic Resources Canal Ring Road, P.O. Dilkusha Near Telibagh, Lucknow, Uttar Pradesh-226002	**Member Secretary**

DISTINGUISHED VISITORS

- Shri Praful Patel, Hon'ble Administrator of Daman & Diu and Lakshadweep visited ICAR-NBFGR Germplasm Centre at Agatti Island.
- Shri P. Krishnamurthy, IAS, Advisor to the Administrator, Lakshadweep visited ICAR-NBFGR Germplasm Centre at Agatti Island.
- Shri O.P. Mishra, Secretary, Animal Husbandry & Fisheries, U.T. Administration visited ICAR-NBFGR Germplasm Centre at Agatti Island.
- Dr. Yugraj Singh Yadava, Director, Bay of Bengal Programme (BoBP) visited ICAR-NBFGR Germplasm Centre at Agatti Island.
- Dr. Gopal Krishna, Director and Vice Chancellor, ICAR-CIFE visited ICAR-NBFGR facility at Airoli, Maharashtra.
- Dr. A.K. Rawat, Scientist G and Senior Advisor, DBT visited ICAR-NBFGR Germplasm Centre at Agatti Island.
- Dr. A.G. Ponniah, Former Director, ICAR-NBFGR & ICAR-CIBA visited ICAR-NBFGR Germplasm Centre at Agatti Island.

Shri. Praful Patel, Hon'ble Administrator of Daman & Diu and Lakshadweep at ICAR-NBFGR Germplasm Centre Agatti Island, Lakshadweep.

Shri. P. Krishnamurthy, IAS and Shri. O.P. Mishra at ICAR-NBFGR Germplasm Centre Agatti Island, Lakshadweep.

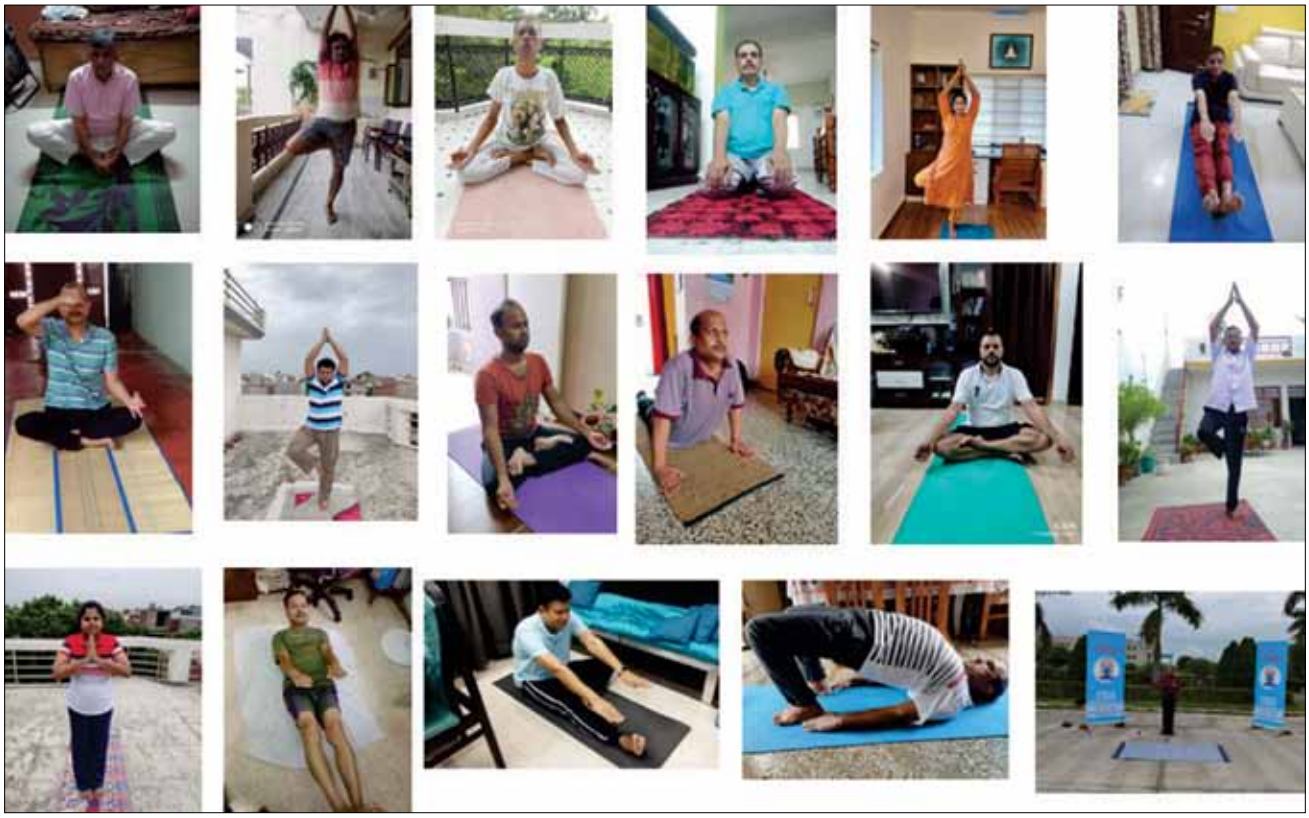
Dr. Gopal Krishna at ICAR-NBFGR hatchery facility, Airoli, Maharashtra

