

ANNUAL REPORT

2017-18

Evolving Till Posterity



भा.कृ.अनु.प.-राष्ट्रीय मत्स्य आनुवंशिक संसाधन ब्यूरो
ICAR-National Bureau of Fish Genetic Resources

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Front Cover

Evolving till Posterity

Description and picture courtesy

1. A traditional fishing boat, Andaman (@ICAR-NBFGR)
2. Traditional simple fishing gear; Cast Net (@ICAR-NBFGR)
3. A traditional fishing trap used by fisherman (@ICAR-NBFGR)
4. A battery of cages (@Das and Kumars, Varanasi)
5. A typical intensive shrimp farm (@ICAR-NBFGR)
6. A Fish Fossil, *Diplomystus Dentatus* is a photograph by Jason Edwards (<https://fineartamerica.com/featured/a-fish-fossil-diplomystus-dentatus-jason-edwards.html>)
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9. Tiger prawn, *Penaeus mondon* (@ICAR-NBFGR)
10. Indian Major Carp, *Labeo rohita* (@ICAR-NBFGR)

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PREFACE

ICAR-National Bureau of Fish Genetic Resources (NBFGR), is one among the seven bureaus under the Indian Council of Agricultural Research (ICAR), Department of Agricultural Research and Education, Ministry of Agriculture and Farmers' Welfare, Govt. of India. A research institute which has a focused mandate to serve the knowledge-based planning process relevant to aquatic genome resource management in the



country. As India has approximately 9.5% of fish genetic resources, the direction to manage these vast genetic resources was materialized through inception of ICAR-NBFGR in 1983. Apart from leading the research on various aspects of aquatic genome resources, the institute is also playing an important role in providing technical backstop to several policy-related bodies such as DADF, NBA and MPEDA (Ministry of Commerce). One of the important point in steady acceleration of this institute is, its in-house expertise with thrust to keep pace with global technological advancements and need-based research. The ICAR-NBFGR is striving to be an institute of global relevance by scientifically supporting national action plans for safeguarding the native stocks and diversifying the aquaculture practices.

During the reporting period (2017-18), the institute has targeted several unexplored rivers, wetlands, lakes and marine ecosystems in the country for documenting the native aquatic germplasm. Apart from continuing the exploratory surveys in the river Mahanadi, Cauvery and marine islands, the institute has initiated exploratory surveys in the river Gandak, Budi Gandak, Baghmata and brackishwater lakes of Kerala. The newly reported species from river Krishna i.e. *Pangasius silasi* is initiated into the process of domestication and can be a potential candidate for future intensive aquaculture system. The characterization of important aquatic germplasms in genome level has been also the flagship area of research of the institute. In this line, the whole genome sequences of three commercially important finfish species, rohu, magur and hilsa and an oomycete pathogen, *Aphanomyces invadans* have been generated and identification of key gene is under process. The *ex situ* and *in situ* conservation of threatened aquatic germplasm is another targeted area perceived by the institute and several efforts are being made towards this direction through development and preserving the cell lines and generating viable progeny through surrogacy. Beside these, a ranching program of 2.0 lakhs IMC fingerlings produced from wild type Gangetic stock has been carried out for in situ conservation of the indigenous genetic populations in the river Ganga. The institute is also focused to support aquaculture sector through research on diagnosis, surveillance and reporting of economically important trans-boundary aquatic animal diseases and emerging diseases. Moreover, several attempts are being made by the researchers of the institute to develop therapeutic and preventive measures against these pathogens to minimize the production loss arising due to disease outbreaks.

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

I take this opportunity to thank Secretary, DADF, Shri Tarun Shridhar and Joint Secretary (Fy.), Dr. E. Ramesh Kumar for their guidance and involving NBFGR in various programs of National Importance. I am thankful to Chief Executive, NFDB, Ms. I. Rani Kumudini for the support to this institute.

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

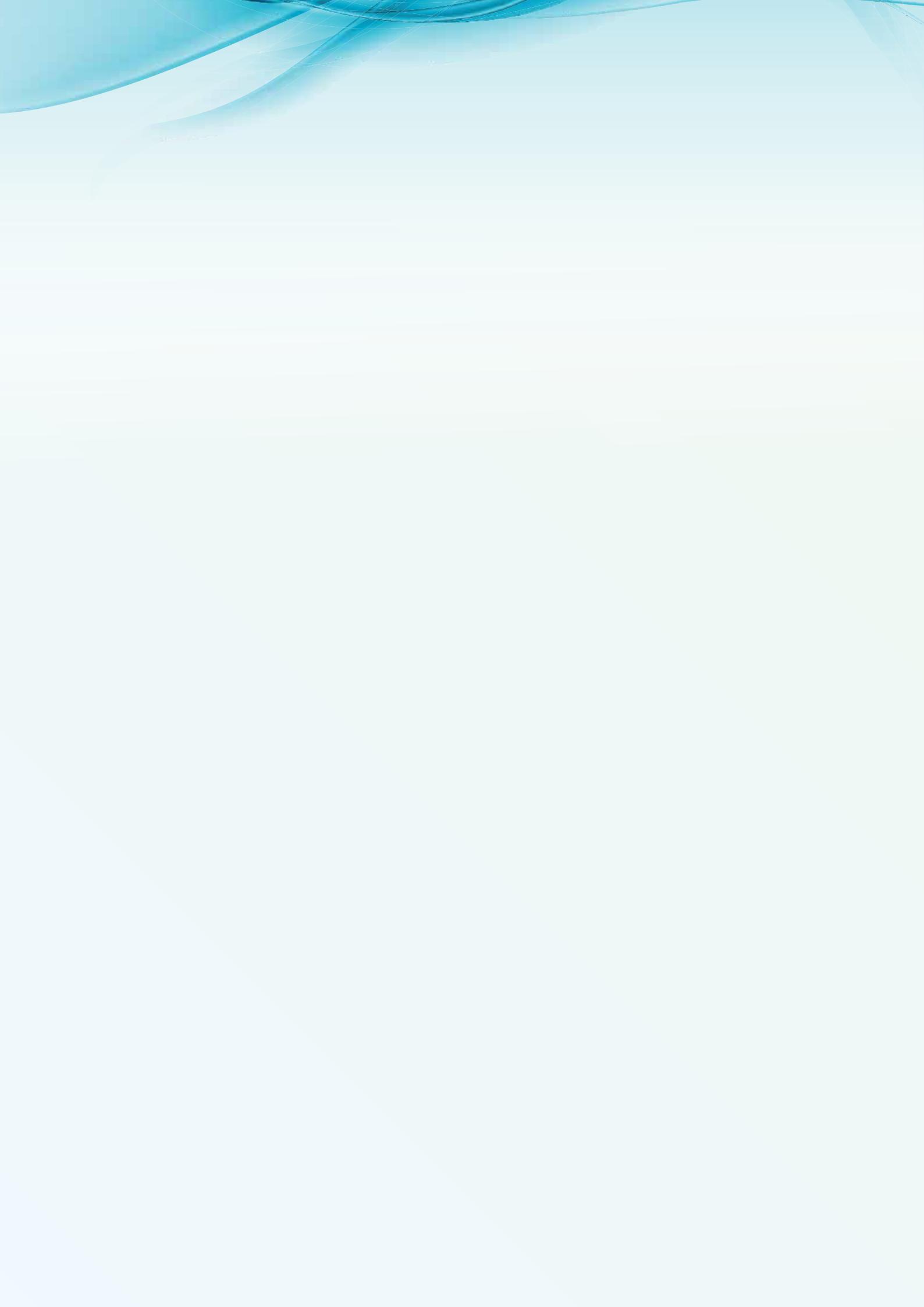
I express my heartfelt thanks to the entire publication team of the institute for their efforts and commitment in timely publication of the Annual Report 2017-18.

June 20, 2018

(Kuldeep K. Lal)
Director

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EXECUTIVE SUMMARY

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

• Lower Mahanadi Basin

To document fish diversity in lower Mahanadi basin, primary exploratory surveys, covering total 28 sites of River Mahanadi and its three main tributaries, Ib, Tel and Ong, were undertaken. A total of 112 species belonging to 13 orders, 40 families and 80 genera have been recorded, so far. Carps (Family: Cyprinidae) constitute the most abundant group (32 species, 39%) followed by catfishes (18 species, 22%). Documentation of perception and experiences of fishing communities on status of fish diversity, its decline, issues and possible measures for conservation and traditional ecological knowledge (TEK) was also carried out by interviewing fisherfolks on exploration sites of lower Mahanadi basin regions.

• Tributaries of River Ganga

For the first time, exploratory surveys in the Rivers Gandak, Budi Gandak and Baghmati - the important tributaries draining into the River Ganga were conducted. Summer and post-monsoon samplings were conducted, covering the selected 14 sites located on these rivers. The exploration covered East Champaran, West Champaran, Sheohar, Muzzafarpur, Samastipur, Vaishali and Darbhanga districts of North Bihar. The diversity rich stretches due to ecotone effect encountered during the study were Valmiki Nagar on upstream of Gandak river, Belwaghat on Baghmati and Sonepur on the River Gandak. More than 60 fish species were recorded from the region during explorations. A total of about 54 fish species covering 8 orders, 17 families and 37 genera were recorded from the River Gandak. Saraiyamaun, an horse-shoe shaped wetland

spread in 319 ha area situated near Bettiah in the East Champaran district was also studied.

• Cauvery River Basin

Exploratory surveys were conducted in the middle stretches of the Cauvery river (7 stations) between the waterfalls at Hogenakkal and its confluence with the River Amaravathi, a distance of about 200 km along the river, and the Bhavani river (6 stations) between Pillur dam and its confluence with the Cauvery, a distance of about 160 km, including the Stanley and Bhavanisagar reservoirs. Eighty one species of fish, including 14 endemic species and 13 exotic species, were collected from the surveys.

• Ramsar sites in Kerala

Exploratory surveys were carried out in Ramsar sites in Kerala, viz., Sasthamkotta, Vembanad and Ashtamudi lake and a total of 127 species (703 individuals) were collected. Twenty species were recorded from Sasthamkotta lake comprising 16 genera of 11 families, 80 species from Ashtamudi lake, comprising 40 genera of 25 families and 104 species recorded from the Vembanad lake comprising 76 genera of 53 families. Ten new records were observed from Vembanad lake. DNA sequences were generated for 104 species from Vembanad lake and 16 species from Ashtamudi lake. Taxonomic ambiguity was noted among gobies, flatheads, and soles distributed in these estuarine waters.

• Andaman Islands

Exploratory survey was carried out at five different locations of Andaman Islands. Among the 85 specimens collected, 79 species (38 families) were identified, besides that, tissue samples and voucher specimens were stored. Sequences of mitochondrial COI gene were generated for few specimens to resolve taxonomic ambiguities.

- **Species Characterization**

New species discovered: A new *Pangasius* species has been discovered from the River Krishna, named as *Pangasius silasi*. Morphologically, *P. silasi* is differentiated from its congener *P. pangasius* by a combination of characters. For several morphological characters, *P. silasi* is also distinct from *P. myanmar*, which is reported from Myanmar and has overlapping distribution with *P. pangasius*. The vomero-palatine dentition in *P. silasi* is distinct from the dentition structures reported for all the other *Pangasius* species.

Four species of the genus *Osteobrama* collected from five different sampling sites of Chindwin and Barak river basin of Northeast India, namely *O. belangeri*, *O. cotio*, *O. cunma* and *O. feae*, were characterized. *O. cunma* was validated to the status of species through combination of morphometric data, molecular marker and truss analysis. Characterization of the genus *Osteobrama* will contribute for future management and conservation program of these highly endemic and threatened fish species, especially *O. belangeri*.

COI and cytochrome b mitochondrial gene sequences were generated in 236 fish samples belonging to 46 species collected from 16 tributaries of Mizoram. Phylogenetic analysis was done for 11 fish genera, viz., *Amblyceps*, *Barilius*, *Crossocheilus*, *Garra*, *Laubuka*, *Lepidocephalichthys*, *Neolissochilus*, *Pethia*, *Pseudolaguvia*, *Psilorhynchus*, and *Schistura* using COI and cyt b genes. The analysis indicated about new species under genus *Amblyceps*, which is compared with congeners based on morpho-meristic traits.

To reveal the phylogenetic relationship among clupeiforms, explorations were carried out in Tamil Nadu, Kerala, Karnataka, Goa, Pondicherry, Mahe and Andaman and Nicobar islands coasts and more than 400 voucher specimens belonging to 30 species were collected. COI sequencing and taxonomic confirmation is being carried out. A total of 237 COI sequences were generated which belonged to 42 clupeiform fish species. Representative voucher specimens were kept for NBFGR museum.

In order to elucidate phylogenetic relationship for the selected molluscan group of species, a total of 27 species (90 individuals) belonging to the

family Conidae and 8 species (40 Individuals) of Strombidae were collected from seven sampling sites along both the coasts of India including Lakshadweep islands. Species-specific molecular signatures using mitochondrial genes (CO1, 12sRNA, and 16sRNA), nuclear gene (H3) were generated for all the collected specimens.

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

- **Validation of microsatellite markers for *Chitala chitala***

A total of 28 novel polymorphic microsatellite markers were used to generate individual genotype data for 75 individuals from 3 distinct riverine populations (Son, Satluj and Brahmaputra) of India. The pairwise F_{st} ranged from 0.0357 (Son-Brahmaputra) to 0.0604 (Son-Satluj). The study indicated the usefulness of markers for population genetics.

- **Development of large scale microsatellite loci**

The microsatellite sequences were identified from the genomes of four important species, such as, *Thunnus albacares*, *Litopenaeus vannamei*, *Scomberomorus commerson*, *Trachinotus blochii* on Pacific Biosciences (PacBio) RS II sequencing platform, using C4 chemistry on single-molecule real-time (SMRT) cells.

- **Genetic Stock characterization**

A total of 374 tissue (muscle, finclip, gonads) samples of target species, such as *Chitala chitala* (22), *Silonia silondia* (63), *Tor tor* (81) *Systomus sarana sarana* (118) and *Mugil cephalus* (33) were collected from 14 various riverine locations of India which includes eight rivers, such as, Narmada, Ken, Son, Mahanadi, Betwa, Godavari, Gandak and Gomti.

Population genetic analysis of *Perna viridis* was carried out along the Indian coast (170 samples from 5 locations) using mitochondrial cyt b gene (885 bp) and ATPase 6 gene (714 bp), which revealed three distinct sub-populations, i.e., West coast, East coast and the Andaman islands.

Multiplex microsatellite marker panels were developed to identify the genetic stocks of *Sillago sihama* and *Perna viridis*. In *S. sihama*, four panels of three primers each and five panels of two

primers each were standardized and in *P. viridis*, six panels of two primers each were developed.

Program: Genomic resources for important fishes

- **Genomics of *Clarias magur* (Hamilton, 1822)**

The *de novo* gene prediction of the assembled draft genome of *C. magur* resulted in 81,493 putative genes. The functional annotation of genes revealed 59,934 Blast hits and 33,974 genes were got annotated in GO terms. Repeat analysis of *C. magur* genome revealed that the repeats covered approximately 40% of the genome and retro-elements, and DNA transposons covered around 17% of the genome.

The variation analysis of 7 AMPs, *viz.*, BPI_1, BPI_2, LEAP, NK lysin type1, NK lysin type2, NK lysin type3 and hepcidin, resulted in identification of SNPs in BPI_1, BPI_2, NK lysin type2 and hepcidin genes.

Transcriptome assembly of both male and female brain was carried out using Trinity software, which resulted in 143,600 transcripts, out of which 1702 were unique in males and 1023 unique in females. Further, differential expression analysis of brain transcripts using DeSeq resulted in up-regulation of 6507 genes and down-regulation of 7218 genes in male and female brains.

Transcriptome data were generated to study the gene expression profile in liver and muscle of *C. magur* exposed to elevated temperature, *i.e.*, 34°C along with control (26°C) through real-time expression. The transcriptome assembly resulted in total of 7,55,418 transcripts with 423 bases median contig length, 840 bases average contig length, 1512 bases contig N₅₀ and 42.76% GC content. The real-time expression observed in muscle, liver, kidney and brain tissues of *magur* subjected to temperature stress indicated maximum expression of Park 2, Hsp 70 and Hsp 90 genes at 34°C in muscle tissue, and of Nupr 1 in kidney.

- **Genome of anadromous hilsa shad, *Tenualosa ilisha* (Hamilton, 1822)**

A high quality draft genome assembly (763.19 Mb) of *T. ilisha* was generated that showed high contiguity, comparative orthology and synteny

with the similar teleost species. The observed N₅₀ of 2.63 Mb, largest contig length of 17.43 Mb and a total of 2,867 contigs, without any ambiguous bases. In addition, with a total of 1,614,914 mined simple sequence repeats in *T. ilisha*, draft genome opens the dynamics to catalogue the population genomics studies which can cater insights for better management and conservation practices for this important fish species.

- **Stress tolerance response in cultivable freshwater fishes**

Indian major carps, *viz.*, *Catla catla* and *Labeo rohita*, were exposed to various water temperatures to estimate their limit of thermal tolerance, which was found as 39°C and 41°C, respectively. The blood parameters of the exposed samples were also estimated and compared to control, *i.e.*, 18°C. In *L. rohita*, increased levels of urea, haemoglobin, glucose and cholesterol but decreased level of serum protein were observed as compared to control.

- **Sequencing and annotation of complete mitogenome of *Chitala chitala***

The whole mitogenome of *C. chitala* was sequenced (16375 bp) and mapped to identify 13 protein coding genes (PCG), 22 transfer RNA genes, 2 rRNA genes (12S and 16SrRNA), and a control region. The ratio of synonymous and non-synonymous substitutions (Ka/Ks) indicated that 10 genes evolved under purifying selection. Phylogenetic trees were constructed on the basis of concatenated 12 PCGs to ascertain its taxonomic relatedness with other seven orders along with osteoglossiformes.

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

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

Five new cell lines [three, *viz.*, DrG (*Danio rerio* gill), DrRPE (*D. rerio* retina) and CSCVE (*Channa striatus* cardiovascular) by C. Abdul Hakeem College, Vellore and two, *viz.*, OST (*Channa striatus* thymus) and TL (*Oreochromis niloticus* liver) by ICAR-NBFGR] were deposited in the NRFC for maintenance and distribution. Thirty cell lines were characterized through sequencing of COI gene, while 18 cell lines were characterized through karyotyping. Characterization of rest of the cell lines are in progress.

Two cell lines, *Oreochromis niloticus* brain (*OnlB*) and *Oreochromis niloticus* liver (*OnlL*) was developed and characterized from Nile tilapia, *Oreochromis niloticus* for the efficient propagation of Tilapia Lake Virus (TiLV).

- **Viable progeny generated from dead brooders of Indian catfish *Clarias magur***

Viable progeny were generated from freshly (Three hours after death) dead sexually mature *C. magur*. Three hours after death, male gametes were used for artificial fertilization. Fertilization success, 85%-93% was seen from gametes derived from dead donors as opposed to 90%-95% from those derived from live control donors. The embryos showed normal development and resulted in the generation of 88%-92% viable progeny, which was similar to the progeny derived from control donors (92%-93%).

Program: Documentation of fish genetic resources of India

An online Fish Genetic Resource Information system included with multiuser data entry and query proficiencies was implemented on the World Wide Web at URL <http://mail.nbfg.res.in/FGRBase>. The system presently provides taxonomy, distribution, type specimen and other information on 3055 species along with fish photographs. The system integrated with the genomic databases like HRGFish, FMiR, FishMicrosat, Fish Karyome and FBIS facilitates user to browse the genomic information for each species.

A GIS based occurrence map of 3035 fishes covering 51,119 occurrence records was published and the existing database on 3,827 mollusc species of India was updated by including taxonomy information of about 1,550 species.

An offline database, named FASGBase: Abiotic stress responsive genes database in fishes, was developed that presently covers information on 853 genes from 38 identified gene types responsive to temperature, ammonia and salinity stresses in 40 fish species belonging to 26 fish families.

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

- **Tilapia Lake Virus diagnosis**

The first time report of infection with Tilapia Lake Virus (TiLV) from West Bengal and Kerala were

confirmed using RT-PCR, histology, isolation using cell lines *OnlL* and *OnlB* and bioassay. Following confirmation of infection with TiLV, alerts along with action points were sent to the competent authority and stakeholders including State Fisheries Departments, industry, and Animal Quarantine and Certification Services. TiLV was isolated from the diseased tilapia specimens and continuously propagated in these cell lines for 20 passages, and the maximum TiLV titre reached 107.3 ± 0.05 and 107.0 ± 0.96 TCID₅₀/ml, in *OnlL* and *OnlB*, respectively.

- **Risk Assessment of exotic species**

Survey conducted to study the presence of exotic fishes in the natural water bodies revealed that, at many places in Cauvery river, African catfish, *Clarias gariepinus*, tilapia, both Nile tilapia, *Oreochromis niloticus* and Mossambique tilapia *Oreochromis mossambicus*, and in lower stretches of Cauvery river sucker catfish, *Pterigoplichthys* sp. were present in good numbers. African catfish, *Clarias gariepinus* was in very high numbers in protected areas such as Sri Krishna temple pond in Calicut and Periyar lake in Thekkadi, Kerala. COI sequence analysis showed presence of four species of sucker catfishes, *Pterigoplichthys anistis*, *P. disjunctivus*, *P. pardalis*, and *P. ambrosetii*.

The status of alien fish species in the country was reviewed by screening all available literature and online searches. The information on historical aspects of introduction of alien fish species made for various uses, was gathered, and tracked various possible pathways responsible for entry and expansion of these alien fish species. Further, the impacts of introductions of exotic species was preliminarily evaluated using the globally available Risk Benefit Assessment models.

An International Symposium on Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture during April 20-21, 2017; Strategy Planning Workshop on Aquatic Animal Diseases Surveillance in India on April 22, 2017 and Epidemiology School on Aquatic Animal Diseases during April 24-28, 2017 involving international resource persons, were organised.

- **EUS Pathogen, *Aphanomyces invadans***

For epidemiological studies on Infection with *A. invadans*, 248 farms were randomly selected out

of a total of 358 farms in Maharajganj district of Uttar Pradesh. Information about the disease encountered during last crop and risk factors was collected from a total of 196 farmers. Total RNA was isolated from experimentally infected common carp and RNASeq data was generated at one time point, and is being analysed.

Effect of different concentrations of CIFAX on sporulation and germination of *A. invadans* was evaluated. A dose of 500 ppm of CIFAX was found to be effective in inhibiting the sporulation.

Inactivated germinated zoospores of *A. invadans* emulsified with adjuvant montanide rendered significant protection against infection with *A. invadans* as evaluated by relative percent survival and the protection was positively correlated with specific antibody level and total antiprotease activity.

- **Innate Immunity variation at Intra-specific Level**

Difference in innate immunity was compared between large-sized *Clarias magur* (25.18 ± 3.0 cm length; 116 ± 31.53 g weight) and small-sized fish (13.71 ± 1.34 cm length; 18 ± 4.54 g weight). For this, four innate immune parameters, i.e., myeloperoxidase (MPO), lysozyme, total-antiprotease and bactericidal activity were measured in mucus and serum (500 µg/mL total protein) collected from 12 large-sized and 8 small-sized fish. In large-sized fishes, lysozyme and bactericidal activity were found to be higher in mucus compared to serum. Total anti-protease and MPO showed lower values in mucus as compared to serum. Small-sized fishes also showed similar immune status in mucus and serum, but with varying level. For studying immune genes, primers were designed for detection of immune genes of TLR pathway of *C. magur*. Successful amplifications were obtained from TLR3, TLR20, TLR22, TRAF6, IRF7, IRAK4 and IL-1β genes in liver and kidney tissues.

Publications

The Institute published 50 research papers in different peer-reviewed journals, along with various popular articles during the year 2017-2018.

New Initiatives

Department of Biotechnology funded program, “Development of biotechnological approach for production of *Clarias magur* (Hamilton, 1822) spermatozoa for aquaculture.”

The Bioversity International sponsored project, “Towards responsible agriculture for preserving sustainable aquatic ecosystems: assessment of impact of agriculture effluents on aquatic food webs”.

Mangrove Board, Maharashtra funded Program, “Setting up of Marine Ornamental Fish Village at Ratnagiri: Way Forward to Promote Livelihood to Mangrove Dwellers and Biodiversity Conservation.”

Capacity Building Programs:

Farmer Oriented Program

Two special residential training programmes of 4 days duration each for the tribal community under Tribal Sub Plan (TSP) on “Fish Culture and Conservation: An option for livelihood of tribals” were conducted in which 69 tribal farmers participated.

Two training programmes of 3 days duration on ‘Fish Culture, breeding and livelihood opportunities for Tribals in fisheries’ were conducted under TSP in Assam state in collaboration with local partners from the Northeastern region, in which 59 tribal farmers participated.

Eight on-campus 03/05 days training programme on Fish Culture cum Horticulture for skill development of farmer beneficiaries under sponsorship of PMKSY-Watershed Development were conducted in which 244 candidate participated.

Utilizing sodic unfertile soil for integrated fish farming, carp fish production has been achieved at level of 5 ton/ha/year under ICAR-NBFGR & CSSRI, Lucknow collaborative institutional project. Benefit cost ratio was 5.1:1 from the aquaculture in zero productive land, besides other agricultural cropping system.

Pangasius was harvested at the level of 6500 kg in 0.23 ha water area and 8 month cultivation along with different product of intergrated farming system on the pond dyke in water-logged sodic soil condition under

ICAR-NBFGR & CSSRI, Lucknow collaborative externally funded (UPCAR) project.

Soil health cards were distributed to the 26 fish farmers of Sameshi, Sansarpur, Chaurhia, Damariya, Laulai villages of district Lucknow and Gangwara, Kursi Road of district Barabanki on World Soil Day, 2017 organized at ICAR-NBFGR, Lucknow.

Under the Tribal Sub Plan scheme of the Govt. 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, including, Sonebhadra district of Uttar Pradesh, and Kamrup (Rural) and Dima Hasao districts of Assam.

Capacity Building of Peer Researchers and Staff

- NBFGR organised a training programme on “Fish taxonomy” during 25-30 November, 2017. Fourteen trainees participated in the programme.
- Training Program on "Integrative Taxonomy and Systematics in Freshwater Fishes" during 5-10 February, 2018.
- A short term training programme on “Fish Cell Culture Techniques” at Peninsular Marine Fish Genetic Resources Centre, ICAR- NBFGR, Kochi during 12-17 February, 2018.
- A hands-on training course on “Fish Cell

Culture Techniques: Cell Line Development and Applications” during 5-9 March, 2018.

- Training program on “Genome Sequencing: Methods and Applications” during 12-17 March, 2018.
- A Human Resource Development Week on “Skill and Competency Enhancement” during 6-10 November, 2017 for enhancing the skills and competency of staffs of ICAR-NBFGR was organised. This training module was mostly focussed on improvement of technical skill of skilled supporting staff.

Farm Activities

- Seed production of Indian major carp & exotic carp was over 700 lakh spawn and sale proceed for carp spawn, fry, fingerling and table fish were at the level of over 8.0 lakhs. A total number of 10 lakh spawn were distributed to the farmers of the adopted villages under Mera Gaon Mera Gaurav programme on the occasion of Fish Farmer Day 2017.
- The advanced fingerlings produced from native broodstock of River Ganga was ranched in the religiously protected area in the River Ganga at Bithoor. A total of 2.0 lakhs fingerlings (two truckloads) were released, and were ceremonially inaugurated by Prof. S. P. S. Baghel, Hon'ble Minister of Fisheries, Govt. of Uttar Pradesh.



INTRODUCTION

Brief History

The research on fish genetic resource (FGR) management was institutionalized through the establishment of ICAR-National Bureau of Fish Genetic Resources during 1986 under the aegis of Indian Council of Agricultural Research, Department of Agricultural Research and Education, Ministry of Agriculture, Government of India. India is among the few countries who took the lead to accelerate scientific research on FGR management. The Bureau has since then made valuable contributions and has become a focal point for technical support on fish genetic resources in the country. ICAR-NBFGR has consistently worked to develop in-house capacity to generate knowledge and address researchable issues relevant to the changing needs of FGR management in

India, with thrust on keeping pace with technological advancement.

With a modest beginning during 1983 as a project, ICAR-NBFGR has metamorphosed into a lead Institute to address issues related to conservation of germplasm resources. The Bureau has advanced into a sprawling campus with administrative and laboratory infrastructure facilities including indoor hatchery, wet laboratories, public aquarium, guest house, staff quarters and above all, experimental tanks and required ponds have been created to serve the multi-faceted needs of research. In view of the fact that management of fish germplasm resources has assumed tremendous significance, it is realized that sound scientific basis is necessary to document,

understand and preserve the genetic resources which can be utilized for nutritional and environmental security of the mankind.

Over the years, the Bureau has created exemplary infrastructure, state of the art facilities and expertise in several research area including, development of fish databases, genetic characterization, gene banks, fish germplasm and habitat inventory, risk analysis of exotic species, diagnostic for OIE notified pathogens, aquatic microbes and other areas of germplasm conservation with special focus on prioritized fish agro-biodiversity species of indigenous and exotic

origin. ICAR-NBFGR has shown dynamic growth both in terms of infrastructure as well as in research programmes by including important areas, viz., whole genome sequencing, conservation genetics, functional genomics, molecular disease diagnostics, national surveillance programme, exploration of new geographical areas and unexplored aquatic resources for assessment of fish diversity. The in-house expertise development and working with networks have been inherent strengths of ICAR-NBFGR and making outreach efforts for the wide distributed and diverse fish genetic resources of the country.



VISION

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



MISSION

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



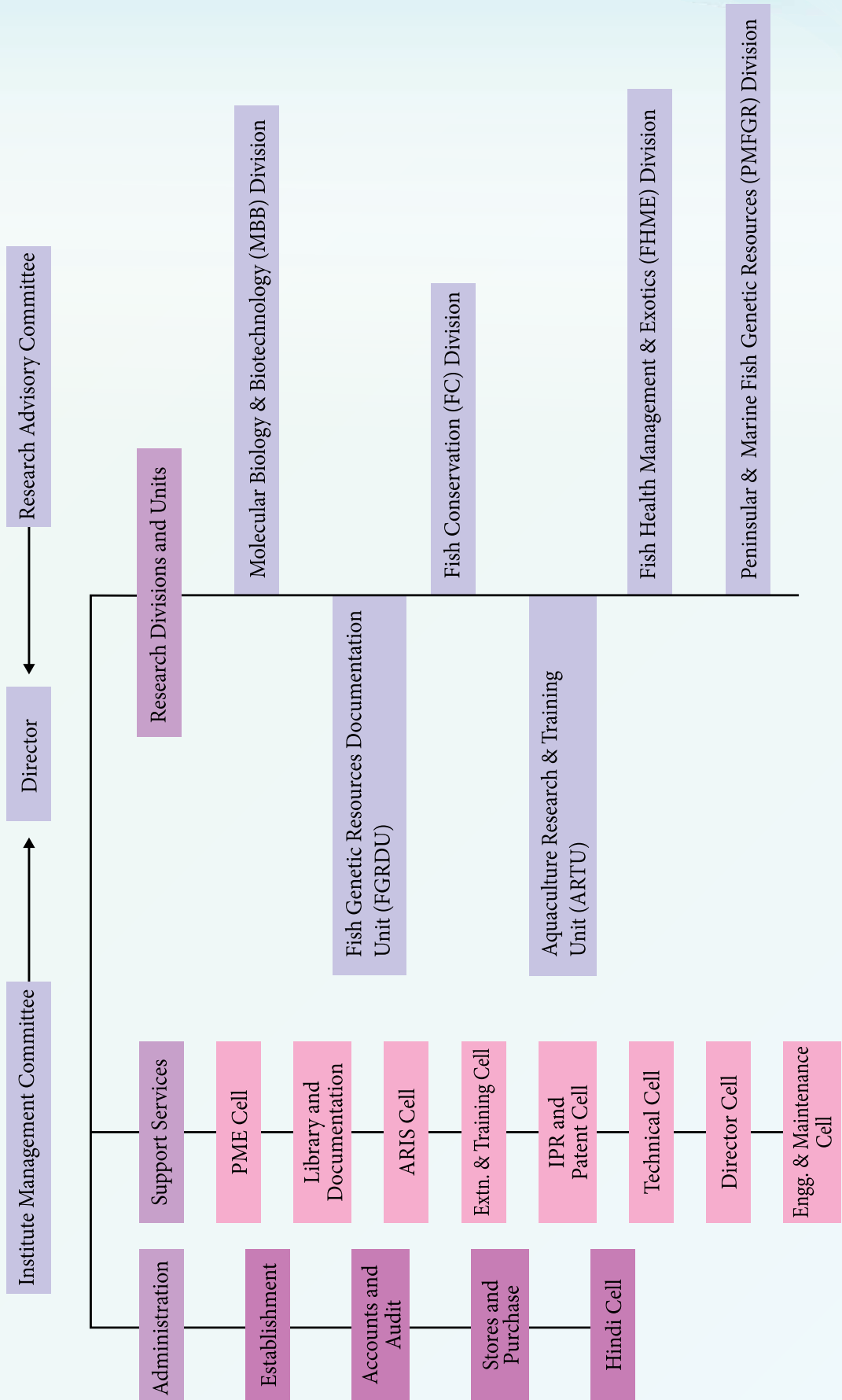
MANDATE

Exploration, characterization and cataloguing of fish genetic resources.

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

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

ORGANISATIONAL CHART



Financial Statement of ICAR-NBFGR, Lucknow

Allocation of funds and expenditure incurred during the year 2017-2018 are as follows:

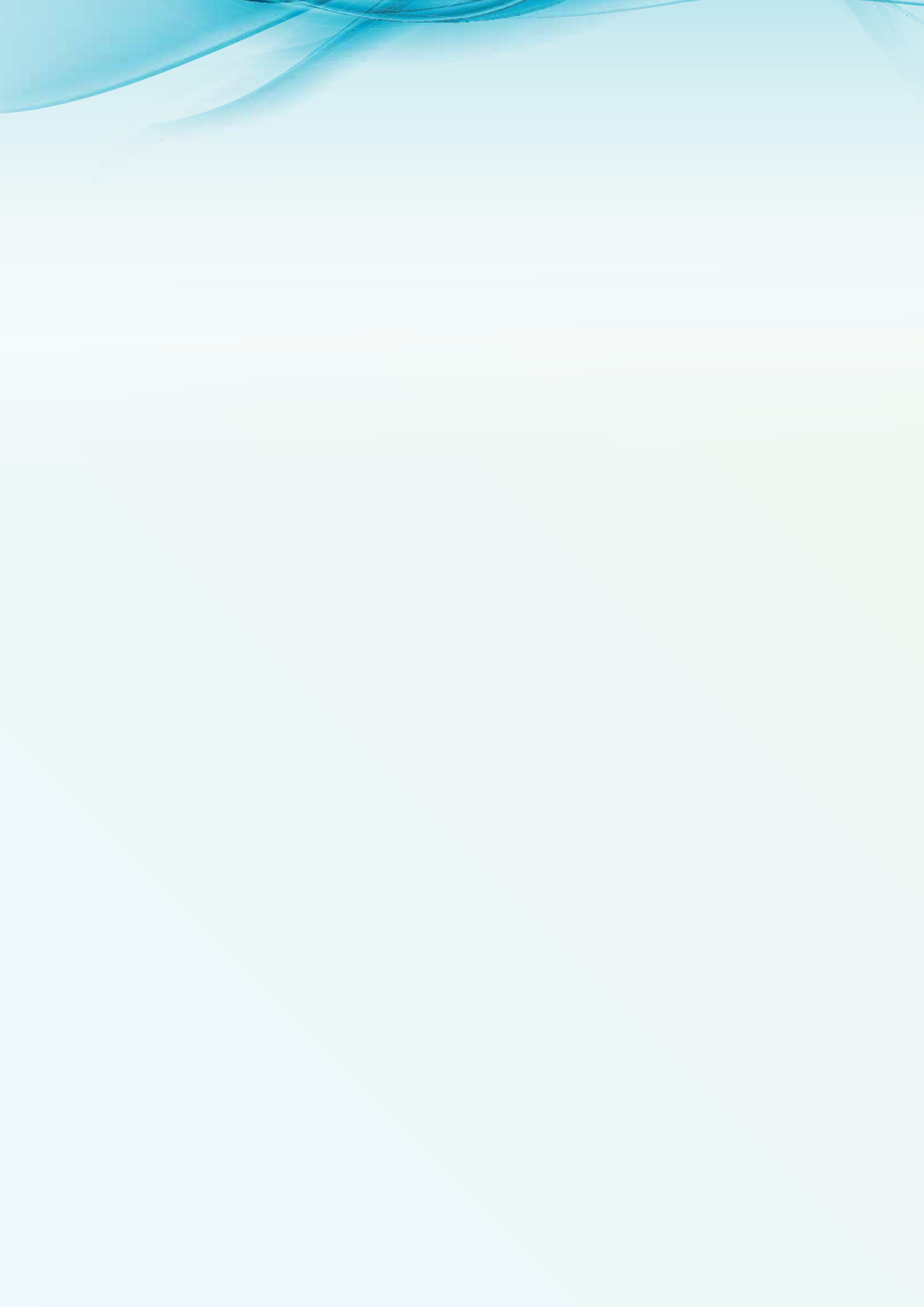
(Rs. in lakhs)

Budget Allocation	Expenditure
2412.00	2410.29

* Including loans and advances



**RESEARCH
ACHIEVEMENTS**



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



Knowing the components of biological diversity is one of the important milestones considered globally so that precise management plans can be put in place. Lack of knowledge raises the risk of losing many important units of biological diversity without even recognising their existence. The exploration is an ongoing activity at ICAR NBFGR, as part of the scientific research on aquatic genetic resource management. Explorations are useful for discovery of new species or to record extension of range of the species from different aquatic resources, which can be further evaluated to ascertain

their ecological or commercial importance. The institute has pursued this activity individually or through networks during the period and added number of species from the rivers, wetlands and other resources. Since, many of the aquatic resources of the country are still not explored or under explored, hence, explorations are essential to update fish diversity of the country including alien fish species and to assess the status of each species in different water bodies. The activity is required to suggest appropriate conservation measures and domestication protocols for the species.

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

Subproject I: Exploration and cataloguing of the fish diversity from Cauvery river basin.

Period: April, 2014 - March, 2019

Personnel: V. S. Basheer (PI), T. Raja Swaminathan, Charan Ravi and C. P. Rajool Shanis

Funding Support: Institutional, ICAR-NBFGR

Exploratory surveys were conducted in the middle reaches of the Cauvery at 7 stations covering a distance of about 250 kms, and its tributary, and the Bhavani river at 6 stations for a distance of about 160 kms, including the Stanley and Bhavanisagar reservoirs. Habitat in the riverine stretches was mostly composed of strong flow over bedrock and boulders, with numerous cascades. The River Bhavani, upstream of Bhavanisagar reservoir flows through densely forest areas with canopy cover extending over the river. The survey yielded an addition of 20 more species of freshwater fish bringing a total of 92 species, belonging to 8 orders, 23 families and 55 genera. The documented species includes, 19 endemic, 57 native, 6 stocked and 10 exotics. Cyprinidae is the most abundant family, contributing 51% of the fish fauna of the Cauvery followed by Bagridae, second most abundant with 9% of the total species. *Clarias gariepinus* was encountered at all sampling stations on the River Cauvery, but not in the River Bhavani. Tilapia was abundant at all landing centres located near reservoirs, with *O. niloticus* dominating the catch. No specimens of the invasive sucker mouth catfish were encountered in this stretch of the river. Majority of the fishes were under conservation status of least concern, while one species under critically endangered and four species under endangered category, as per the IUCN status.

Due to poor monsoons in 2015-16 and 2016-17, water levels in the river channel downstream of major reservoirs was low, and large species were infrequently encountered. Bhavanisagar reservoir yielded the most diverse catch with 38 species, followed by Hogenakkal and Hemmige with 34 species each. Commercially important indigenous species in this stretch of the river included *Hypselobarbus carnaticus*, *Wallago attu*, *Ompok bimaculatus*, *Etroplus suratensis*, *Sperata*

sp., and *Labeo* sp. Interviews with fishermen revealed that destructive fishing practices involving dynamite and sand mining have negatively impacted fish populations in the river and need to be addressed on a priority basis. The majority of fishing activity in the region is based on gill nets, and fishermen also noted significant losses due to otters scavenging netted fish in some stretches of the river.

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

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



Fig.1 Map of the sampling locations during the study

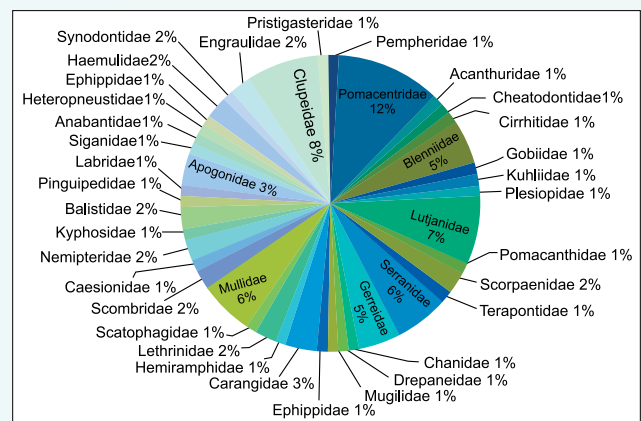


Fig. 2 Family-wise distribution and proportion of fish species, found during the study

Period: April, 2017 – March, 2019

Personnel: T. T. Ajith Kumar (PI), A. K. Pandian and Teena Jayakumar T. K.