COMMITMENT TO SOCIETAL INITIATIVES OF GOVERNMENT OF INDIA AND ICAR

International Yoga Day

The International Yoga Day was celebrated at ICAR-NBFGR, Lucknow, on June 21, 2020 following COVID-19 protocols. The Yoga session was open for all the staff and their family members. Dr. Basdeo Kushwaha, Principal Scientist and Nodal Officer, Yoga welcomed the participants and explained the benefits of practicing Yoga in daily life in order to maintain overall body fitness as well as peace of mind. He demonstrated various *Aasana* and *Pranayama* as per International Yoga Day protocol of AYUSH Ministry, Government of India, followed by Yoga practice by the participants. The same was also observed by staff of PMFGR Centre, Kochi of ICAR-NBFGR. Those who were unable to join the programme at office campuses due to COVID-19 guidelines, practiced Yoga at their home as per the common Yoga protocol.

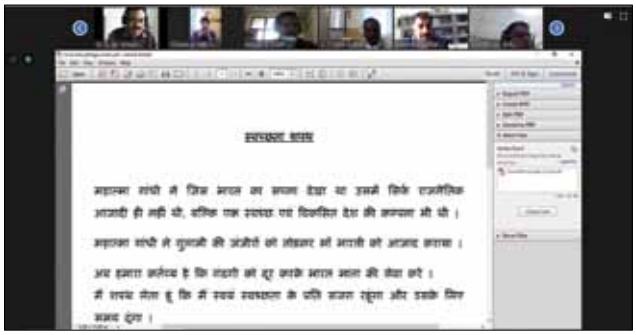
A glance of Yoga practice by ICAR-NBFGR staff at Institute campus