Funding Support: Institutional, ICAR-NBFGR

Surveys were carried out at fish landing centers, markets and tidal pools at Junglighat, Wandoor, Bathu basti, Chidiya tapu, Ross and Havelock islands (Fig. 1). Total 86 species of marine fishes belonging to 8 orders, 41 families and 66 genera were documented (Fig. 2).

Taxonomic ambiguity was observed in specimens of the family Blennidae. Rare occurrences of *Pempheris adusta*, *Plesiops corallicola*, *Cephalopholis nigripinnis*, and *Hemiramphus lutkei*, were recorded from Chidiya tapu and Junglighat sampling locations. Important water quality parameters were recorded from the sampling locations.

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

Period: April, 2016 – March, 2019

Personnel: Lalit K. Tyagi (PI), Sangeeta Mandal, Trivesh S. Mayekar, Rejani Chandran, Amit S. Bisht and Sanjay K. Singh

Funding Support: Institutional, ICAR- NBFGR

Three primary exploratory surveys were undertaken during the year. Total 28 sites of river Mahanadi and its three main tributaries (Ib, Tel and Ong) in the lower basin were explored for fish and tissue collections during the survey (Fig. 3). Taxonomic identification of fish specimen recorded during exploratory surveys was undertaken based on morphological and meristic characters. In addition to the 67 species recorded in the first year (2016-17), 45 additional species were identified during two explorations of this year (2017-18) and the identification is in progress for 3rd exploration (total 6th) collections. A total 112 nos of fin fish species belonging to 13 orders, 40 families and 80 genera have been identified, so far. Out of the 13 orders, Cypriniformes was the most prevalent order which consisted of 46 species followed by Perciformes (21 fish species) and then Siluriformes (20 fish species). Cyprinidae was the most dominant family comprising 44 species (Fig. 4).

Site-wise fish diversity data was analysed for lower Mahanadi. Results indicated low species dominance, high diversity and high evenness throughout all major

sites of lower Mahanadi across three seasons (Table 1). Individual rarefaction curve of all the major sites of lower Mahanadi were generated which showed adequacy of sampling for the diversity obtained (Fig. 5). Rarefaction allows the computation of species richness for a given number of individual samples, based on rarefaction curves. This curve is a plot of the number of species as a function of the number of samples. Most relatively abundant species was *Cirrhinus reba* with 6.46%, followed by, *Rita chrysea* and *Labeo bata* with 4.83% and 4.3%, respectively. Five exotic species were recorded namely *Oreochromis mossambicus*, *Oreochromis niloticus*, *Ctenopharyngodon idella*, *Cyprinus carpio* and *Hypophthalmichthys molitrix* with relative abundance 0.89%, 0.78%, 0.52%, 0.36% and 0.07%, respectively. Site-wise fish diversity data was analyzed for Tel, Ong and Ib tributaries. Results indicated low species dominance, high diversity and high evenness across all major sites of both the rivers (Table 2-4). Data (length, weight and truss image) on a total of 3366 fish samples were recorded during the year.

In order to resolve taxonomic ambiguity in case of Mahseer, *Tor sp.*, 25 sequences of Cytochrome c oxidase I (COI) were generated for species confirmation. All the sequences were found to be *Tor putitora*. COI sequencing was undertaken for several other samples for assisting in identification of fish species. Sequence data were analyzed and compared with the morpho-meristic identification. Habitat parameters i.e., micro-habitat type, riparian and aquatic vegetation, dominant substratum were recorded from all the surveyed sites along with water parameters like temperature, dissolved oxygen, salinity, total dissolved solids and turbidity which are being tabulated and analyzed. Documentation of perceptions of fishing communities and other stakeholders about fish diversity, associated socio-economic aspects and traditional ecological knowledge of fishing communities at micro level along selected rivers was undertaken in 6 villages along the Tel and Ong rivers.



Fig. 3. Exploration of fish diversity in lower Mahanadi basin

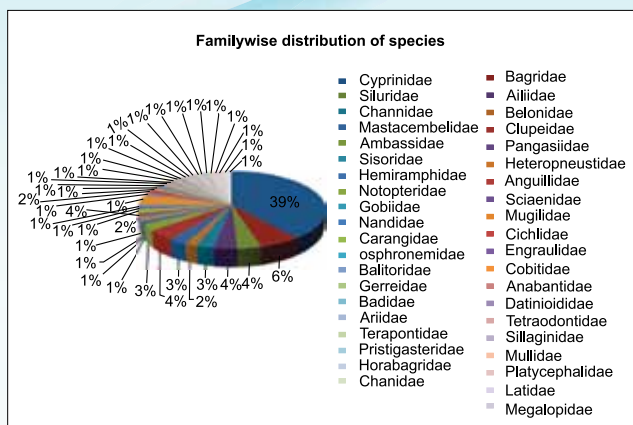


Fig. 4. Family-wise distribution of fish species in lower Mahanadi basin during this study

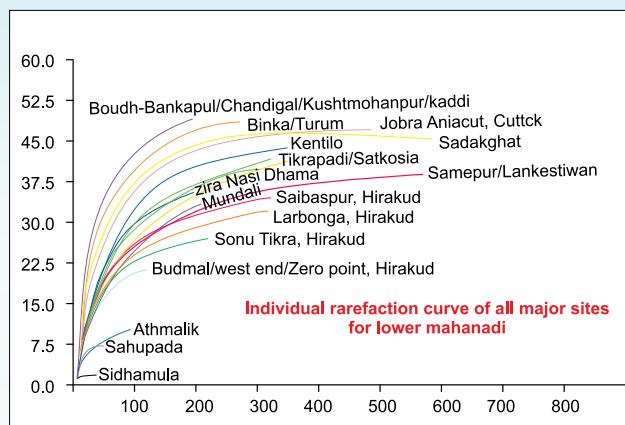


Fig. 5 Individual rarefaction curve of all major sites for lower Mahanadi

Table 1 Site-wise fish diversity in lower Mahanadi during this study

Indices	Lower Mahanadi sites														
	Larbonga, Hirakud	Balbaspur, Hirakud	Sonu Tikra, Hirakud	Budmal/ West end/ Hirakud	Sadak-ghat	Dhama	Binka/ Turum	Sonepur/ Lanke-shwari/ Sahupada	Boudh- Bankapul/ Chandigal/ Kushtmohanpur	Athmalik	Tikrapada/ Satkosia	Kentilo/ Sidhamula	Mundali	Jobra, Cuttk	Zila nasi
Dominance_D	0.047	0.039	0.057	0.084	0.057	0.045	0.034	0.0489	0.032	0.187	0.056	0.041	0.090	0.029	0.053
Shannon_H	3.310	3.446	3.096	2.831	3.38	3.417	3.582	3.4	3.66	1.919	3.258	3.454	2.969	3.69	3.303
Evenness_e ^{H/S}	0.677	0.747	0.691	0.678	0.554	0.648	0.705	0.525	0.762	0.567	0.530	0.645	0.512	0.756	0.663
Margalef	6.901	7.768	5.733	5.022	8.679	8.028	8.973	8.329	9.173	2.427	8.163	8.26	6.97	8.953	7.834

Table 2 Site-wise fish diversity in Tel river during this study

	Tel river sites			
	Manmunda	Paanmura	Belgaon	Kisinga
Taxa_S	39	30	39	7
Individuals	216	144	214	19
Dominance_D	0.1705	0.05883	0.05053	0.2355
Simpson_1-D	0.8295	0.9412	0.9495	0.7645
Shannon_H	2.718	3.038	3.252	1.658
Evenness_e ^{H/S}	0.3884	0.6955	0.6624	0.7499
Margalef	7.069	5.835	7.082	2.038

Table 3 Site-wise fish diversity in Ong river during this study

Parameters/ Indices	Ong river sites		
	Dhaura Khaman	Sale Bhata	Bhelua Padar
Taxa_S	20	20	8
Individuals	91	99	36
Dominance_D	0.1011	0.1025	0.1667
Simpson_1-D	0.8989	0.8975	0.8333
Shannon_H	2.57	2.559	1.91
Evenness_e ^{H/S}	0.6531	0.6463	0.8445
Margalef	4.212	4.135	1.953

Table 4 Site-wise fish diversity in Ib river during this study

Parameters/ Indices	Ib river sites					
	Barghat	Sundargarh	Bhogapalli	Samdama	Pamsala	Ranikombo
Taxa_S	49	48	24	22	13	13
Individuals	1576	1304	383	293	217	200
Dominance_D	0.04234	0.02902	0.05284	0.05895	0.09197	0.08595
Simpson1-D	0.9577	0.971	0.9472	0.941	0.908	0.9141
Shannon	3.542	3.689	3.022	2.929	2.467	2.501
Evenness_e^H/S	0.7049	0.8337	0.8554	0.8503	0.907	0.938
Margalef	6.519	6.552	3.867	3.697	2.231	2.265

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

Period: April, 2017– March, 2019

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

Funding Support: Institutional, ICAR- NBFGR

A new work was initiated for exploration of fish diversity in three least studied mid-Himalayan tributaries namely, Gandak, Burhi Gandak and Bagmati of the River Ganga in North Bihar. Two exploratory surveys were conducted during summer

and post-monsoon seasons in the selected rivers covering the districts of East Champaran, West Champaran, Sheohar, Muzaffapur, Samastipur, Vaishali and Darbhanga during the period. All the rivers are left bank tributaries of the River Ganga and traverse 300 to 394 km distance in North Bihar before joining the River Ganga (Table 5). Samples for fish diversity and related parameters were collected and analysed from 14 sites covering 5 each in the Rivers Gandak and Burhi Gandak, and 4 in Bagmati (Fig. 6). The fish diversity of the rivers was documented for the first time comprising a total of 79 fish species under 9 orders, 23 families and 64 genera (Fig. 7). A coldwater endangered fish *Tor putitora* was also collected from upstream of River Gandak. For the first time, a rare fish, *Sisor rheophilus* was collected from these river systems.

Table 5 Characteristics of selected rivers of North Bihar

Rivers	Total length (km)	Length in Bihar, India (km)	Catchment area (km ²)	Names of the sampling sites	Remarks
Gandak	640	300	46,300	Valmikinagar, Bagaha (Dhanada Pul), Dumarigaon, Badichak, Bariyapur, Rewaghat, Hadsarganj, Hajipur	Snow-fed river with course shifting nature
Burhi Gandak	320	320	12,180	Dumri, Sagauli, Tharghatwa-Lalmania, Mahua gaon, Gangati, Saidpur, Singhiya Ghat	Spring-fed river also shifting of course
Bagmati (tributary of Kosi)	589	394	14,384	Dheng, Maniyari, Belwaghat, Kewatsa, Akarha	Snow-fed. The main river Kosi is known for shifting of lateral channels exceeding 120 km during the past 250 years

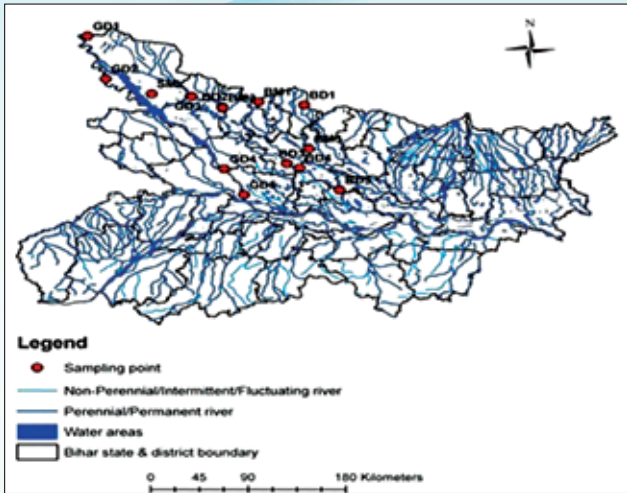


Fig. 6 Map of the region showing different rivers and sampling sites

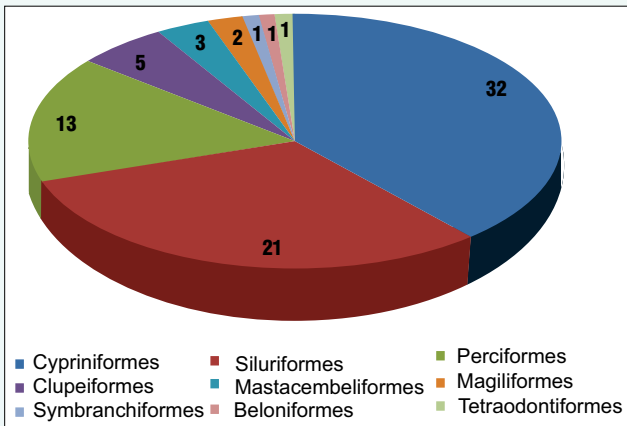


Fig. 7 Distribution of fish species under different orders from three rivers of North Bihar

Rivers and their fish diversity

The Gandak River: A total of 67 fish species under 9 orders, 22 families and 51 genera were collected and identified from river Gandak. A coldwater endangered fish *Tor putitora* was collected from upstream Valmikinagar site. As per IUCN, out of total 67 species recorded one species is categorised as endangered, 5 near threatened, 58 least concern and one each as not evaluated (NE) and data deficient (DD).

Burhi Gandak: A total of 60 fish species under 9 orders, 20 families and 47 genera were collected and identified from river Burhi Gandak. As per IUCN, out of total 60 species collected so far, 5 species are categorised as near threatened and 55 as least concern.

Bagmati River: The total length of the river is about 589 km. It traverses nearly 394 km in Bihar and the rest in Nepal. A total of 63 fish species were collected and identified from the river under 9 orders,



Fig. 8 *Sisor rheophilus* (Ng, 2003), a very rare cat fish species collected from river Bagmati at Belwaghat, is reported for the first time from the system.

22 families and 50 genera. As per IUCN categorisation, one species is categorised as endangered (EN), 5 near threatened (NT), 56 least concern (LC) and one Data deficient (DD). A rare species, *Sisor rheophilus* (Fig. 8) was collected from river Bagmati at Belwaghat, is reported for the first time from the system.

Saraiyamaun wetland

Saraiyamaun (E 84° 26.112', N 26° 48.798') is a horse-shoe shaped wetland located about 8 km distance from Bettiah in West Champaran district of Bihar (Fig. 9). The wetland is situated at 65 m from mean sea level. Saraiyamaun is famous in the region for its fishery, tourism importance and also for the water, which is believed by the locale for therapeutic importance in digestive disorders. The wetland appears to be formed after dereliction of river stretch. The wetland is spread over 319 ha area encircling the land of Majharia village more or less in the form



Fig. 9 Google map of horse-shoe shaped Saraiyamaun wetland

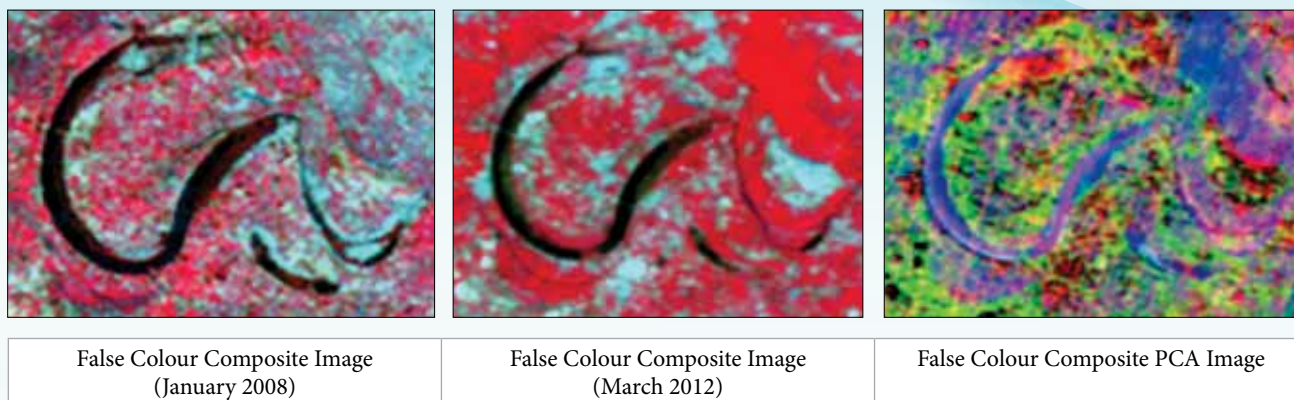


Fig. 10 False colour composite image and PCA image generated for the study area for two different years.

of an island and seasonally connected to a rivulet Haraha. The main source of water is precipitation and runoff from the catchment area. The wetland was previously connected with the river Gandak but disconnected later due to massive anthropogenic activities. The average depth of the wetland is about 6.0 m, while maximum depth is 9.0 m. The riparian region comprises mixed forest dominated by Jamun tree (*Syzigium cumini*), mango orchards, agricultural fields and human settlements including fishers.

A total of 58 fish species were collected and identified from the wetland belongs to 9 orders, 23 families and 52 genera. The fishes were of smaller sized, because of intensive fishing activities.

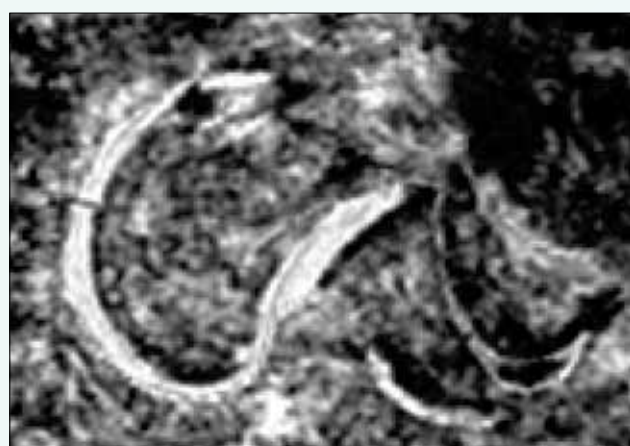
Surface water and vegetation analysis of the wetland

Remote sensing techniques (Panchromatic and Multispectral) were applied in Saraiyamaun wetland for assessment of the change in water extent and

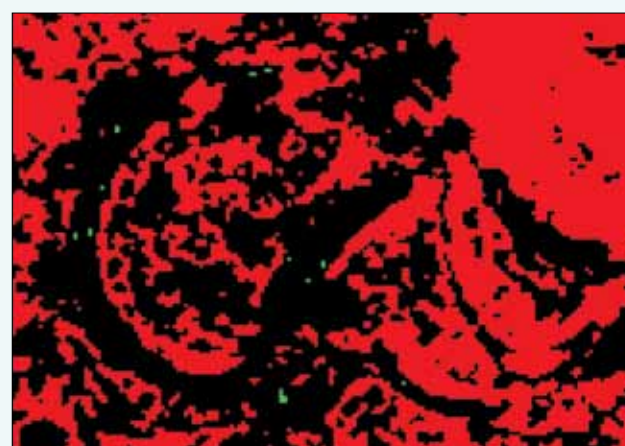
quality, and change in the riparian cover. Bhuvan, an Indian Geo-Platform of Indian Space Research Organization was used to download the satellite data of different time periods for the study area.

Principal Component Analysis (PCA) was done for water surface monitoring of the wetland to assess changes in water levels, water extents and turbidity. (Fig. 10) depicts the false colour composite image generated for the study area for two different years.

The Normalized Difference Vegetation Index (NDVI) was applied for assessment of change and loss in vegetation cover, which determines the density of green image on a patch of land. NDVI was calculated from the visible and near-infrared light reflected by vegetation. To assess the vegetation of different years, NDVI images were generated using the band 3 and band 4 images of 2008 and 2012 years. The images of 2008 and 2012 years (Fig. 11), indicated that vegetation has increased in and around wetland immensely



NDVI difference image between January 2008 and March 2012



Images highlighting increase or decrease in vegetation

Fig. 11 NDVI difference image between January 2008 and March 2012

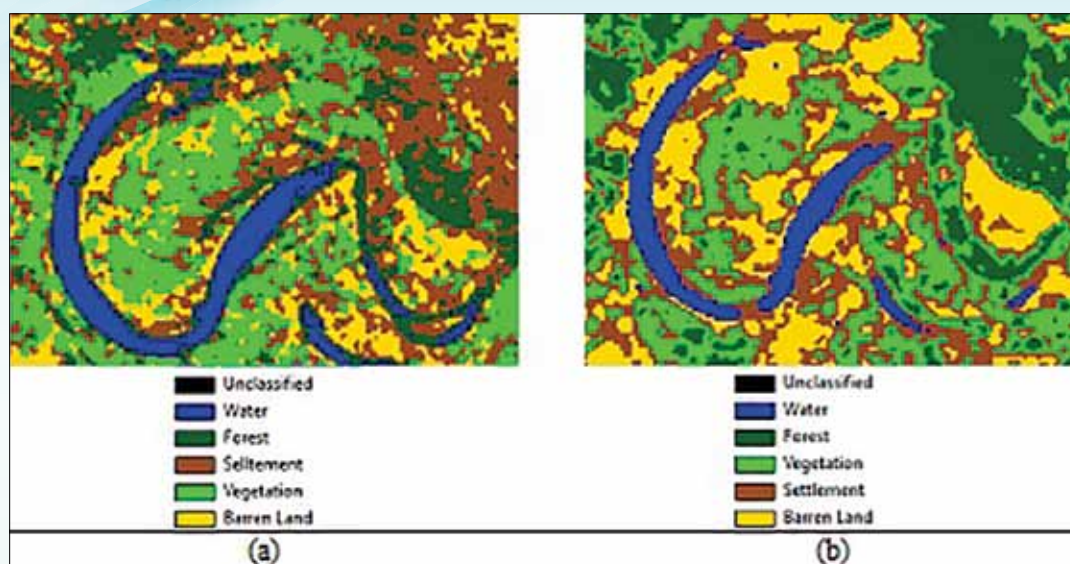


Fig. 12 Land use / land cover map of the study area (a) January 2008 (b) March 2012

during the span of four years and encroaching towards water area at few places.