Glance of Yoga practice by ICAR-NBFGR staff at their homes

Swachh Bharat Abhiyan

ICAR-NBFGR, Lucknow as a research institute has been promoting Swachh Bharat Abhiyan since the program's inception in 2014 to ensure a clean and green campus and contribute in making India more beautiful. In the year marked by COVID-19, a lot of emphasis was placed on personal hygiene and cleanliness of the institute and surroundings. In the reporting year, other than the routine monthly activities, the institute observed Swachhta Pakhwada of 16 days during December 16-31, 2020. Since, the pakhwada was conducted following COVID-19 protocol; most of the activities were undertaken through digital means. On occasions, where physical activities were organised, adequate precautions like social distancing and use of face masks were undertaken. During this period, 13 different cleaning and awareness activities were undertaken by the staff and research scholars of the institute. The Swachhta Pakhwada was kick-started on December 16, 2020 by holding a mass online Swachhta Pledge administered by the Director to all the staff and research scholars of the institute and an awareness program on "Plastic Segregation" was undertaken by the staff. To create awareness, a webinar on swachhta, "Mission Clean India" was also conducted where discussions were held to make India cleaner and greener. On the occasion, a hindi essay contest was also conducted. A special swachhata program for farmers while observing "Kisan Diwas" was celebrated with the farmers on December 23, 2020. Under the program, masks, sanitizers, soap and other safety-related products were distributed to the farmers.



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 4100 transactions amounting to Rs. 4021.02 lakhs were carried out electronically.

Government E-Market (GeM)

The Institute is implementing e-procurement policy of Government of India. During the year under report, 135 different kinds of items worth 1.09 crores were processed through GEM. All the tenders were implemented through e-tendering process.

CHALLENGES AND STRATEGIES ADOPTED TO OVERCOME COVID-19 CRISIS

COVID-19 outbreak and global spread was an unprecedented shock that simultaneously affected all aspects of life including health, transportation, travel, economy, research & development initiatives etc. To combat this crisis, new strategies had to be adopted which was challenging especially in research institutes. A brief overview of various activities undertaken during this period are summarized below:

General Activities

The institute ensured that all the staff and research scholars must adhere to the phase-wise guidelines and SOPs issued by the Government of India regarding COVID-19. Social distancing and use of face masks were advised for containing the spread of disease. Facial biometric system was adopted for touchless/ contactless recording of attendance. All surface touch points were sanitized daily. Sensor based hand sanitizers, soap dispensers and taps were installed at all desired points. All the mandatory meetings for project discussions, progress monitoring activities like RAC, IRC meetings etc. were conducted online.

Explorations/ field studies conducted at various parts of country

Sampling and exploratory surveys were undertaken following COVID-19 guidelines and quarantine measures. Exploratory surveys for documentation of fish diversity were undertaken for various river systems like the Luni, Banas, Gandak, Burhi Gandak, Bagmati and Saraiyaman wetland. A field survey was also undertaken to document fish diversity and habitat parameters from West Godavari, Karimnagar and Adilabad districts along the Godavari River. A total of 16 sites were surveyed for habitat and water quality assessment and experimental fishing was conducted at 4 sites. A total of 43 species could be recorded from this study. Another team from the institute undertook exploratory survey and collected live specimens of *Tor putitora* and *Schizothorax richardsonii* from Uttarakhand for studying thermal tolerance in these species. Survey for documentation of alien fish species was undertaken at Yamuna, Ganga and Tons rivers. Exploratory surveys were also conducted for collection of fish species for breeding purposes. Live samples of a critically endangered catfish, *Hemibagrus punctatus* were collected from Karnataka, during October 2020. Similarly, live samples of another endangered endemic catfish of Western Ghat, *Clarias dussumieri* were collected from Kerala.

Research output

During the lockdown period maximum impetus was given for publication and dissemination of research findings through research manuscripts, popular articles etc. This resulted in submission of record 123 research manuscripts of which 70 were published or accepted.

Extension, Farm Activities and other Services

Farm activities and farmer services were provided continuously by the institute following COVID-19 guidelines. In July, 2020, a team from the Institute under the leadership of the Director, ICAR-NBFGR travelled to different partner hatcheries situated in Bihar, Haryana, Madhya Pradesh, Rajasthan and Uttar Pradesh to supply cryopreseved fish milt to farmers for quality seed production and broodstock improvement. By this initiative, approximately 25 lakhs spawn were produced and fish farmers across the states could be supported. Information on economic losses due to fish diseases in Uttar Pradesh was collected through telephonic discussion with 126 farmers.

Kisan Diwas was celebrated involving fish farmers on December 23, 2020. Under the program, masks, sanitizers, soap and other safety-related products were distributed to farmers.

Seeds of prized ornamental fishes, *Dawkinsia rubrotinctus* (500), and *Pethia setnai* (200) were sold to ornamental fish entrepreneurs. Fingerlings of *Clarias dussumieri*, *Horabgrus brachysoma*, *Labeo dussumieri, Catla catla, L. rohu* etc. were provided to farmers. Retail sale of marine ornamental fishes was launched at Thane District, Maharashtra.

A total of 21 fish cell lines were distributed for R&D activities to 8 researchers belonging to 7 institutions, *viz.* Jawaharlal Nehru University, New Delhi; ICAR-

CIFE, Mumbai; CUSAT, Kochi; College of Fisheries, Mangaluru; Yenepoya University, Mangaluru; MS University, Baroda; and GN Khalsa College, Mumbai, for research purposes.

ICAR-NBFGR hatcheries (located at head quarter and ARTU, Chinhat) produced a total of 1017 lakhs quality fish seed of Indian major carps and other carps in the form of spawn, during ongoing breeding season.

Training Activities

Training and skill upgradation programmes were mostly held online. To achieve the United Nations-Sustainable Development Goals (especially SDG-17 on Partnerships), ICAR-NBFGR and Asia Pacific Associations of Agricultural Research Institutions (APAARI), Bangkok, Thailand, organized a 10 days online International training programme on 'Regional capacity building on biotechnological tools in aquatic genetic resource management and ex-situ conservation' for Asia-Pacific countries' during December 07-18, 2020 in which a total of 35 participants from 14 countries participated.

Since, physical mode of training was not possible, the staff of the institute virtually participated in various national and international trainings, workshops etc. for skill upgradation.

राजभाषा गतिविधियाँ

हिंदी माह

संस्थान में 14 सितम्बर, 2020 से हिंदी माह का आयोजन किया गया तथा इसके अंतर्गत ऑन लाइन विधि से नौ विभिन्न प्रतियोगिताओं का आयोजन किया गया। हिंदी माह का समापन समारोह कार्यक्रम 28 अक्टूबर, 2020 को ऑन लाइन विधि से आयोजित किया गया जिसकी अध्यक्षता डॉ. कुलदीप कुमार लाल, निदेशक, भाकृअनुप–राष्ट्रीय मत्स्य आनुवंशिक संसाधन ब्यूरो, लखनऊ ने की तथा मुख्य अतिथि डॉ. गोपाल कृष्ण, निदेशक/कुलपति, भाकृअनुप–केंद्रीय मात्स्यिकी शिक्षा संस्थान, मुंबई ने प्रतिभाग कर कार्यक्रम का मान बढ़ाया एवं पुरस्कार वितरित किये गए।

हिंदी कार्यशाला एवं प्रशिक्षण कार्यक्रम

संस्थान के वैज्ञानिकों, प्रशासनिक कर्मचारियों, तकनीकी कर्मचारियों एवं कुशल कार्मिकों के लिए निम्नलिखित कार्यक्रमों का आयोजन किया गया।

– दो दिवसीय प्रशिक्षण कार्यक्रम का आयोजन जनवरी 30–31, 2020 तक किया गया।

– फरवरी 1, 2020 को एक दिवसीय कार्यशाला का आयोजन किया गया।

– नवम्बर 26–28, 2020 तक 'कर्मचारियों के कार्य क्षमता में वृद्धि के लिए प्रभावी स्वास्थ्य प्रबंधन' पर तीन दिवसीय प्रशिक्षण कार्यशाला का आयोजन किया गया।

– नवम्बर 26, 2020 को एक हिंदी कार्यशाला का ऑनलाइन विधि से आयोजन किया गया।

राजभाषा पत्रिका मत्स्यलोक (अष्टम अंक)