The relative loss of water, shrinkage in the lake area, discontinuity, change in turbidity and vegetation, support the results of PCA. NDVI analysis were done by using these classified images (Fig. 12).

Fisheries and Fishing Activities in rivers and Saraiyamaun wetland:

The most of the stretches of the Gandak, Burhi Gandak and Baghmata rivers are inhabited by sizeable fishermen population in which good number of fishers are engaged in fishing by using all sorts of gears including cast and gill nets of varying mesh sizes, rod & lining, and traps. As a result of over exploitation, only small sized fishes are generally caught throughout the year except monsoon. Generally the gears operated in the systems are resource specific. Maximum fishing activities reported during monsoon to post-monsoon seasons, and intensify towards cut waters and floodplains after receding of flood. Deeper pools are also targeted using cast and drag nets. The various gears in vogue i.e., monofilament and multifilament gill nets, drag nets, cast nets, mosquito nets, seines, traps and baskets: hook and lines, and harpoons are recorded from the region.

Project: Characterization and DNA barcoding of fishes from Mizoram
Period: December, 2014 – May, 2018
Personnel: Mahender Singh (PI)

Funding Support: Department of Biotechnology, Govt. of India

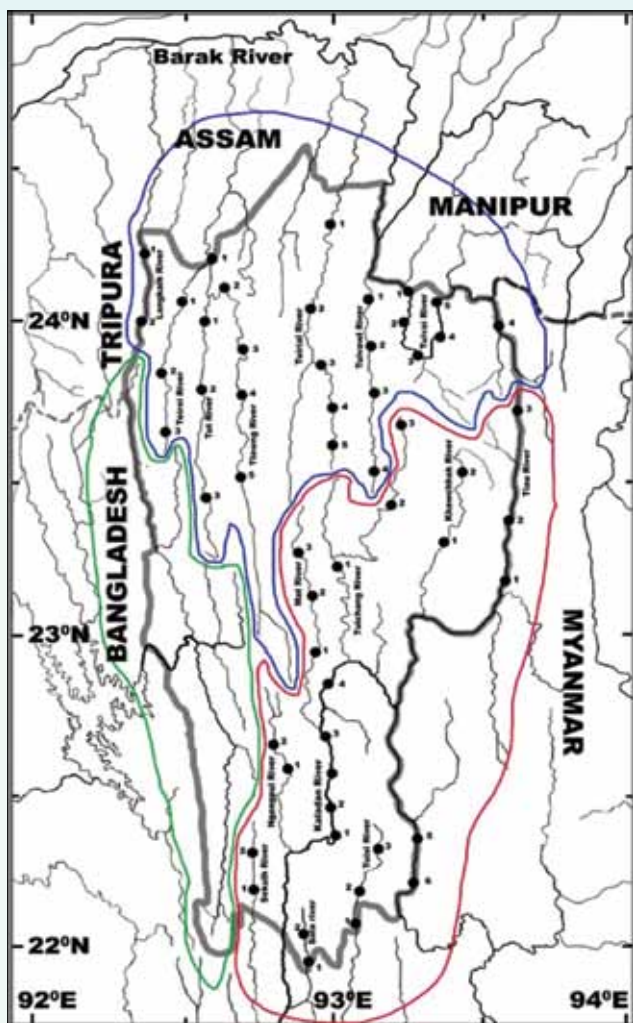
During the year (2017-18) Karnaphuli drainage (encircled by a green line in the map (Fig. 13), 24 sites from five rivers (De, Seling, Keisalam, Aivapui and Mar) were surveyed. Further, the Kaladan and Barak rivers drainage were revisited. Each site had been visited once each. Fishes were collected using cast net, drag net and other local fishing methods. Depending on the availability of the specimens, 4-5 samples were preserved in good quality alcohol and another 4-5 samples were preserved in formaldehyde for further morphological assessment in the laboratory. Samples from different collected localities (though belonging to the same species) were preserved separately in both alcohol and formalin to analyze any variation in gene composition and morphology.

DNA isolation was carried out for 395 samples, including re-isolation of 176 tissue samples collected earlier and 219 samples of newly collected specimens of 23 species. PCR amplification for Cytochrome c oxidase I was carried out for 516 samples and selected PCR product were used for 448 DNA sequencing reactions with forward/ reverse primers belonging to 228 samples, 24 species. Similarly, PCR amplification for Cytochrome b was carried out for 396 samples and selected PCR product were used for 328 DNA sequencing reactions with forward/ reverse primers belonging to 198 samples of 23 species.

Phylogenetic analysis using COI & CB genes was done for eleven genera namely *Amblyceps*; *Barilius*; *Crossocheilus*; *Garra*; *Laubuka*; *Lepidocephalichthys*;

Neolissochilus; *Pethia*; *Pseudolaguvia*; *Psilorhynchus*; and *Schistura*. The analysis gave clue about one new

species (Fig. 14), which is being compared with congeners based on morpho-meristic characters.



Encircling Green line- Rivers of Karnaphuli drainage
 Encircling Blue line- Rivers of Barak drainage
 Encircling Red line - Rivers of Kaladan drainage

Fig. 13 Map of River system of Mizoram showing different drainage and collection spots

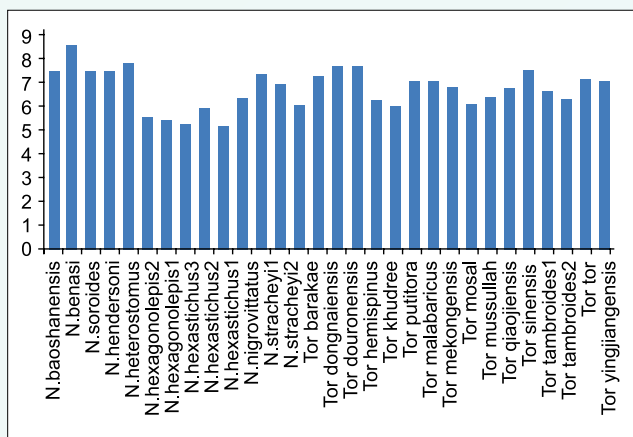


Fig. 14 Genetic distance (%; Y-axis) of *Neolissochilus* sp. as calculated against 24 species/ clades of *Neolissochilus* and *Tor* genus (X-axis)

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

Period: January, 2016 – January, 2019

Personnel: P. R. Divya (PI)

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

Four repeated collections were made from 5 sampling sites (Sasthamkotta, Water Tank Fish Market, Anjilimood, peruvellikara and Muthupillakkadu) of Sasthamkotta lake comprising of 16 genera of 11 families. Three collections each were made from 8 sampling sites (Koivila, Thekkumbhagom, Sakthikulangara, Kavanad, Sambranikodi, Ashtamudi, Perumon and Edachal) of Ashtamudi lake and total 80 species were collected from Ashtamudi lake, comprising of 40 genera of 25 families. Fig. 15 represents the image of *Plotosus* species collected from Ashtamudi lake using gillnets. Additional 2 collections were made from three major sampling sites of Vembanad lake. One hundred and four species collected from the lake comprising 76 genera of 53 families. The family Cyprinidae was the most predominant group followed by Gobidae, Cichlidae, Channidae, Engarulidae, Bagridae and Carangidae (Fig. 16). Newly recorded species from this region includes, *Apistus carinatus*, *Butis koilomatodon*, *Odontamblyopus roseus*, *Myripristis cf. berndti*, *Bodianus cf. neilli*, *Myripristis cf. berndti*, *Monodactylus argenteus* and *Abudefduf cf. vaigiensis*.



Fig. 15 *Plotosus* species collected from Ashtamudi Lake

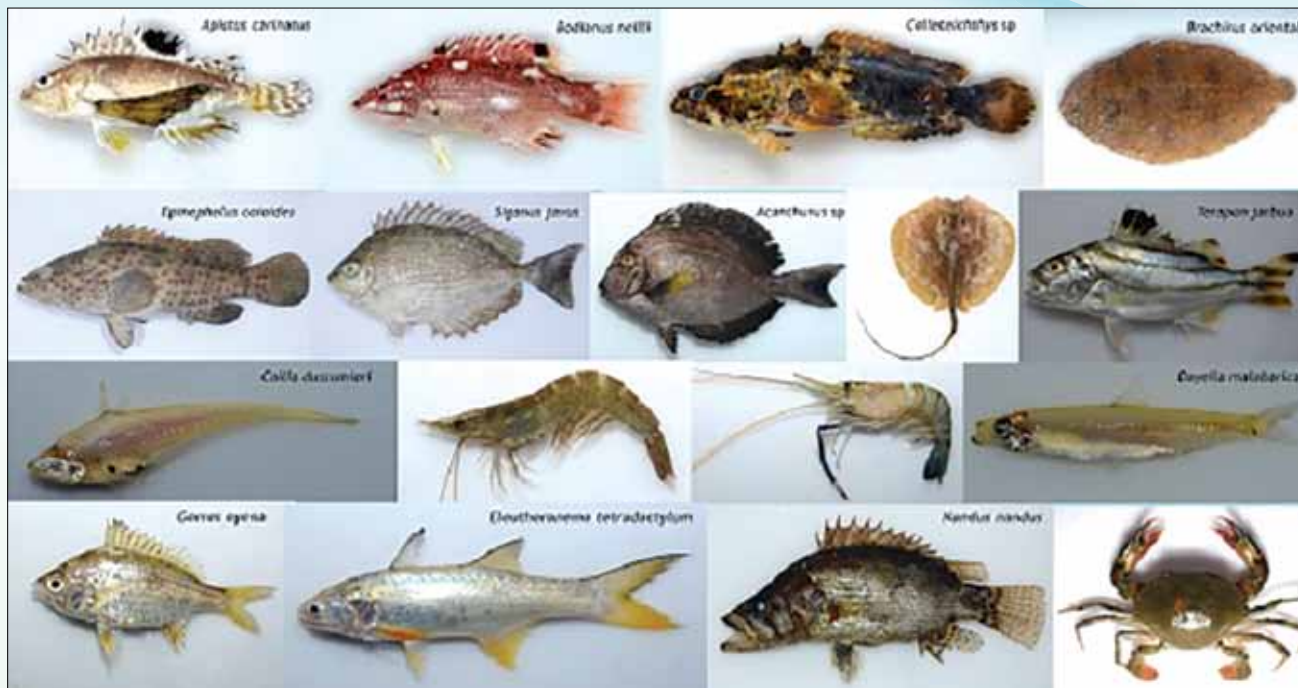


Fig. 19 Some important fish and shellfish species observed in the Vembanad Lake during the study

handbook on the fishery resource of Ramsar sites. Photographs (Fig. 19) of fishes of Vembanad lake, taken for the preparation of handbook.

Project: Molecular taxonomy and phylogeny of Cones (Cone, snails) and Strombs (Mollusca, Gastropoda) of the Indian coast.

Period: November, 2015 – November, 2018

Personnel: Laxmilatha P. (PI), Ranjith L. (ICAR-CMFRI, Kochi); A. Kathirvelpandian (ICAR-NBFGR, PMFGR Center, Kochi)

Funding Support: Department of Biotechnology, Govt. of India

In total, 52 individuals from 21 species of the families Conidae (15) and Strombidae (6) were collected from five sites along the Lakshadweep islands (Kalpeni, Kavarati, Agati, Kadamat and Androth) of India (Fig. 20). Specimens were identified based on shell morphology, and morphometric and meristic data were recorded. Muscular tissue from the foot or mantle of the conus and strombid specimens were used for total genomic DNA extraction using marine animal kit according to manufacturer's instruction. DNA isolation was standardized to obtain optimum quality DNA. DNA (50-75ng) from

each genomic extraction was used as template for *in vitro* amplification using polymerase chain reaction (PCR). Fragments of the mitochondrial genes; 12S rRNA, 16S rRNA, cytochrome oxidase subunit I (COI) and nuclear H3 gene were amplified using universal primers 12S1/12SB. PCR amplification of 52 individuals from 21 species of the family Conidae and Strombidae for all the four genes as mentioned above have been completed. The product size of 640bp (COI); 420bp (12s rRNA), 510 bp (16s rRNA) and 320bp (H3) were obtained.

Various life stages of stromb, *Lambis lambis* were collected from Thoothukkudi and Mandapam. Since the species exhibits considerable morphological differences during various stages, molecular analysis to confirm the species at various life stages was done using 3 mitochondrial (COI, 16s rRNA and 12s rRNA) and a nuclear (H3) gene. (Fig. 21) Molecular confirmation of morphotypes of three species under genera *Conus*, *Conus inscriptus*, *C. amadis* and *C. malacanus* have been reported with two totally varying colour pattern. To confirm the genetic identity of varying specimens of the species collected from Kollam, Mandapam and Thoothukkudi, respectively; molecular analysis was carried using three mitochondrial (COI, 16s rRNA and 12s rRNA) and a nuclear (H3) gene which resolved the morphological plasticity of the species. (Fig. 22). Four specimens of *Conus sp.* which were collected

from Androth, Lakshadweep were initially identified as *C. distans* using morphological parameters. However, molecular analysis (COI, 16s rRNA, 12s



Fig. 20 Specimens collected through field sampling in Lakshadweep Islands

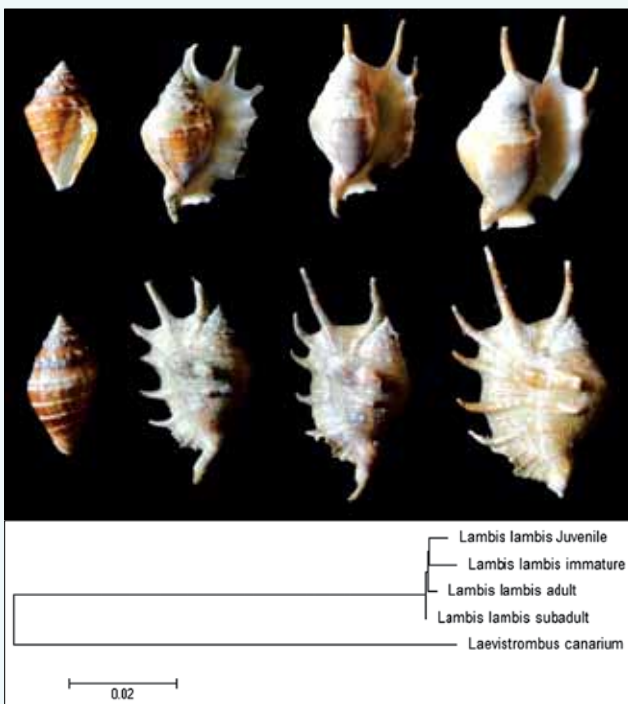


Fig. 21 Molecular identification of life stages of stromb, *Lambis lambis* using mitochondrial COI gene

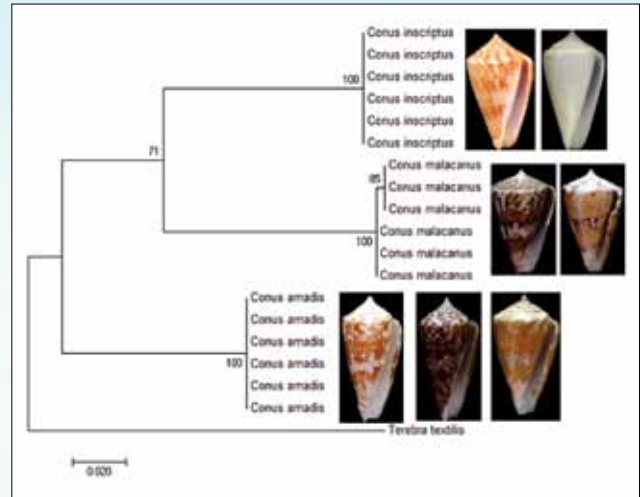


Fig. 22 Molecular confirmation of morphotypes of three species under genera *Conus* using mitochondrial COI gene

rRNA and H3 gene) revealed cryptic speciation in *C. distans* in Indian waters warranting further study for confirmation.

Project: Systematic review and evolutionary study of Indian Clupeiform fishes

Period: April, 2017– March, 2019

Personnel: Mahender Singh (PI), T. T. Ajithkumar, Teena Jayakumar T. K. and Akhilesh K. Mishra

Funding Support: Department of Biotechnology, Govt. of India

During the exploration of marine waters, 557 tissue samples (Fig. 23) and selected voucher specimens (Fig. 24) of 33 clupeiform species were collected from Pamban (Mandapam), Punnakayal (Tuticorin), Tuticorin fishing harbour, Colachel (Kanyakumari), Pattinapakkam (Chennai), Pondicherry, Cuddalore (Chidambaram), Nagapattinam, Andaman, Mahe, Goa, Karwar, Mangalore and Calicut. The voucher specimens were coded, photographed and preserved in formaldehyde, and tissue samples were preserved in 95% ethanol. The morphomeric characters were studied for all samples. DNA isolation was carried out for all samples, and concentrations and quality of DNA samples were assessed. Out of 557 tissue samples used for DNA isolation, 426 DNA samples showing intact bands on agarose gels and having concentration above 50 nanogram per microlitre, and 260/280 spectrophotometer absorption ratio from 1.8-2.0, were used for PCR amplification of mitochondrial gene Cytochrome c oxidase I (COI). The rest 131

samples were re-processed for DNA isolation. PCR amplification for COI was carried out for 351 DNA samples. DNA sequencing of 351 samples was performed with forward and reverse primers. The edited sequences were blasted in NCBI GenBank for the nearest similar sequence matches. Sequences were

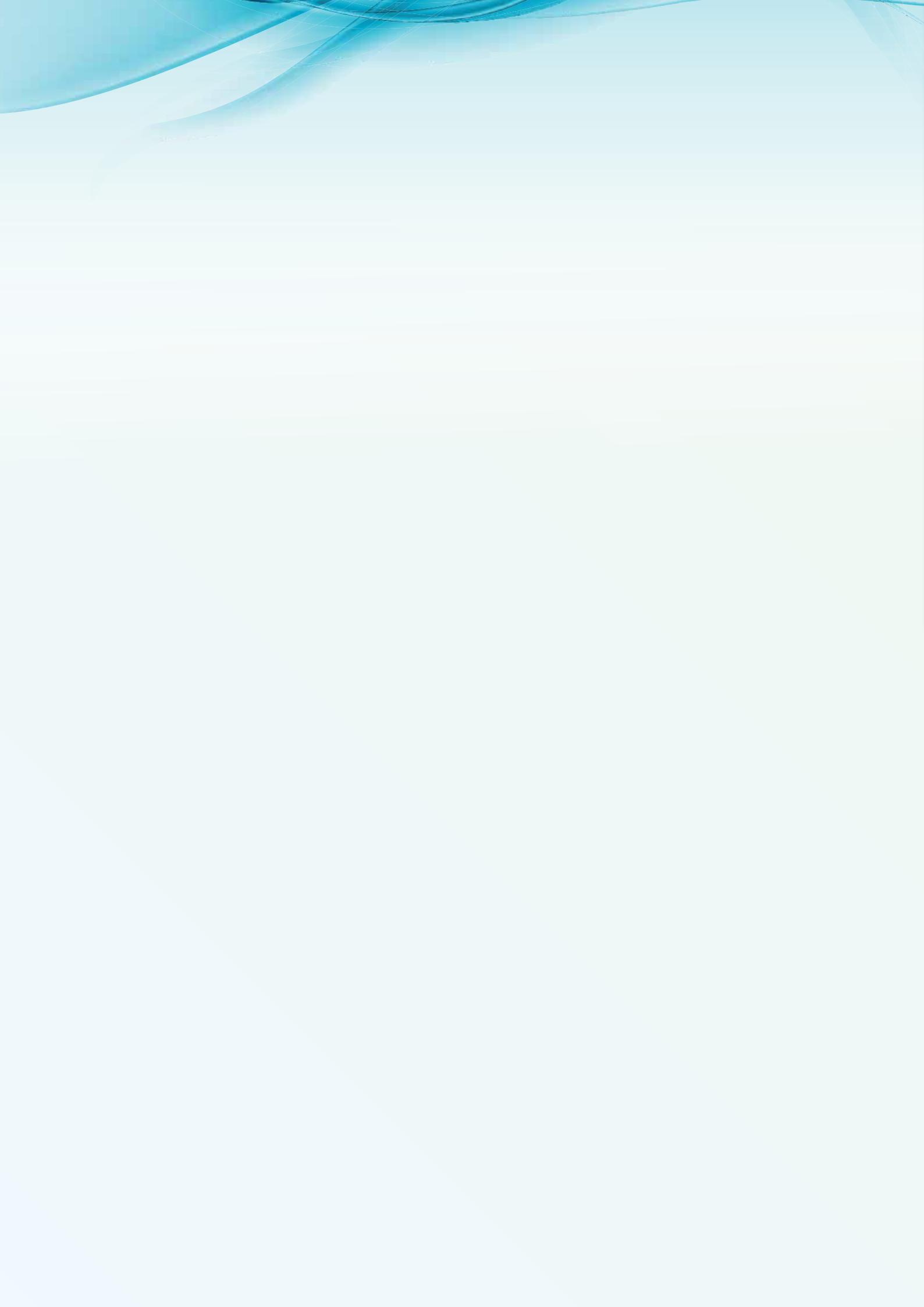
analysed by multiple sequence alignment using MEGA 7 software for nucleotide composition, number of polymorphic sites (S), pairwise genetic distance, and phylogenetic analysis based on maximum likelihood. COI DNA sequencing was completed for 351 samples of 33 clupeiform fish species. Various sets of primers, reported in literature were aligned with RAG 1 gene sequences of clupeiform fishes from NCBI. Four sets of primers were used for PCR amplification and one set was finalised based on maximum use as available in NCBI.



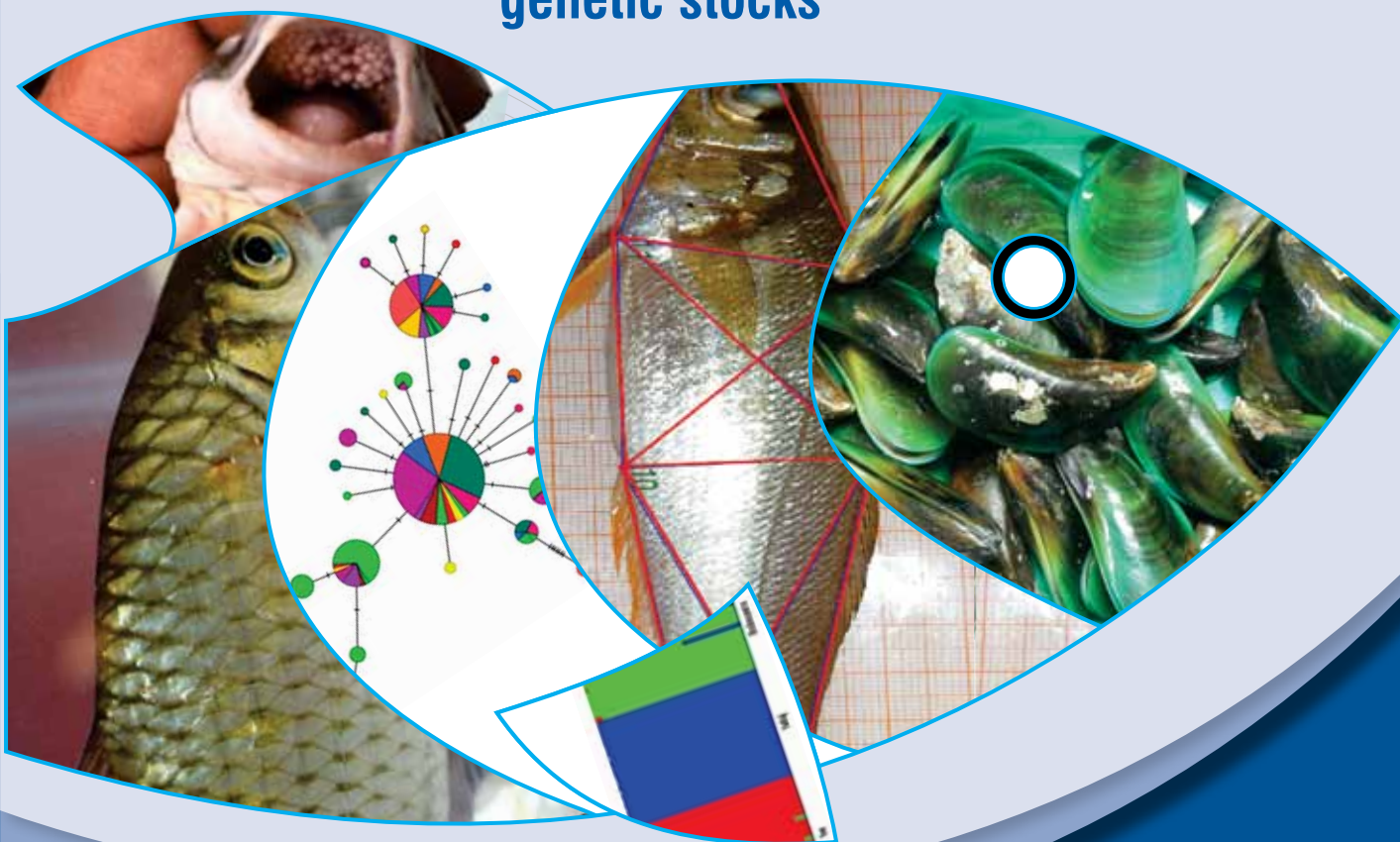
Fig. 23 The processing the collected specimens for collection of tissue samples



Fig. 24 A voucher specimen



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



Documentation of the genetic variability in natural populations of commercially or ecologically important species is essential to plan its use in domestication, genetic improvement and for conservation of the natural gene pool. Intraspecific variability is level next to species, to understand the components of biological diversity. Different populations of a species or genetic stocks are locally evolving units, which develop attributes of adaptive significance to the diversified environments. The diversely evolved through intra-specific variability in the species will be a source of useful traits with potential application in domestication and genetic improvement. Complete understanding of the existing genetic stocks of the target species can be an

important tool for genetic improvement of the species. Lack of knowledge on genetic stocks and their production descriptors is a gap and need to be bridged to improve domestication in aquaculture. Hence, there is need to unravel the genetic variability of the species to resolve the issues related to biodiversity, genetic erosion in cultured species, IPR protection and technological advancements. Molecular markers could be useful to provide direct assessment of genetic divergence and the identified genetic stocks can be assessed for performance in culture. ICAR-NBFGR has been engaged in the work on population genetics to determine genetic stocks in important Indian fish species, using standardized molecular markers and biological methods.

Project: Outreach activity on fish genetic stocks (Phase II)

Period: April, 2014 – March, 2019

Coordinator: Kuldeep K. Lal

Co-coordinator and Lead Centre PI: Rajeev K. Singh

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

Personnel (PMFGR): P.R. Divya (PI), V.S. Basheer, A.K. Pandian and Charan Ravi

Funding Support: Institutional, ICAR-NBFGR

Assessment of genetic variability is crucial for the scientific management of natural fish genetic resources. This variance is responsive to evolutionary forces, such as, migration, mutation, selection, and genetic drift. Molecular markers can potentially estimate the amount of genetic variation among different subpopulations. Under this project, eight important fish/shellfish species are being investigated using molecular markers along with their morphological descriptors, to quantify baseline information on genetic variability existing in natural populations. The program is implemented with two subprojects, one at NBFGR HQ and another at PMFGR Center. A total of six species (*Chitala chitala*, *Anguilla bengalensis*, *Systemus sarana sarana*, *Silonia silondia*, *Mugil cephalus*, *Tor tor*) are being investigated at Lucknow (HQ), and two species (*Perna viridis* and *Sillago sihama*) at PMFGR (Kochi) division of ICAR-NBFGR.

Total 445 tissue samples (muscle, blood, and fin) were collected from 15 sites belonging to 9 rivers namely, Narmada, Ken, Mahanadi, Godavari, Betwa, Ganga, Gandak, Son, Gomti and eight marine/estuarine sites. The species collected are *Chitala chitala* (n=38), *Tor tor* (n=81), *Anguilla bengalensis* (n=18), *Mugil cephalus* (n=54), *Systemus sarana sarana* (n=118), *Silonia silondia* (n=63), *Sillago sihama* (n=63) and *Perna viridis* (n=10).

Genetic diversity in mitochondrial gene sequences

Chitala chitala

In *Chitala chitala*, mitochondrial ATPase 6/8 genes (842 bp) were amplified for the samples

(n=309) collected from 13 different locations. The two fragments of ATPase gene were analyzed together for the determination of genetic variation. A total of 28 different haplotypes were observed. Upon alignment, 808 nucleotides were found to be conserved, while 34 sites were variable. Ts/Tv was 7.77 and AMOVA analysis resulted in variance within population to be 72.81%. Unique haplotypes were observed in some rivers including Satluj, Ghaghra and Brahmaputra. Tajima D was observed to be significantly negative in the samples from Brahmaputra.

Full length mitochondrial gene Cytochrome b (1139 bp) was analysed from n=441 individuals of *C. chitala*. A total of 27 haplotypes were observed including 24 variable positions and 19 parsimony informative sites. The average frequency of nucleotides were A (30.3%), T (26.7%), C (29.4%) and G (13.7%). The nucleotide sequences of Cytb were A+T rich (57%). AMOVA revealed that out of total variations, 65.96% contributed variation within population. The haplotype network demonstrated the existence of two distinct clades (Fig. 25)

Anguilla bengalensis

In *Anguilla bengalensis*, individual samples (n=42) were analysed using cytochrome b gene of mitochondrial genome. The alignment of sequences displayed 26 haplotypes. The variance among groups was 1.07%, 34.64% among populations within groups while the within population was 64.29%. Overall Fst was found to be 0.35. Private haplotypes were observed in the samples from River Godavari. Tajima's D and Fu's Fs were significantly negative in Rajamundry and Dhawaleswaram sites of River Godavari.

Systemus sarana sarana

Total 182 individuals of *Systemus sarana sarana* collected from six different rivers, Gandak (19), Ganga (36), Godavari (4), Krishna (27) and Mahanadi (68), were analysed for nucleotide variability. The genetic variability was represented by 46 distinct haplotypes. The hierarchical analysis of variance (AMOVA) presented 21.69% among populations within groups while the within population was 78.31%. Overall Fst was found to be 0.21.

Silonia silondia

In *Silonia silondia*, variability in mitogene cytochrome b was analysed in 139 individual samples. A total of 14 haplotypes were observed, i.e., Ganga

(8), Narmada and Son (4 each), Ken and Mahanadi (5 each). The hierarchical analysis of variance presented 19.43% among populations within groups while the within population was 81.83%. Overall F_{ST} was found to be 0.18. Neutrality tests were non-significant for all sampling sites.

Mugil cephalus

In *Mugil cephalus*, the analysis of cytochrome b gene fragment in 227 individual samples, from five estuarine and three marine locations, revealed 29 variable sites, while seven were parsimony-informative. Fifteen sites were found to be singletons. Nucleotide composition was: T-28.9%, C-31.6%, A-25%, G-14.5%. T(s)/t(v) bias was 6.81. The ATPase 6/8 gene sequence was aligned for 131 *M. cephalus* samples. The variable sites were 22, of which singletons were 15. Nucleotide composition was: T-28%, C-33%, A-27.6%, G-11.4%. The interrelatedness of different haplotypes is presented in Fig. 26.

Perna viridis

The mitochondrial cyt b gene sequences (885 bp) were analyzed for *P. viridis* (n=170) belonging to five locations of Indian waters. A total of 58 haplotypes were identified and the average frequencies of nucleotides were: A=22.4%, T=43.9%, C=12.5%, G=21.2%. Haplotype and nucleotide diversity ranged from 0.4038-0.9013 and 0.000675-0.002818, respectively. The haplotype network tree for the population was constructed in PopART software (Fig. 30). The coefficient of genetic differentiation (F_{ST} : 0.255) and AMOVA indicated significant genetic differentiation among three populations, i.e., East coast, West coast and Andaman waters of Indian waters.

A total length of 714 bp fragment of ATPase 6 gene was amplified to determine genetic variability in *P. viridis* (n=170). A total of 58 haplotypes were identified. The average nucleotide frequencies were A=24.4%, T=44.1%, G=22%, and C=9.5%. Haplotype and nucleotide diversity ranged from 0.5141-0.9167 and 0.001190-0.007066 respectively. The haplotype network tree for the population was constructed in PopART. The coefficient of genetic differentiation (F_{ST} : 0.252) and AMOVA indicated significant genetic differentiation among three populations, i.e., East coast, West coast and Andaman waters of Indian waters.

Sillago sihama

Mitochondrial ATPase 6/8 genes (842 bp) were

amplified in *S. sihama* (n=80) collected from four locations, viz., Ratnagiri, Goa, Mangalore and Cochin. A total of 16 haplotypes were identified. Among the 13 polymorphic sites observed, 8 were singleton variable sites and 5 were parsimony-informative. Nucleotide frequencies were 22.96% (A), 30.92% (T/U), 30.71% (C), and 15.40% (G). Haplotype and nucleotide diversity ranged from 0.73-0.84 and 0.0006-0.001 respectively. Mean haplotype (gene) diversity (H_d): 0.817 and mean nucleotide diversity (π) 0.0015 was observed. The haplotype network tree were also constructed (Fig. 31). AMOVA and coefficient of genetic differentiation (F_{ST}) indicated unit stock of *S. sihama* in Indian waters.

Microsatellite (SSR) genotype analysis:

Chitala chitala

The freshwater fish, *C. chitala* is a commercially important fish of a primitive order, Osteoglossiformes. The present study assesses genetic diversity from wild population through SSR markers. A total of n=72 individuals from three riverine populations, namely, Son, Satluj and Brahmaputra were genotyped using 28 polymorphic microsatellite markers. The number of alleles per locus ranged from 2 to 11. The PIC value ranged from 0.281 to 0.901 while, the pairwise F_{ST} between Son and Satluj was 0.0604, between Son and Brahmaputra is 0.0357 and between Satluj and Brahmaputra is 0.0424. The overall F_{ST} was 0.04 and AMOVA result indicated that 4.78% of the variance was maintained among populations, 9.84% among individuals within populations and 85.38% was maintained within individuals.

Systemus sarana sarana

In *S. sarana*, a total of n=75 individuals from three riverine populations, namely, Krishna, Godavari and Mahanadi were genotyped using 11 polymorphic microsatellite markers. The number of alleles per locus ranged from 2 to 11. The PIC value ranged from 0.281 to 0.901.

Tor tor

A total of n=96 individuals of *T. tor* belonging to three rivers namely, Godavari (two tributaries, Satnala and Penganga), Narmada and Madhar reservoir (Udaipur), were assayed for 22 polymorphic microsatellite loci. The species-specific tailed primers were multiplexed for genotyping which is under progress.

Anguilla bengalensis

In *A. bengalensis*, a total of n=85 individuals belonging to three rivers, namely, Godavari, Ganga and Chambal were assayed for 25 polymorphic microsatellite loci. The species-specific tailed primers were multiplexed for genotyping.

Silonia silondia

In *S. silondia*, microsatellite loci were identified through NGS, in addition to already existing 11 validated markers, to genetically characterize the populations. The contigs containing microsatellite repeats were identified and primers were designed.

Perna viridis

Sixteen polymorphic microsatellites were identified in *P. viridis*. Out of 16 polymorphic microsatellites, twelve loci were standardized and used for further analysis. Genotyping was done at 5 loci for n=240 individuals samples (four locations).

Sillago sihama

In *S. sihama*, a total of 22 polymorphic loci were standardized and selected for further analysis. A total of 9 multiplexed genotyping panels were optimized. This consisted of four panels with three primers each and five panels with 2 primers each.

Length Weight relationships:

Fish length-weight relationships have been used to estimate weight from length. The study is a widely applied approach in fisheries management as it provides information on stock condition. The LWR for two important species was examined. A total of 281 specimens of *S. silondia* collected from seven different locations were examined to ascertain regression parameters and coefficient of determination. The growth pattern was measured as an exponent, which ranged from 1.15-3.17. The high coefficient of determination was found in four rivers which indicated the linearity of the equation. The better nutritional conditions of fish in the rivers Gerua, Chambal, Betwa and Ganga were evident. Significant difference in the condition factor between the locations was found in *S. silondia* (Fig. 27).

The length-weight relationship of *M. cephalus* collected from various locations was calculated. The specimens collected from different locations, viz., Manakudy Estuary (14), Vellar estuary (56), Kolli dam (16), Pondicherry (11), Marakanam (13), Cuddalore

(6), Pulikat Lake (13), Tuticorin (6) and Punnakayal (12). The regression analysis of Log W (y) on Log L (x) was significant for all the locations (Fig. 28a, b). No significant difference in condition factor was observed among different locations.

Truss Network Analysis:

Truss morphometry is an image based system to investigate shape characteristics. In fishes, this geometric method has been widely used. A total of 244 individuals of *M. cephalus* were used for the study wherein each specimen was morphologically covered by 13 landmarks. With a total 77 truss parameters, 12 principal components (Eigen value >1) contributed 92.27% of variation. The significant and positive (or negative) truss loadings on each principal component helped in identification of *M. cephalus* specimen through truss network system. The canonical discriminant analysis (Fig. 29) indicated that 77.5% of original grouped cases correctly classified and 50.4% of cross-validated grouped cases correctly classified.

In *S. sihama*, the samples were collected from Ratnagiri (N=26), Mangalore (N=17), Cochin (N=20) in the west coast of India. Specimens of *Sillago sp.* collected from all the locations from east (Vishakhapatnam, West Bengal, and Tamil Nadu) and west coast were analysed using truss morphometry. The results ascertained that the samples collected from four locations in the west coast except Gujarat, as *S. sihama*. Additional specimens of 75 *S. sihama* were collected for truss morphometric analysis from four sampling locations by using 10 landmarks with 18 variables. Transformed truss measurements were subjected to principal component analysis using PAST software for differentiating the population structure. Principal component analysis (PCA) on size-corrected variables revealed *S. sihama* exists as a single stock in Indian waters. The screen plot of Eigen values for each truss measurements also revealed samples are homogenous and clustered together.