संस्थान की राजभाषा पत्रिका, मत्स्यलोक के अष्टम अंक का प्रकाशन किया गया। पत्रिका में विभिन्न वैज्ञानिक लेख, सामान्य लेख, रोचक लेख एवं अन्य रचनाओं का समायोजन किया गया।

पुरस्कार

– भाकृअनुप–राष्ट्रीय मत्स्य आनुवंशिक संसाधन ब्यूरो, लखनऊ को वर्ष 2018–2019 के लिए ''क'' और ''ख'' क्षेत्र के छोटे संस्थानों के लिए राजर्षि टंडन राजभाषा पुरस्कार योजना के अन्तर्गत परिषद् द्वारा प्रथम पुरस्कार प्रदान किया गया, जिसकी घोषणा 16 जुलाई, 2020 को की गई।

– संस्थान की राजभाषा पत्रिका, मत्स्यलोक को अक्टूबर 2019 से मार्च 2020 वर्ष के लिए, नगर राजभाषा कार्यान्वयन समिति (नराकास, लखनऊ), द्वारा प्रथम पुरस्कार प्रदान किया गया।

– भाकृअनुप–राष्ट्रीय मत्स्य आनुवंशिक संसाधन ब्यूरो, लखनऊ को वर्ष 2019–2020 के लिए नगर राजभाषा कार्यान्वयन समिति (नराकास, लखनऊ) द्वारा कार्यालयी कार्यो में उत्कृष्ट प्रदर्शन हेतु द्वितीय पुरस्कार प्रदान किया गया है।

भारतीय कृषि अनुसंधान परिषद

प्रशस्ति-पत्र

राजर्षि टंडन राजभाषा पुरस्कार

वर्ष 2018-19 के दौरान सरकारी कामकाज में हिन्दी के प्रयोग में उल्लेखनीय योगदान के लिए भा.कृ.अनु.प.-राष्ट्रीय मत्स्य आनुवंशिक संसाधन ब्यूरो, लखनऊ को 'क' एवं 'ख' क्षेत्र के अन्य संस्थानों की श्रेणी में प्रथम पुरस्कार से सम्मानित किया जाता है।

दिनांक: 16 जुलाई 2020
नई दिल्ली

सचिव
(भा.कृ.अनु.प.)

महानिदेशक
(भा.कृ.अनु.प.)

भारत सरकार, राजभाषा विभाग, गृह मंत्रालय

नगर राजभाषा कार्यान्वयन समिति (कार्यालय-3), लखनऊ

भाकृअनुप-भारतीय गन्ना अनुसंधान संस्थान, लखनऊ

क्रमांक : 02

दिनांक : 24 अगस्त, 2020

प्रमाण पत्र

प्रमाणित किया जाता है कि भा.कृ.अनु.प. -राष्ट्रीय मत्स्य आनुवांशिक संसाधन ब्यूरो, लखनऊ ने अक्टूबर 2019-मार्च 2020 छमाही (2019-20) में कार्यालयी कार्यों में उत्कृष्ट प्रदर्शन कर द्वितीय 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

(अश्विनी दत्त 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 at 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 waters. The aquaria are maintained in air-conditioned galleries with amazing backdrops and environment. 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 filtered water to mermaid tank at the entrance.

Amongst important exotic ornamentals; several variants of goldfishes (bubble-eye, telescopic-eye, pearl-scale, red cap, red oranda, shubunkin, blackmoor), freshwater angels, alligator gar, tetras, ghostfish, parrotfish, fire mouth, malawi cichlids, oscars, discus, severum and many others are maintained. Many indigenous freshwater fishes like denisoni barb (Kerala Queen), flamingo barb, loaches, freshwater eels, etc. and freshwater food fishes including the State Fishes of India are also housed. Four aquaria also display marine fauna like scorpion fish, chaetodonts, wrasse, clownfish, damsels, tangs, sea anemones and starfish. Fishes of prosperity like flowerhorn and arowana are another main attraction. The live aesthetic display serve as an avenue to enhance awareness towards fish diversity and its conservation among public.