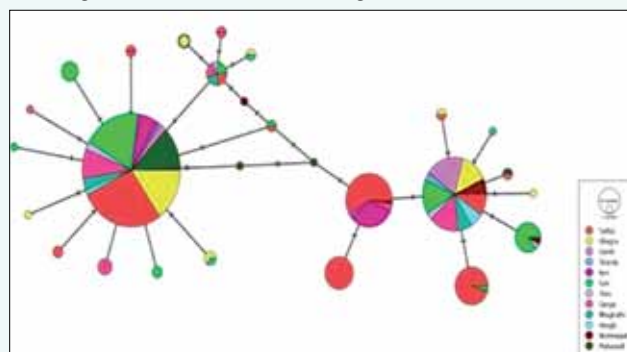


Fig. 25 Haplotype network of *C. chitala* based on cytochrome b gene

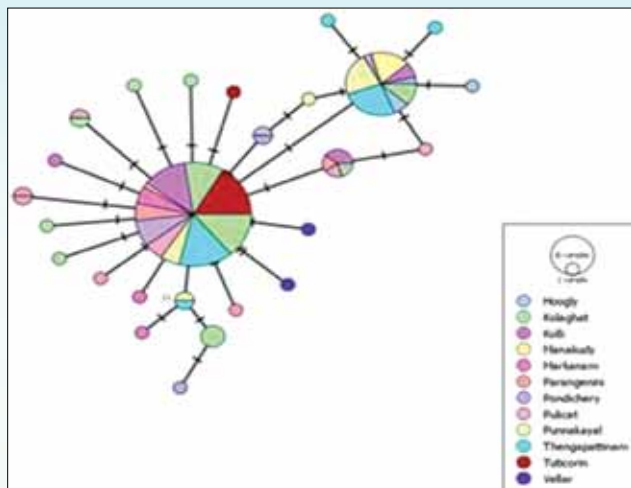


Fig. 26 Inter-relatedness of haplotype in *M. cephalus* based on ATPase 6/8 genes

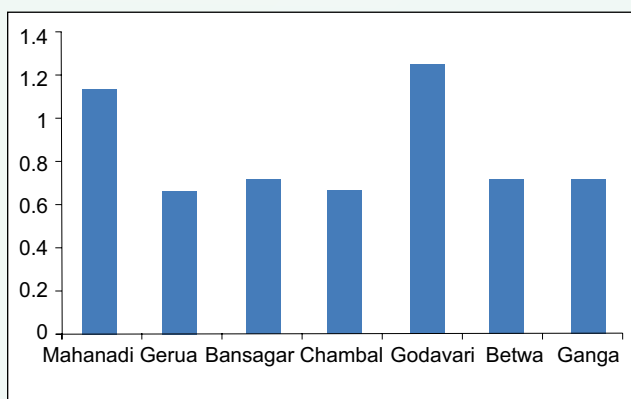


Fig. 27 Variation in condition factor (K) in *S. silondia* from different rivers

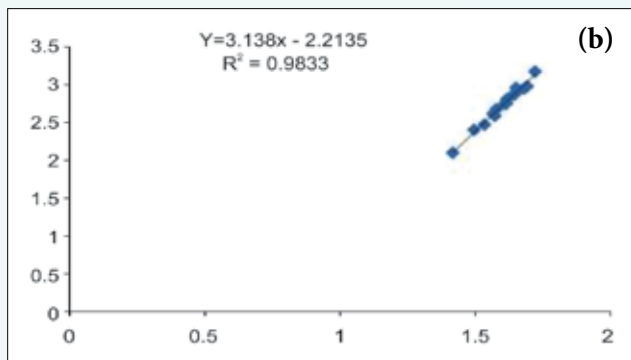
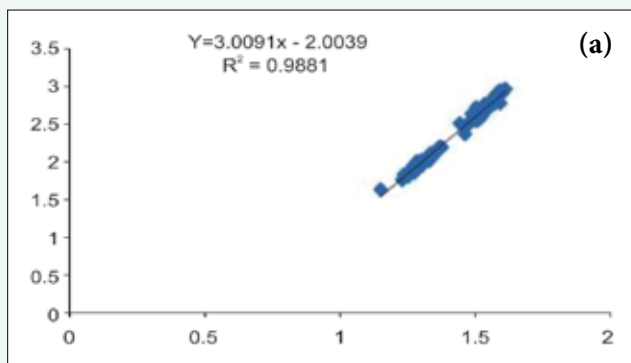


Fig. 28 Linear regression plots for *M. cephalus* from Vellar Estuary (a) and Tuticorin (b)

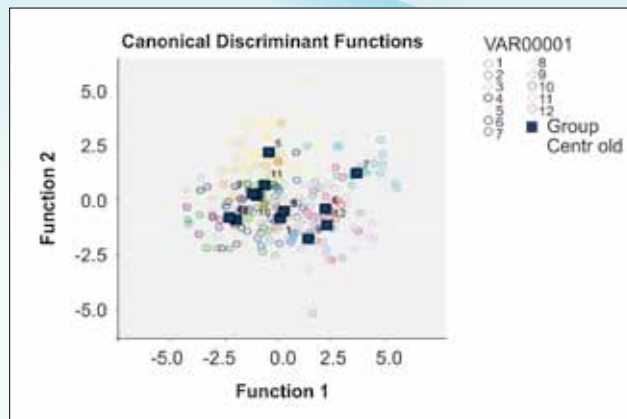


Fig. 29 Canonical discriminant analysis in *M. cephalus*

Large scale microsatellite discovery:

Small insert libraries were constructed for important species, such as, *Litopenaeus vannamei*, *Clarias magur*, *Lates calcarifer*, *Macrobrachium rosenbergii*, *Scomberomorus commerson*, *Thunnus albacares* and *Trachinotus blochii* sequenced on SMRT sequencer, PacBio RSII. Microsatellites were extracted from the sequences and used for their utility in genetic diversity studies. This will help establishing validated set of microsatellite markers for the important fish species.

The statistics obtained for three species is as follows. A total of 671, 298, 2157 contigs with repeat motifs were observed in *S. commerson*, *T. albacares* and *T. blochii*, respectively. Number of SSRs in the observed motifs was of 472, 150, and 813 in *S. commerson*, *T. albacares* and *T. blochii*, respectively. Microsatellite primers were designed considering various attributes, such as, Tm, GC content and secondary structures using software PRIMER 3.0 tool. In *T. albacares*, a total of 100 microsatellite primers were designed consisting of 69 di repeat motif, 25 tri repeats and 6 tetra repeats. In *S. commerson*, a total of 203 microsatellite primers

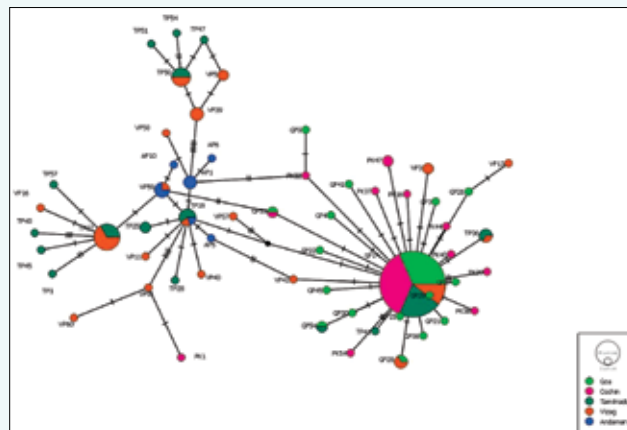


Fig. 30 Haplotype network tree of four populations of *P. viridis* from Indian waters using mito ATPase 6 gene

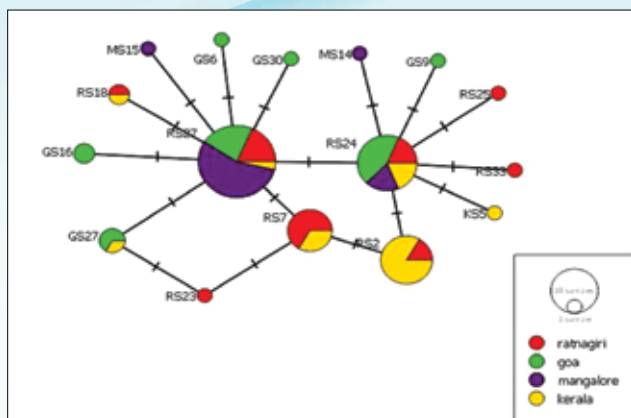


Fig. 31 Haplotype network tree of four populations of *S. sihama* from Indian waters using mt ATPase gene

were designed consisting of 131 di-repeat motif; 52 tri repeats, 16 tetra repeats and 4 penta repeats. In *T. blochii*, a total of 215 microsatellite primers were designed consisting of 75 di repeat motif, 96 tri repeats, 33 tetra repeats, 8 penta repeats and 3 hexa repeats. The developed primers will be validated for utilization in genetic structure analysis of the selected fish species.

Project: Signatures of natural selection and genomic diversity in important freshwater fish species, *Tor putitora* and *Clarias magur*

Period: May, 2014 - March, 2018

Personnel: Vindhya Mohindra (PI) and Trivesh S. Mayekar

Funding agency: Institutional, ICAR-NBFGR

Information on the genetic diversity is of great importance for fisheries conservation and management. At present, genetic based studies use large number of neutral genetic markers, the variation influenced by mutational dynamics and demographic effects and not by selection. However, these approaches may be ineffective if populations are recently diverged, as this is not reflected at neutral loci. Recently, several

methods have been developed for studying population structure using molecular markers, such as, genomic (gSSRs) and expressed sequence tag-derived simple sequence repeats (EST-SSRs) facilitating the measurement of genetic variation on a genomic scale. Out of these, non-neutral (outlier) loci are in association to environmental factors and could bias estimates of genetic structure, as selection affects the genome at specific loci by either reducing the genetic diversity in a specific region in favor of advantageous alleles (positive selection) or by maintaining similar levels of variation across populations (balancing selection). Nevertheless, these loci can better explain the adaptive genetic variation that is not accounted by neutral loci and detecting the footprints of selection, since they occur in coding regions or the sequences that flank them. The aim of this project is to build genomic resources and to gain knowledge about functional biodiversity that can be applied to sustainably manage biodiversity of important freshwater fish species, *Tor putitora* and *Clarias magur*.

Identification of Genomic polymorphic SSR loci in *Tor putitora*:

After the sequencing of 1.5Kb genomic DNA library, sequences assembled into 1,478 contigs and different SSR's repeats in 524 contigs of *Tor putitora* were identified. Out of which, 257 are annotated and 356 SSR repeats were observed in these sequences (Table 6). Primers for a total of 172 gene-associated microsatellite loci were tested for amplification from samples of Beas river, Pathankot, Kosi river, Ramnagar and Mahanadi river. Out of these, 52 were found to be polymorphic, repeatable ones were 30 and 36 monomorphic and 32 with multiple bands. Two populations, Kosi river, Ramnagar and Mahanadi river were genotyped with repeatable 30 microsatellite polymorphic loci for identification of outlier loci (Fig. 32 & 33).

Table 6 Identification of Genomic polymorphic SSR loci in *Tor putitora* from 1.5 kb library sequenced with PACBIO RSII

SSR type	Total Contigs	No. of total SSRs associated with sequences	
		Annotated	Unannotated
Compound	170	76	246
Dinucleotide	359	172	531
Trinucleotide	152	70	222
Tetranucleotide	63	31	94
Pentanucleotide	10	7	17
Hexanucleotide	2	0	2
	756	356	1112

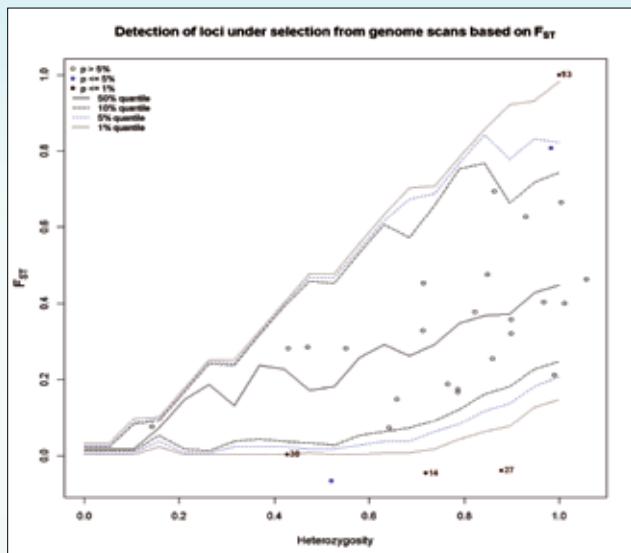


Fig. 32 Loci under selection pressure in *Tor putitora*, analyzed from two divergent populations

Two and four genes associated with microsatellites were found to be under positive and balancing selection, respectively. Both the locus under selection had alleles with different molecular weights for both the populations and almost all loci showed private alleles for one or both populations.

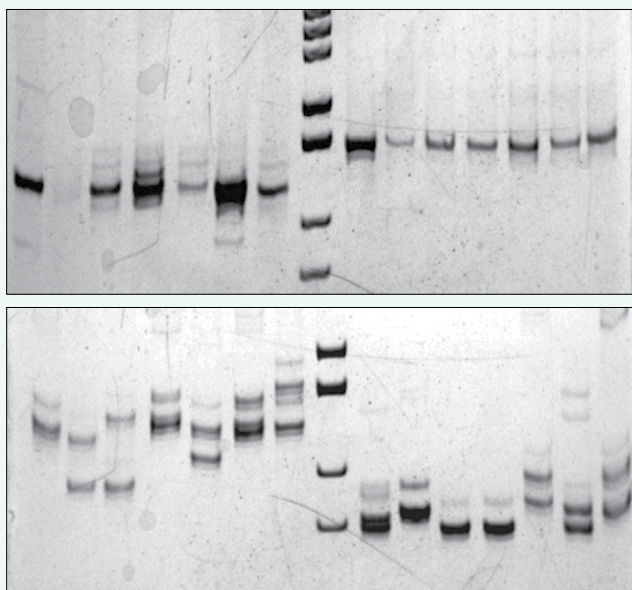


Fig. 33 Outlier microsatellite loci in two populations

For all three data sets, taking into account all the 30 loci, 24 neutral loci, 2 outlier loci and neutral+2 outlier loci under selection (taking out 4 loci under balancing selection), percentage of variation among populations were 32.31, 33.34, 100% and 43.84%, respectively, while F_{ST} values were 0.3231, 0.3334, 1.0 and 0.43839, respectively (Table 7).

Table 7 Percent variation (AMOVA) and F_{ST} values for all three data sets in two populations of *Tor putitora*

No.	Data sets	% variation AMOVA	Fst values
1	Total 30 loci	32.31 %	0.3231
2	24 neutral loci	33.34%	0.3334
3	2 outlier loci (+ve selection)	100%	1.0
4	Neutral+2 outlier loci	43.84%	0.43839

The results suggest that adaptive microsatellite should not be excluded prior to analysis from neutral ones as a combination of both marker sets resulted in better resolution of genetic differentiation between populations than either marker set alone. These results demonstrate the utility of adaptive loci for resolving population genetic structure in a non-model organism.

Project: CRP-Agrobiodiversity: National network on agrobiodiversity management
Period: April, 2017 – March, 2019
Personnel: Kuldeep K. Lal (PI), Sulip K. Majhi, Santosh Kumar, Ajay K. Singh, T. T. Ajithkumar, Aditya Kumar and Charan Ravi

Funding Support: ICAR, New Delhi

Efforts were made to establish facility for establishing fish germplasm resource centers at three locations, ICAR-NBFGR Headquarters, Lucknow; PMFGR, Kochi and Nagarjuna Sagar, Telangana. The agreements were made with respective authorities to obtain rearing facilities and working arrangements. The Government of Kerala provided farm area in KUFOS campus, Kochi for use by PMFGR center of ICAR-NBFGR and State Fisheries, Telangana gave farm facility at Nagarjuna Sagar. The objective is to raise endemic fish species collected from the wild and evaluate them for their biological traits and breeding.

ICAR-NBFGR Headquarters, Lucknow:

Target species for the headquarters are: Indian major carp, *Clarias magur* and *Ompok bimaculatus*. Besides older brood stock being maintained at the farm, 705 advance fingerlings of *Labeo rohita* (length 11 - 18 cms and weight 11.5 - 70.5 g) were collected from River Ghaghra. With this now, the Institute has wild type collections from Ghaghra and Ganga rivers.

Institute also has over 800 *C. magur* stock (150 - 300 gms) which are farm bred and will be evaluated for use in domestication. The arrangements are made to collect wild types of some important species from Assam, Bihar and Chhattisgarh during the coming seasons. Collection of *Ompok bimaculatus*, 165 nos. from River Sharda are being reared at farm. In addition, some other threatened species, such as *Chitala chitala* (50 nos) and *Rita rita* (113 nos) were also collected from River Sharda which are being reared in the farm.

Nagarjuna Sagar, Telangana:

Target species are: *Pangasius silasi*, *Ompok bimaculatus* and *Etroplus maculatus*. Two nos. of cages (size 6x4x4 meters) were installed in the Nagarjuna Sagar reservoir for stocking of above three species (Fig. 34). For further expansion of the research activities of ICAR-NBFGR, a farm area located at Thummadam, 36 km from the reservoir has been provided by the state government of Telangana. The programme was formally launched on 14th September 2017 by Shri T. Srinivas Yadav, Honorable Minister for Fisheries and Animal Husbandry, Govt. of Telangana in presence of Dr. Gaurav Uppal, I.A.S., Collector, Nallagaonda District (Fig. 35).

Pangasius silasi is the new species recently discovered by ICAR-NBFGR from this region. This was obtained from local fishermen and transportation was standardized over the course. Among the 45 nos. of *P. silasi* stocked in the cages during August - December, 2017, 30 nos. are surviving well in the cages. Size of the fishes ranged between 290.0 to 950.0 gm and progressive growth rate is observed. Standardization of the feeding regime is in progress with inert feeds. *P. silasi* has been found to consume snails and indicate bottom feeding. The preliminary studies on the nutritional profile (amino and fatty acids) of the fish was done at the ICAR-CIFT and made comparison with *Pangasianodon hypophthalmus*, available in Indian fish markets and basa fillets, coming from Vietnam to India. The result reveals that the *P. silasi* has good qualities as food fish.

As the *O. bimaculatus* and *E. maculatus* have good market demand in table consumption and as well as has ornamental value and are being heavily exploited from this reservoir, the Institute has also started stocking of these two fish species for brood stock development and hatchery propagation. A total of 150 nos. of *O. bimaculatus* (average size 122 - 278g) and

500 nos. of *E. maculatus* (average size 5-8g) collected from the reservoir were reared in cage for two months and shifted to Thummadam farm for initiating the breeding programme. Progressive growth (130 - 283g) was observed in *O. bimaculatus* and gonadal maturity was noticed.



Fig. 34 Cages installed by the ICAR-NBFGR at Nagarjuna Sagar



Fig. 35 Honorable Animal Husbandry and Fisheries Minister, Govt. of Telangana launching the conservation aquaculture programme of *Pangasius silasi*, a newly described fish by ICAR-NBFGR in Nagarjuna Sagar, Telangana

ICAR-NBFGR, PMFGR Center, Kochi:

Target species are: *Clarias dussumieri*, *Horabagrus brachysoma* and *Labeo dussumieri*. ICAR-NBFGR and KUFOS, Kochi signed a MoU for research collaboration and transfer of approximately 1.0 ha farm land in the campus of KUFOS. The MOU was signed in the presence of Mrs. Mercy Kutty Amma, Honorable Minister for Fisheries. After pond preparation, more than 140 nos. (40 - 60 g) of *H. brachysoma* were stocked in the pond for broodstock development. *C. dussumieri* is an air breathing catfish, endemic to the Western Ghats experiencing a sharp decline in catch along its entire range of distribution during recent years. As a measure towards conservation of germplasm, adult fishes of *C. dussumieri* size range (90-150g) were collected from Thodupuzha, Kerala.

Conditioning and induced spawning trials were successfully carried out with 5 pairs of brooders. Mean fecundity observed was about 2000 eggs per female with fertilization rate and hatching rate of 85%. The larval rearing experiment was carried out in two different conditions, i.e., FRP tanks and earthen ponds. The growth rate was recorded with mean observed weight of 35g and 80g with corresponding length of 16.5 cm and 22 cm, respectively, after 6 months of rearing period. The fishes are being maintained in ponds and tanks for raising them to broodstock for large scale breeding programme. Feeding trials were carried out during larval rearing using four different diets, i.e., larval feed (A), formulated feed (B), commercial starter feed (C) and frozen artemia (D). Post hatched 8th day old larvae were randomly distributed into 12 plastic tanks at a density of 20 fish per tanks. All the parameters exhibited (after 60 days) significantly high growth ($p < 0.05$) in fry fed with frozen Artemia, followed by, commercial starter diet, while the least growth was observed with formulated diet.

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, 2019

Personnel: Gaurav Rathore (PI), Chinmayee Muduli, Rajeev K. Singh, Anutosh Paria and Ranjana Srivastava

Funding Support: Institutional, ICAR-NBFGR

Estimation of immune parameters of *Clarias magur* in serum and mucus

Twenty four healthy *Clarias magur* were collected from nearby places of Lucknow and acclimatized in wet laboratory at NBFGR, Lucknow. Among the collected fish, twelve were of 25.18 ± 3.0 cm (116 ± 31.53 g) size and rest of the eight were of 13.71 ± 1.34 cm (18 ± 4.54 g) length. Five innate immune parameters, i.e., myeloperoxidase (MPO), lysozyme, total-antiprotease, protease and bactericidal activity were measured in mucus and serum (500 µg/mL total protein) collected from all 24 fishes. MPO activity was significantly higher ($p \leq 0.01$) in serum than mucus. Serum exhibited significantly higher levels

($p \leq 0.01$) in summer as compared to winter months. However, small-sized fish showed significantly higher levels of MPO in serum ($p \leq 0.01$) during winters. No significant effect of fish size was seen on MPO levels in mucus. Bactericidal activity was significantly higher ($p \leq 0.01$) in mucus than serum. Mucus exhibited significantly higher levels ($p \leq 0.01$) of bactericidal activity than serum; both in summer and winter months. No significant effect of fish size was seen on bactericidal activity in serum and mucus in either summer or winter months. Total antiprotease activity was significantly higher ($p \leq 0.05$) in serum than mucus. Serum exhibited significantly higher levels ($p \leq 0.05$) in summer as compared to winter months. No significant effect of fish size was observed on total antiprotease activity in serum and mucus in either summer or winter months. Protease activity was significantly higher ($p \leq 0.01$) in mucus than serum; both in summer and winter months. Both serum and mucus showed significantly higher levels ($p \leq 0.05$) in summer as compared to winter. Small-sized fish showed significantly higher levels of protease activity in mucus ($p \leq 0.05$) during winters; whereas large-sized fish showed significantly higher levels of protease activity in mucus ($p \leq 0.05$) during summers. No significant effect of fish size was observed on protease activity in serum. Lysozyme activity was significantly higher ($p \leq 0.01$) in mucus than serum; both in summer as well as winter. Both serum and mucus showed significantly higher levels ($p \leq 0.05$) in summer as compared to winter. Large-sized fish showed significantly higher levels of lysozyme in serum ($p \leq 0.01$) during winters. No significant effect of fish size was observed on lysozyme activity in mucus.