LIST OF PERSONNEL(S)

Research Management

S. No.	Name		Designation
Dr. Kuldeep Kumar Lal		-	**Director**
Scientific Staff			
1.	Dr. Ravindra Kumar	-	HoD (MBB Division)
2.	Dr. (Mrs) Vindhya Mohindra	-	HoD (FC Division)
3.	Dr. Gaurav Rathore	-	HoD (FHM Division)
4.	Dr. Kripal Datt Joshi	-	Principal Scientist
5.	Dr. Basdeo Kushwaha	-	Principal Scientist
6.	Dr. Neeraj Sood	-	Principal Scientist
7.	Dr. V.S. Basheer	-	Principal Scientist (PMFGR)
8.	Dr. Pravata Kumar Pradhan	-	Principal Scientist
9.	Dr. Sharad Kumar Singh	-	Principal Scientist
10.	Dr. Lalit Kumar Tyagi	-	Principal Scientist
11.	Dr. Satish Kumar Srivastava	-	Principal Scientist
12.	Dr. Rajeev Kumar Singh	-	Principal Scientist
13.	Dr. Mahender Singh	-	Principal Scientist
14.	Dr. T. Rajaswaminathan	-	Principal Scientist (PMFGR)
15.	Dr. T.T. Ajith Kumar	-	Principal Scientist & SIC (PMFGR)
16.	Dr. Sullip Kumar Majhi	-	Principal Scientist
17.	Dr. Achal Singh	-	Principal Scientist
18.	Dr. Ajey Kumar Pathak	-	Senior Scientist
19.	Dr. (Mrs.) Divya P.R.	-	Senior Scientist (PMFGR)
20.	Dr. Poonam Jayant Singh	-	Scientist
21.	Dr. (Mrs.) Sangeeta Mandal	-	Scientist
22.	Dr. Rejani Chandran	-	Scientist
23.	Dr. Santosh Kumar	-	Scientist
24.	Dr. Aditya Kumar	-	Scientist
25.	Dr. Charan R.	-	Scientist (PMFGR)
26.	Dr. Labrechai Mog Chowdhury	-	Scientist
27.	Dr. Murali S.	-	Scientist
28.	Dr. Anutosh Paria	-	Scientist
29.	Shri Chandra Bhushan Kumar	-	Scientist
30.	Ms. Teena Jayakumar T.K.	-	Scientist (PMFGR)
31.	Ms. Chinmayee Muduli	-	Scientist
32.	Sh. Kantharajan G	-	Scientist
33.	Dr. Raghvendra Singh	-	Scientist

Technical Staff

S. No.	Name		Designation
1.	Dr. Rajesh Dayal	-	Chief Technical Officer
2.	Dr. Satyendra Mohan Srivastava	-	Chief Technical Officer
3.	Dr. Akhilesh Kumar Yadav	-	Chief Technical Officer
4.	Shri Amar Pal	-	Chief Technical Officer
5.	Shri Surendra Pratap Singh	-	Chief Technical Officer
6.	Shri Babu Ram	-	Assistant Chief Technical Officer
7.	Dr. Ajay Kumar Singh	-	Assistant Chief Technical Officer
8.	Mrs. Reeta Chaturvedi	-	Assistant Chief Technical Officer
9.	Shri Ramashankar Sah	-	Assistant Chief Technical Officer
10.	Shri Subhash Chandra	-	Assistant Chief Technical Officer
11.	Shri Prem Chandra	-	Assistant Chief Technical Officer
12.	Dr. Akhilesh Kr. Mishra	-	Assistant Chief Technical Officer
13.	Dr. (Mrs.) Ranjana Srivastava	-	Assistant Chief Technical Officer
14.	Shri Ravi Kumar	-	Assistant Chief Technical Officer
15.	Shri Sanjay Kumar Singh	-	Assistant Chief Technical Officer
16.	Shri Amit Singh Bisht	-	Senior Technical Officer
17.	Shri Satyavir Chaudhary	-	Senior Technical Officer
18.	Shri Raj Kumar Shukla	-	Technical Officer
19.	Shri Bhola Nath Pathak	-	Technical Officer
20.	Shri Samarjit Singh	-	Technical Officer
21.	Shri Om Prakash	-	Technical Officer
22.	Shri Rajesh Kumar	-	Technical Officer
23.	Shri Vijay Kumar Singh	-	Technical Officer
24.	Shri Raj Bahadur	-	Senior Technical Assistant (Retired on 31.07.2020)
25.	Shri Bal Krishna Rao	-	Technical Officer
26.	Shri Om Prakash-II	-	Technical Officer
27.	Dr. Vikash Sahu	-	Technical Officer
28.	Shri Gulab Chandra	-	Senior Technical Assistant
29.	Shri Krishna Kumar Singh	-	Senior Technical Assistant