Molecular characterization of immune genes of *C. magur*

I. Primer designing and partial amplification of immune genes of TLR pathway:

Available sequences of immune genes of TLR pathway from super order Ostariophysi consisting of catfish and cyprinids were downloaded from NCBI ($n=10$). The obtained sequences were aligned with CLUSTALW and conserved regions were identified through MEGA 7.0 software. Primers for genes belonging to TLR signalling pathway of *C. magur* were designed from conserved regions. Genes include; TNF receptor-associated factor-3 (TRAF-3), TRAF-6,

Interferon regulatory factor 3 (IRF-3), IRF-7, IRAK-4 (IL-1 receptor-associated protein kinase), TIRAP (TIR domain-containing adaptor protein) and TBK-1 (TANK binding kinase). Primers were designed and tested for binding using NCBI primer designing tool available online.

RNA extraction, cDNA synthesis and PCR amplification: Kidney and liver tissue were collected from *C. magur*, and cDNA was prepared by revert-Aid first strand cDNA synthesis kit (Thermo Scientific) from total RNA. Amplification of target immune genes was carried out using the designed primers. Successful amplifications were obtained for TRAF-6, IRF-7 and IRAK-4 genes in both liver and kidney tissues. Amplified fragments of these genes were sequenced and partial CDS sequences were obtained. Two sequences (301 bp and 404 bp) of TRAF-6 gene, two sequences (168 bp and 295 bp) of IRF-7 gene; and one sequence (400 bp) of IRAK-4 gene were obtained. Blastn homology of these sequences showed 80-85% similarity with *Ictalurus punctatus*.

II. Cross-species evaluation of channel catfish primers for amplification of different TLR genes in *C. magur*:

Kidney, gills and liver tissue were collected from *C. magur*, and cDNA was prepared by revert-Aid first strand cDNA synthesis kit (Thermo Scientific) from total RNA extracted from each tissue. Real time PCR primers for different TLR genes (TLR-1, TLR-2, TLR-3, TLR-4, TLR-5, TLR-7, TLR-8, TLR-9, TLR-18, TLR-19, TLR-20, TLR-21, TLR-22, TLR-25, TLR-26) reported in channel catfish were evaluated for cross amplification in kidney, gills and liver tissues of *C. magur*. TLR3 was amplified in all tissues whereas TLR-20 and TLR-22 genes were detected in kidney and gills of magur. Other TLRs could not be amplified with primers reported from Channel catfish.

III. Cross-species evaluation of channel catfish primers for amplification of other immune genes in *C. magur*:

Kidney, gills and liver tissue were collected from *C. magur*, and cDNA was prepared by revert-aid first strand cDNA synthesis kit (Thermo Scientific) from total RNA extracted from each tissue. Real-time PCR primers for immunogenes (C3, B/C2A, IFN- γ , IL1- β , MHC-I, MHC-II) reported in channel catfish were

also evaluated for cross amplification in *C. magur*. Amplification was obtained in IL-1 β and MHC-I genes in all the tissues tested; whereas C3 could be amplified only in gill and liver tissues of magur.

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

Period: December, 2015 – December, 2020

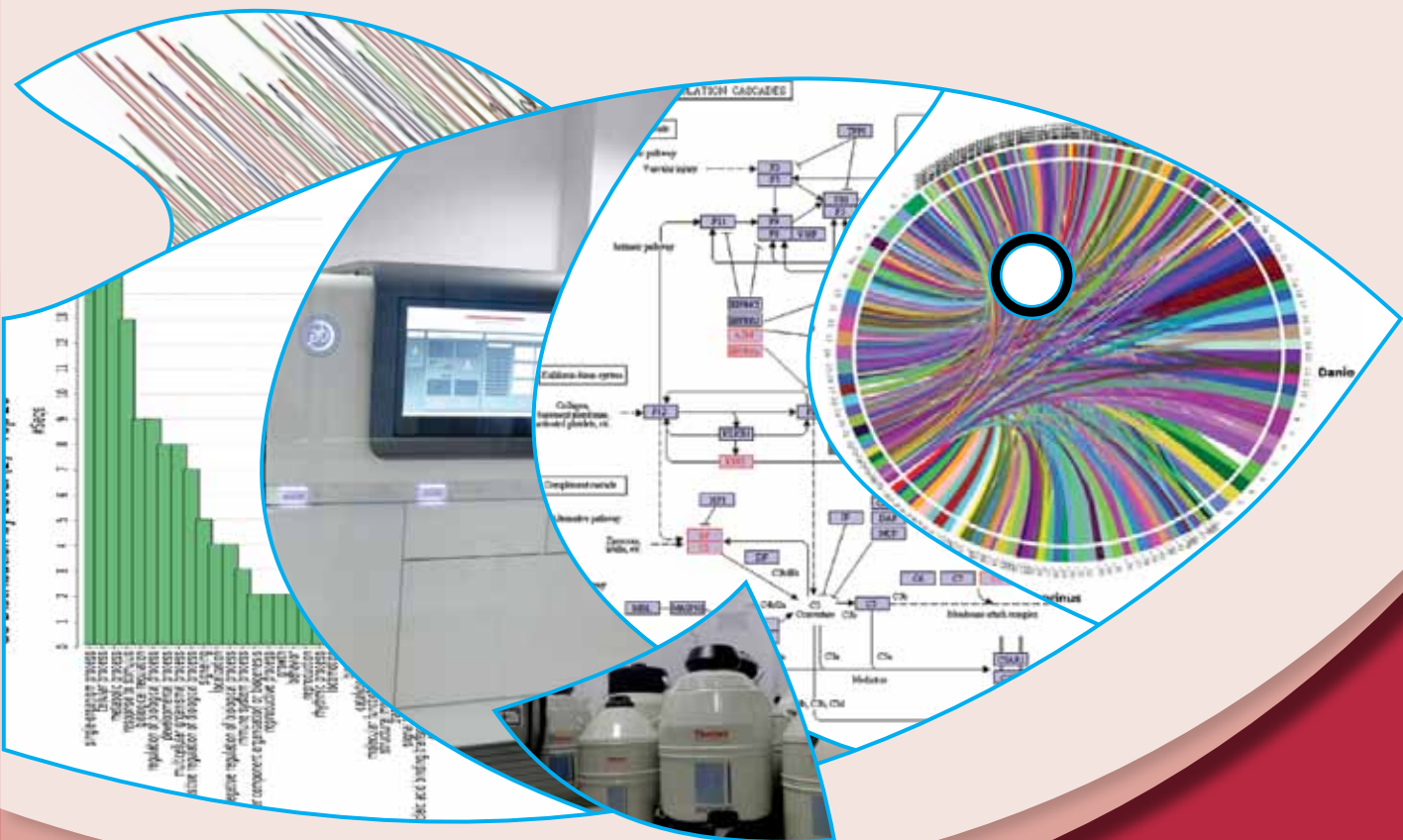
Personnel: Rupesh Kumar (PI) and Rajeev K Singh (Supervisor)

Funding Support: UGC-Rajiv Gandhi Fellow

Sampling was done for the three Indian major carp species from six different hatcheries from Uttar Pradesh (Moth and Baruasagar), Madhya Pradesh (Dhajrayi and Beniganj) and West Bengal (Bankura and Badtala). Sampling includes tissue collection from individual fish specimen (fingerlings) during and after the breeding season. The brood fish was sampled for fin clips, non-invasively. Total 763 tissue samples of the three Indian Major Carp species (*Labeo rohita*- 258; *Cirrhinus mrigala*- 255; *Catla catla*- 250) were collected from the six distant hatcheries from the states of Uttar Pradesh, Madhya Pradesh and West Bengal (n~50/ hatchery). Total 340 samples (*L. rohita*-166; *C. mrigala*- 72; *C. catla*- 102) from the selected hatcheries were collected (n~50 tissue samples per hatchery) and DNA was extracted using Phenol-chloroform method and quantified on agarose gel as well as spectrophotometrically.

The already identified 21 polymorphic microsatellite loci, *Lro43**, *Lro34**, *Lro14**, *Lro44**, *Lro25**, *MFW1**, *Lr45**, *Lr37**, *Lro49**, *Lro33**, *Lro12**, *Lr28**, *Lro37**, *Lr14a**, *Lr41**, *Lro31**, *Lr128**, *Lr147**, *Lr158**, *Lr63** and *Lro23** were optimized on Polyacrylamide Gel Electrophoresis (PAGE) with seven individuals each from *L. rohita*, *C. mrigala* and *C. catla* for the use of the genetic variation analysis. Microsatellite genotyping is being done using polymorphic loci. A total 655 truss images (*L. rohita*-188; *C. mrigala*- 239; *C. catla*- 228) were captured at the time of sampling and converted in to TPS format with the assigned 13 landmarks for the three Indian major carps. The data has been generated and is being analyzed.

Program 4.3: Genomic resources for important fishes



The genomic research has globally transformed the dimension of biological studies. Advancements in sequencing technologies and increase in computational capacity is leading to generation of huge amount of genomic data like whole genome sequence information, transcript information of specific tissues, BAC resources, ESTs, mitogenome data generation at large scale etc. These resources are important not only as a form of *ex situ* conservation but are essential for understanding various biological processes, to identify genes differentially expressed among different conditions, to understand the development and function of different cell types that make up complex tissues etc. Comparative genomics has helped in genome annotation, gene discovery

and evolutionary studies. Knowledge of the genomic mechanisms through mining of genes can provide technologies for fast selection of economically important adaptive traits and improvement of the target species.

ICAR-NBFGR has taken up lead in this regard for genomics of non-model species. *De novo* genome and transcriptome sequencing of three finfish species Rohu, Indian catfish and Hilsa and one oomycete fish pathogen is completed and is using for bioprospecting of genes. NBFGR has accomplished bioprospecting of genes involved in immune response and hypoxia tolerance in Indian catfish. The in-house capacity built, now is taking forward the research on gene discoveries and population genomics.

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

Tenualosa ilisha (Hamilton 1822), the hilsa shad, is a highly relished fish and has high consumer preference for its nutritional value, taste and delicacy. In recent times, many factors, such as, irrational exploitation involving both adults and juveniles, habitat modification, increased pollution load, etc., have caused declining trend in natural stocks, particularly in the Hooghly estuary and therefore, *T. ilisha* has been categorized under moderate vulnerable category. Thus, there is a compelling need for domestication of the species through captive breeding and culture, to harness the aquaculture potential and also to conserve and rehabilitate the fishery in its distribution range, where it has declined. The present work aims to generate whole genome sequence information and allied resources in *T. ilisha*. The consolidated knowledge of sequenced genome will facilitate understanding of genetic mechanisms influencing production traits in this potential aquaculture species, integration and implementation of above resources to support improvement of production traits.

Annotations and bioinformatic analysis of Hilsa genome for identification of important genes involved in adaptability to varying salinity

The study provides a high quality draft genome assembly of 762.512 Mb covering 92.2% of the genomic region (estimated genome size of 827 Mb), of *T. ilisha* that showed high contiguity, comparative orthology and synteny with the similar teleost species. The observed N_{50} of 2.63 Mb with largest contig length of 17.43 Mb and a total of 2864 contigs, without any ambiguous bases. The genome completeness analysis of PacBio self-corrected and Illumina corrected draft assembly against 3 BUSCO databases, revealed a highest quality estimate of 96.4% genome completeness.

Gene models prediction and annotations against Swissprot and NR database by BlastP searches ($e < 10^{-5}$) from the draft assembly of *T. ilisha* showed that a total of 33702 gene models matched against sequences in databases. A total of 28249 orthogroups were obtained among 12 analyzed fish proteomes. Among them, 17015 orthogroups were observed in *T. ilisha*, while 18 orthogroups were specific to *T. ilisha*, comprising 55 protein sequences.

In assembled draft genome with 2864 contigs, a total of 17,280 repetitive elements were identified, which included both interspersed and tandem repeats. Tandem repeats identified covered 0.2% (11, 87,926 bp size) of total genome, while simple sequence repeats (SSRs) have represented 8.39% (64006510 bp) of draft genome.

The synteny analysis of *T. ilisha* draft genome and chromosomal level assemblies of *Danio rerio*, *Salmo salar* and *Cyprinus carpio* resulted in mapping of 660 sequences from *T. ilisha* (>100Kb size) against *Danio rerio* (25 chromosomes), *Salmo salar* (29) and *Cyprinus carpio* (50) (Fig. 36). Comparisons of *T. ilisha* largest assembled contig (Contig 630) against *S. salar* and *D. rerio* chromosomes showed highly contiguous anchors with two chromosome of *S. Salar* (Chr 11 and Chr26), while with one chromosome of *D. rerio* (Chr 7). It was also found that in all the three comparisons of syntenic blocks approximately 50% of the blocks were inverted, whereas with *S. salar* chromosome 26, there were 21 blocks inverted, followed by 13 and 10 inverted blocks against *S. salar* chromosome 11 and *D. rerio* chromosome 7.

A total of 28249 orthogroups were obtained among 12 fish proteomes analyzed, with 518 species specific orthogroups comprising of 3175 genes among all selected species. Among them, 17015 orthogroups were observed in *T. ilisha* (Fig. 37), while 18 orthogroups were specific to *T. ilisha*, comprising 55 protein sequences. There were a total of 39 orthogroups, in which all the selected species were present, while 2721 protein sequences from *T. ilisha* were not assigned to any orthogroup. Further, 91.9 % (30981/33702) proteins sequences of *T. ilisha* were included in orthogroups. The OrthoVenn database results showed that a total of 9157 orthogroups were common to *T. ilisha*, *Clupea harengus*, *D. rerio*, *Oryzias latipes*, *Poecilia formosa* and *Xiphophorous maculatus* species.

In *T. ilisha* genome, Claudins (68 copies), Aquaporins (21 copies), Gap Junction/Connexin (55 copies) and Adenylate cyclase (32 copies) genes were identified. Individual genes orthology analysis showed that most of the species had highly similar orthogroups based on these genes. Its complete mitochondrial genome of 16745 bases with the average reference consensus concordance; accuracy was 99.83%. The *T. ilisha* mito genome was found to have 13 protein coding genes, 2 ribosomal RNA, 22 tRNAs and a D-loop region.

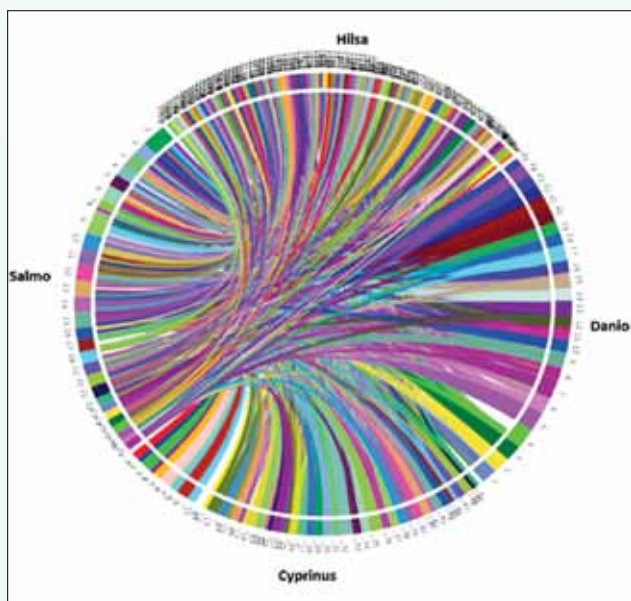


Fig. 36 Synteny analysis showing the mapping of *T. ilisha* genome (660 sequences) against *Danio rerio* chromosomes (25), *Salmo salar* (29) and *Cyprinus carpio* (50)

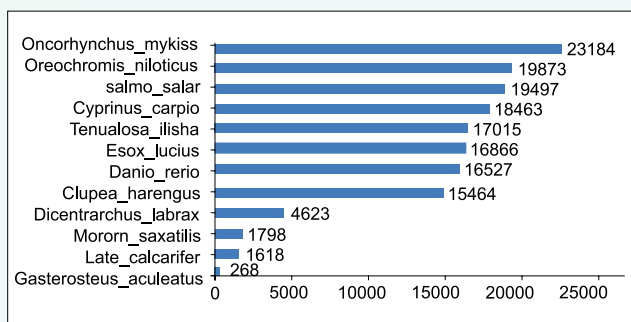


Fig. 37 The OrthoFinder results shows the number of orthogroups containing species in *T. ilisha* (n: 17015) as compared to other fish species

Project: Establishment of mapping and marker panel for first generation linkage map in Indian Catfish, *Clarias magur*

Period: April, 2014 – March, 2018
Personnel: Rajeev K. Singh (PI), Santosh Kumar, Rama Shankar Sah, Rajesh Kumar and Vikash Sahu
Funding Support: Institutional, ICAR - NBFGR

The Indian catfish, *Clarias magur* is a important aquaculture species and ICAR-NBFGR is constantly striving for comprehensive research on this important species. Several economically important genes, involved in hypoxia tolerance and immune response, have been identified. However, genetic improvement has the potential to address the low growth potential of this species. Genetic linkage maps are essential and powerful tools for genomic research. Among the most important applications of genetic maps are QTL mapping, genome annotation and comparative genomics.

Mapping Populations

Four full-sib F2 families were obtained by mating of F1 hybrids derived from a cross between a *C. magur* female and male parent obtained from Madhya Pradesh and Jharkhand, respectively. The brooders were prepared by injecting Gonopro in females @ 2 ml and males @ 1 ml per kg of body weight. The male was sacrificed to obtain testis after 17 hours. The testes were cleaned with saline solution and macerated with physiological saline. The extract, thus obtained, was used to fertilize eggs that were obtained through stripping of the female. Washing was done with water (2-3 times) to remove unused seminal fluid. The fertilized eggs were incubated in flow through system. The hatching took place after 20-22 hours. After the absorption of the yolk sac, the zooplanktons were fed to the juveniles. At the age of one month, the juveniles were reared family-wise in FRP tanks.

Tissue sampling

The tissue samples (muscle, fin clip and blood) of about 50 individuals per family were collected and preserved in 95% ethanol. The high quality genomic DNA was extracted using Phenol-chloroform methodology and quantified on agarose gel, as well as, micro volume spectrophotometer, Nanodrop. The genomic DNA of high molecular weight and high purity was selected for molecular studies.

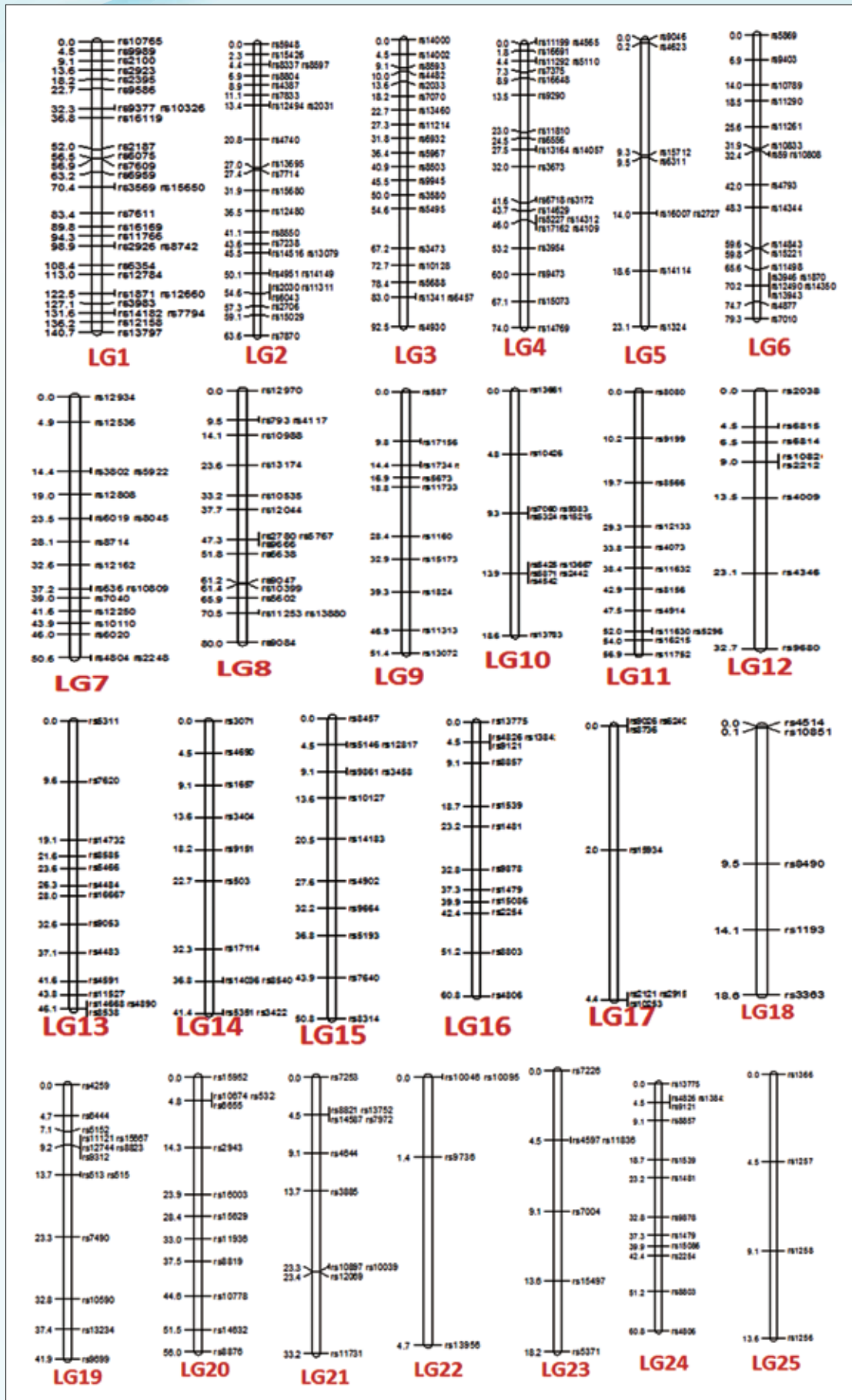


Fig. 38 Female specific linkage map in *C. magur*

Marker development and genotyping

Enrichment of marker panel by inclusion of SNPs through ddRAD sequencing was undertaken, which is a low coverage sequencing of the randomly restricted genome. The high quality genomic DNA was extracted from the blood tissue of parents/juveniles of respective family. The ddRAD libraries were prepared by digesting with a combination of restriction enzymes, NlaIII and MluI. The digested genomic DNA was ligated to adapters and then PCR-amplified with forward and reverse primers that added unique sample-identifying index sequences and Illumina flowcell annealing sequences. To increase the probability of sampling homologous restriction sites between individuals with sufficient coverage depth, DNA was then size-selected on agarose gel. Following sequencing, samples were identified and demultiplexed using the unique combination of barcodes added during PCR. The data was analyzed using Stacks pipeline for variant call. SSR markers were identified using small insert library which was sequenced on PacBio RSII. Out of 529 primers, 337 primers yielded amplification of which 145 were polymorphic in parents (single or both).