Administrative Staff

S. No.	Name		Designation
1.	Shri Ravi Bhadra	-	Finance & Accounts Officer (Relieved on 11.12.2020)
2.	Shri Tej Singh Seepal	-	Assistant Administrative Officer
3.	Shri Pramod Kumar Awasthi	-	Assistant Administrative Officer
4.	Smt. Mamta Chakraborty	-	Private Secretary
5.	Shri Ram Sakal	-	Personal Assistant
6.	Shri Sandeep	-	Personal Assistant
7.	Smt. Kaneez Fatima	-	Assistant
8.	Shri Swapan Debnath	-	Assistant
9.	Shri Surendra Nath Srivastava	-	Assistant
10.	Smt. Sunita Kumari	-	Assistant
11.	Shri Sajivan Lal	-	Assistant
12.	Shri Shreelal Prasad	-	Senior Clerk
13.	Shri Vinay Kumar Srivastava	-	Senior Clerk
14.	Shri Santosh Kumar Singh	-	Senior Clerk
15.	Shri Ram Baran	-	Junior Clerk
16.	Shri Phool Chandra Verma	-	Junior Clerk
17.	Shri Rajan Kumar Malhotra	-	Junior Clerk
18.	Shri Vikrant Gupta	-	Junior Clerk

Supporting Staff

S. No.	Name		Designation
1.	Shri Laxman Prasad	-	Skilled Support Staff (Voluntary Retirement on 31.07.2020)
2.	Shri Dukhi Shyam Deo	-	Skilled Support Staff
3.	Shri Anil Kumar	-	Skilled Support Staff
4.	Shri Indrajit Singh	-	Skilled Support Staff
5.	Shri Chhote Lal	-	Skilled Support Staff
6.	Shri Ashok Kumar	-	Skilled Support Staff
7.	Shri Dinesh Kumar	-	Skilled Support Staff
8.	Shri Balram Babu Bajpai	-	Skilled Support Staff
9.	Shri Ashok Kumar Awasthi	-	Skilled Support Staff
10.	Shri Sidhnath	-	Skilled Support Staff
11.	Shri Ram Lakhan	-	Skilled Support Staff
12.	Shri Sunit Kumar	-	Skilled Support Staff
13.	Shri Jai Narain Tiwari	-	Skilled Support Staff
14.	Shri Anwar	-	Skilled Support Staff
15.	Shri Sanjay Kumar	-	Skilled Support Staff
16.	Smt. Seema Devi	-	Skilled Support Staff
17.	Smt. Raj Kumari	-	Skilled Support Staff
18.	Shri Mayank Pratap Singh	-	Skilled Support Staff
19.	Shri 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

B. National Institutes and Universities

The Bureau has been collaborating with a number of national research institutions, colleges and universities.

- Anand Agricultural University, Gujarat
- Awadhesh 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, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand
- 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, Gauhati University, Guwahati
- Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar

- Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences Technology of Kashmir, Jammu & Kashmir
- Faculty of Fishery Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata
- 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
- ICAR-Agricultural Technology Application Research Institute, Kanpur, Uttar Pradesh
- 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
- Chaudhary Charan Singh Haryana Agricultural University, Hisar

C. International

On the international level, ICAR-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
- Bioversity International, South and South-East Asia Office
- Asia Pacific Associations of Agricultural Research Institutions (APAARI), Bangkok, Thailand

- World Fish, Malaysia
- Asian Fisheries Society, Malaysia

D. Extension and Development Agencies

ICAR-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, Government 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
- IFFCO, CSR, Lucknow, Uttar Pradesh
- FAARD Foundation, Varanasi, Uttar Pradesh
- Unnaya Sanstha, Mahoba, Uttar Pradesh
- M.S. Swaminathan Research Foundation, Chennai
- Aquaculture & Biodiversity Center of the Gauhati University and District Administration, Bongaigaon, Assam

APPENDIX-I

HUMAN RESOURCE DEVELOPMENT INITIATIVES

The HRD cell of the ICAR-NBFGR, Lucknow actively encouraged and promoted its staff for attending various training programmes for capacity building and also extended support in organizing training programmes in the Institute. The HRD cell organized three training programs:

1. Awareness for Utilisation of Natural Resources under Constitutional Frame (physical mode) for all ICAR-NBFGR staff and staff from ICAR-CISH, ICAR-IISR during January 30 - February 1, 2020.
2. Demystifying Interactive Dashboards (virtual mode) for nominated staff; Scientists-9, Technicals-3 & Administrative-1 during June 22-23, 2020.
3. Effective Health Management for Enhancing Work Efficiency of Employees (Physical mode) for SSS (16) during November 26-28, 2020.

HRD Cell also coordinated creation of training resource material (demonstration-modules) on lab activities for online training. The trainings acquired by ICAR-NBFGR staff from other ICAR & Non-ICAR institute were as follows:

A. Physical targets and achievements (Cat. 1-3: Virtual mode & 4: Physical mode)

S. No.	Category	Total No. of Employee	No. of trainings planned for year 2020 (Jan-Dec) as per ATP	No. of employees undergone training during Jan-June, 2020	No. of employees undergone training during July -Dec, 2020	Total number of employees undergone training during Jan -Dec, 2020	% realization of trainings planned during Jan-Dec, 2020
1	2	3	4	5	6	7 (5+6)	8
1	Scientist	34	10	16	0	16	160
2	Technical	30	3	3	0	3	100
3	Administrative & Finance	20	1	1	0	1	100
4	SSS	18	1	0	18	18	100

B. Financial targets and achievements (All employees)

S. No.	RE for HRD (April 2020- March 2021)			Actual Expenditure (Jan1 to Dec 31, 2020) for HRD			% Utilization
	Plan (Lakh Rs.)	Non-plan (Lakh Rs.)	Total (Lakh Rs.)	Plan (Lakh Rs.)	Non-plan (Lakh Rs.)	Total (Lakh Rs.)	
1	2	3	4 (2+3)	5	6	Col. 5+6=7	(Col 7*100/ Col.4)=8
1	6.0	0	6.0	4.15	0	4.15	69

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 - June, 2020	No. of trainings organized during July - Dec, 2020	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	0	1	34	4	38
2	Technical	1	0	1	30	0	30
3	Administrative & Finance	1	0	1	20	0	20
4	SSS	1	1	2	18	0	18

Back cover

Description

1. Field trial of cryopreserved milt in Madhya Pradesh fish hatchery for genetic improvement of broodstock
2. Fertility trial at selected hatcheries using cryopreserved fish milt
3. Sale of ornamental fish seed to entrepreneurs
4. Induced breeding
5. Experimental fishing in the river Banas using cast net at the outlet of Bakerikanaka dam

ICAR-National Bureau of Fish Genetic Resources
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