Construction of linkage maps

Sex specific linkage maps were constructed based on male and female segregation using genomic pedigree data as input for the analysis on Joinmap 4.1 (Kyazma, Wageningen, Netherlands). Maternal and paternal genotypes were converted from 11:1:1:1-ratio type ($\text{♀} \times \text{♂}$: AB \times CD or AB \times AC), 1:1 ♀ type (AB \times AA or CC), and 1:1 ♂ type (AA or CC \times AB). All the statistical analyses were made with the cross-pollinating (CP) coding scheme. A chi-square (goodness-of-fit) test was used to assess the deviations from the expected Mendelian segregation patterns. Linkage between markers was examined by estimating LOD (logarithm of the odds) scores for recombination rate (T) and map distances were calculated using Kosambi mapping function. For the female map, the LOD score ranged 5.0-7.0, in order to generate the linkage groups based on the segregation data. Total SNP 4579 were used for genotyping the mapping panel. A total of 2231 loci were used for generating male map (n_xn_p). Segregation distortion was found at 887 loci. After removing distorted loci and similar loci, 401 SNPs were assigned into 25 linkage groups. For female mapping, 2348 SNPs were employed to observe linkage. After removing distorted loci and

similar loci, 486 SNPs could be assigned (Fig. 38). The number of markers on linkage groups varied from 8 to 26 markers. Total length of female map was 847.1 cM, whereas, male map was 785 cM long. These findings have application in marker assisted selection program through QTL mapping for superior traits.

Project: Whole genome sequencing and development of allied genomic resources in two commercially important fish- *Labeo rohita* and *Clarias batrachus* (*C. magur*)

Coordinator: J. K. Jena

Period: September, 2013 – March, 2018

Personnel: Basdeo Kushwaha (PI), Ravindra Kumar and Mahendra Singh

Funding Support: Department of Biotechnology, Govt. of India

The *Clarias batrachus* is now known as *magur*, is a popular catfish in India having excellent flavor, high quality protein and single central bone with high aquaculture potential. The study aimed to generate whole genome sequence information utilizing various genomic data generated on different NGS platforms and bioinformatics tools. The draft genome generated of this important cultivable species is first of its kind and will pave the way for comparative genomics in fishes leading to holistic increase in fish productivity in the country.

Assembly and scaffolding of *C. magur* genome

The draft genome of *C. magur* has been successfully completed from NGS data generated by different sequencing platforms using MaSuRCA genome assembler followed by scaffolding and gap closing. The genome draft of *C. magur* resulted in approximately 93% coverage with maximum scaffold size 5.2 Mb (Table 8). Quality of the assembled genome was assessed by BUSCO with prediction of 93% of the known vertebrate genes.

Repeat analysis on *C. magur* whole genome

The repeats in the *C. magur* genome was analyzed using various repeat identification tools. RepeatMasker (v.3.3.0) was employed to detect known TEs based on a homologous search against the Repbase, TE library (release 17.01). RepeatProteinMask (v.3.3.0) was used to identify the

TE relevant proteins. Subsequently, LTR FINDER and RepeatModeller (v.1.05) were used with the default parameters to construct the *de novo* repeat library. Further, RepeatMasker was employed to identify and classify novel TEs against the *de novo* repeat library. All the repeats were finally combined together by filtering redundant repetitive sequences (Fig. 39). The repeats covered approximately 40% of the genome. Retroelements and DNA transposons cover around 17% of the genome, respectively.

Evolutionary analysis of annotated genes of *C. magur*

The assembled genome sequence of *magur* was compared with that of the zebrafish, channel catfish and fugu genomes to determine genes orthology. The homologous chromosomes were determined as the chromosomes with maximal gene homology. First, all proteins of the *magur*, zebrafish, channel catfish and fugu were combined and all-versus-all BLASTP was carried out with a maximal e-value of $1e-5$. The OrthoMCL pipeline was used to define protein similarities with a minimum of 50% length coverage and maximal e-value of $1e-5$. MCL generated the potential orthologue relationships between *magur*, fugu, channel catfish and zebrafish with the inflation parameter set at 1.5. A total of 2760 single copy genes were detected between *magur*, zebrafish, channel catfish and fugu, while 1412 genes were absent in channel catfish and *magur* but present in zebrafish.

Gene prediction and annotation of *C. magur* genome

Three different software, *i.e.*, Augustus, Glimmer Hmmer and GeneMark were used for *de novo* prediction of genes from masked genome of *C. magur*. This resulted in the prediction of 27832, 715180 and 50957 genes, respectively. The transcriptome reads of brain, testis, ovary, skin, liver and muscles tissues were mapped on to the *C. magur* genome using Hisat tool with default parameters and assembled into transcripts using Stringtie. This resulted in the identification of 136447 genes. The resultant genes were further used as training set in Augustus followed

by gene prediction which resulted in identification of 45838 genes. Furthermore, mRNAs and ESTs related to *C. magur* were downloaded from NCBI and mapped onto the *C. magur* genome using Exonerate software. This resulted in the identification of 53283 genes. Finally, the gene model based on *de novo* prediction, transcriptome as well as EST based prediction was merged to form a comprehensive and non-redundant gene set using Ipred followed by cuffcompare. This resulted in identification of 53,591 genes. These genes were further refined by removing duplicated genes and the genes with less than 150 bp size. This resulted in identification of 51,200 genes. These genes were further annotated using BLAST2GO against UniProt database followed by Interpro mapping that resulted in annotation of 34,666 genes (Fig. 40 & 41).

Structural variation analysis in antimicrobial peptide genes in *C. magur*

NGS Illumina NextSeq reads of 3 populations, *viz.*, CBH, CBM and CBO (*C. magur* hatchery, *C. batrachus* wild population from West Bengal and *C. batrachus* wild population from Orissa) were mapped on to 7 anti-microbial peptide genes, *viz.*, BPI_1, BPI_2, LEAP, NK lysin type1, NK lysin type2, NK lysin type3 and hepcidin, using Bowtie and Mpileup. This resulted in identification of SNP variation in BPI_1, BPI_2, NK lysin type2 and hepcidin. These genes were further mapped on the transcriptome assemblies of brain, testis, ovary, skin, liver and muscles tissues. Ovary showed no hit for the above 7 reported antimicrobial peptide genes but all the 7 genes were mapped in liver, muscle and skin (Table 9).

Transcriptome expression analysis male and female brain tissues of *C. magur*

The transcriptome assembly of both the male and female brain was carried out using Trinity which resulted in 143600 transcripts and out of which, 1702 genes were unique in males and 1023 genes were unique in females. Further, differential expression of brain transcripts were analyzed using DeSeq which resulted in 6507 up-regulated genes and 7218 down-regulated genes in male and female brains.

Table 9 Expression analysis of antimicrobial peptide genes in different tissues/organs of *C. batrachus*.

Tissue	BPI_1	BPI_2	NK Lysin-1	NK Lysin-2	NK Lysin-3	LEAP2	Hepcidin
Female Brain	+	+	+	+	+	-	+
Male Brain	+	-	+	+	+	+	-
Testis	+	-	+	+	+	-	+
Ovary	-	-	-	-	-	-	-
Muscle	+	+	+	+	+	+	+
Liver	+	+	+	+	+	+	+
Skin	+	+	+	+	+	+	+

Table 8 Assembly statistics of scaffolds with ≥ 1 Kb size.

Scaffolds generated	35,313
Maximum scaffold length (bp)	5,216,833
Average scaffold length	135,582
Total scaffolds length (bp)	1,010,309,606
Non-ATGC characters (%)	6.906
Scaffolds size ≥ 1 Kb	35,313
Scaffolds size ≥ 10 Kb	8,001
Scaffolds size ≥ 1 Mb	139
N50 value	332,510

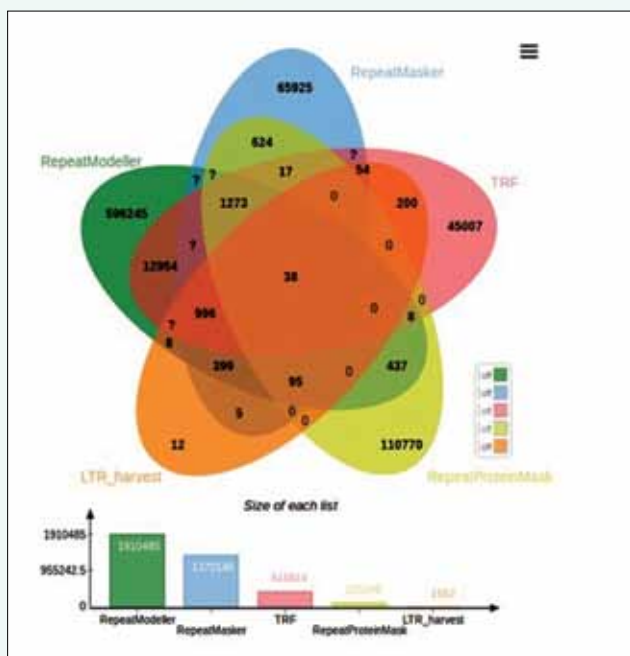


Fig. 39 Venn diagram and Bar diagram of distribution of repeats in *C. magur* (*C. batrachus*) assembled genome identified using different repeat analysis software

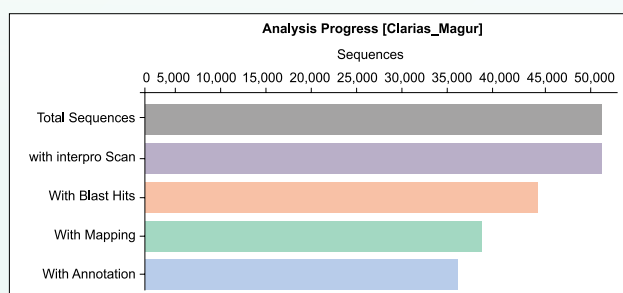


Fig. 40 Analysis progress of Blast2Go annotation of *C. magur* (*C. batrachus*) genes

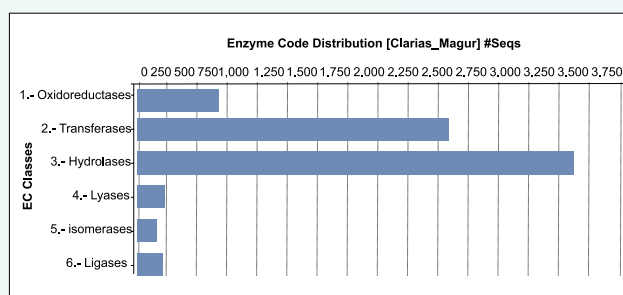


Fig. 41 Enzyme code distribution resulted from Blast2Go annotation of *C. magur* (*C. batrachus*) genes

Project: Network Project on Agricultural Bioinformatics and Computational Biology

Subproject: Construction of physical map of *Clarias magur* genome

Period: May, 2017 – March, 2020

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

Funding Support: ICAR - Indian Agricultural Statistics Research Institute, New Delhi

Research on fish genetics, molecular biology and genomics aspects has taken momentum in the country. In terms of genomic characterization, the information on genome sequence along with bacterial artificial chromosome (BAC) library, resource have already been generated in *Clarias magur*. The utilization of these BAC resources have not been undertaken further. Physical mapping is needed for generating complete genomic resource of *C. magur*. The present study aims to generate physical map of *C. magur* using BAC clones.

A total of 429 BAC clones from various 384 well plates (mainly from plate numbers 6 and 7) were cultured and revived. From the cultured clones, a total of 421 clones were used for DNA isolation. During the reporting period, a total of 108 forward, as well as, reverse BAC end sequences from plate numbers 6 and 7 were generated using T7 and pbRP1/ pbRP2 primers on ABI Genetic Analyzer 3500 using Sanger's chain-terminating dideoxynucleotide method. The length of the end sequences ranged from 44 - 910 bp. These end-sequences were mapped on the contigs generated in the *Clarias batrachus* (*magur*) whole genome sequencing project.

A total of 4 probes were constructed by labelled with Fluorescein 12-dUTP and Rhodamine 5-dUTP fluorophores. The DNA of BAC plate 001 (384 wells) were pooled together and labelled with Rhodamine 5-dUTP using nick translation. Similarly, pooled DNA of plate 002 was labelled with Fluorescein 12-dUTP fluorophore. Clone number D19 of plate number 001 was labelled with Fluorescein 12-dUTP. Bioinformatic analysis of genome sequence of *C. magur* revealed that D19 clone of plate number 001 contains around 39 genes. Similarly, clone number D1 of plate number 003 was labelled with Rhodamine 5-dUTP. These four DNA probes were further used for mapping on metaphase chromosome complements of *C. magur*.

All the four DNA probes were mapped on metaphase chromosome complements of *C. magur*, which showed different locations on the chromosomes. In pooled DNA probes, the localization of probes were detected on many chromosomes, but single signal on homologous chromosomes was observed in single clone DNA probe (Fig. 42).

The forward and reverse BAC end sequences were mapped on the contigs/scaffolds generated in the whole genome sequence data of *C. magur*. During the reporting period, a total of 108 BAC end sequences were mapped on the contigs, where 11 end sequences did not show any hit with the contigs. A bioinformatics pipeline, named BACPipe: Bioinformatics Pipeline for BAC-end Sequence Analysis of *C. magur*, is developed for mapping of the end sequence on the contigs/scaffolds of whole genome sequence of *C. magur* (Fig. 43). This pipeline can give various information after mapping, like scaffold number, as well as, size of the scaffold, simple sequence repeats (SSR), GC content (%) query coverage, number of genes located, etc (Table 10).

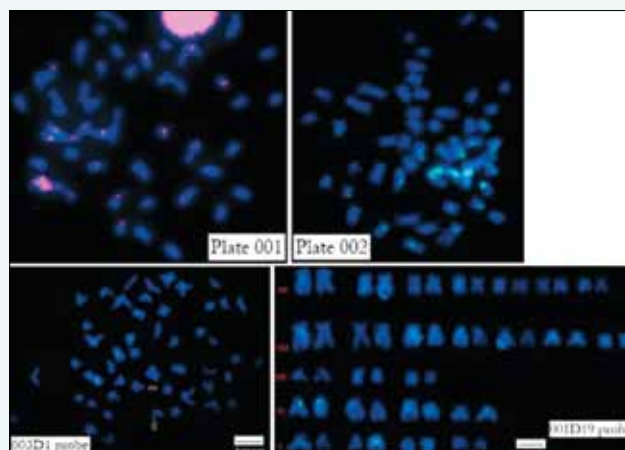


Fig. 42 Metaphase chromosome complements showing localization of probes of BAC clones DNA of plate no. 001 and 002, BAC clone 003D1 and karyotype with 001D19 clone DNA in *C. magur*

Table 10 Sample data on mapping of BAC end sequences on contigs.

S.N.	Sequencing date	CloneID_Primer	Sequence length (bp)	SSR	GC%
1.	2017.08.24	006A17_pbRP1	401	(C)17: 70..86	38.15
2.	2017.08.24	006A3_pbRP1	835	(TTTA)3: 253..264, (TATT)6: 767..790, (TTAT)5: 794..813	37.05
3.	2017.08.24	006A3_T7	552	-	40.26
4.	2017.08.24	079A17_T7	789	-	43.58
5.	2017.08.24	007A3_pbRP1	439	(GAAG)3: 274..285	33.72



Fig. 43 Bioinformatic tool ‘BACPipe’ for mapping of BAC on contig of whole genome sequence

Project: Stress tolerance response in cultivable freshwater fish species
Period: April, 2017- March, 2018
Personnel: Satish K. Srivastava (PI), Ravindra Kumar and Murali S.
Funding Support: Institutional, ICAR- NBFGR

Climate change is predicted as major threat that has both direct and indirect impacts on fishes. There is substantial global evidence that climate change has impacted fish populations and communities. Farmed organisms are susceptible to a wide range of stressors like temperature, oxygen, nitrogen, salinity, etc. that can pose a major threat to thriving aquaculture industry with considerable economical repercussions. This new work was undertaken with the purpose to estimate the critical limits of these abiotic stressors in fishes and also investigate the biological changes taking place in the organisms during the exposure to these abiotic stresses. A water re-circulatory system was designed and fabricated for the experiment (Fig. 44). Water quality parameters of experimental and control tanks, such as, water temperature, pH, dissolved oxygen, TDS were monitored (Fig. 45). Thermal tolerance limits for *Labeo rohita* and *Catla catla* were found to be 41 °C and 39 °C, respectively, after exposing to high water temperature stress. Behavioral studies of fishes, such as, abnormal swimming and widening of fins were observed at critical thermal limit in exposed groups of both *L. rohita* and *C. catla*.

Physiological parameters were recorded and analysed from the control and exposed *L. rohita* (40 °C) and *C. catla* (38 °C) specimens at sub-lethal thermal limits for longer duration of 60 days. Blood samples drawn from the control and exposed *L. rohita* and *C. catla* specimens at sub-lethal thermal limits were analysed for serum protein, urea, haemoglobin,

glucose and cholesterol levels. In the control, *L. rohita* samples, the blood cholesterol was found to be 142.0 mg/dl, while the glucose was 74.0 mg/dl, haemoglobin-8.6 mg/dl, glucose-74 mg/dl, serum protein-3.0 mg/dl and urea was 5.0 mg/dl. In the specimens exposed at 41 °C water temperature, there was increased level of urea, haemoglobin, glucose and cholesterol, while the serum protein decreased as compared to control (Fig. 46). Similar patterns were observed in *C. catla* specimens.

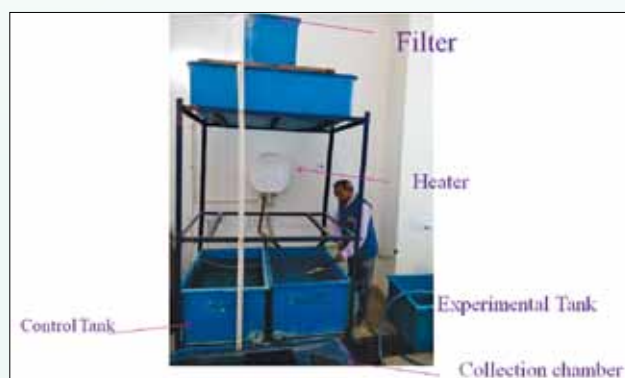


Fig. 44 Water re-circulatory system was designed and fabricated for the experiment

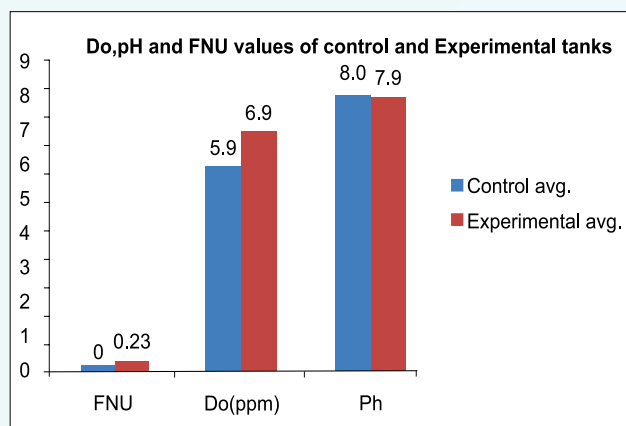
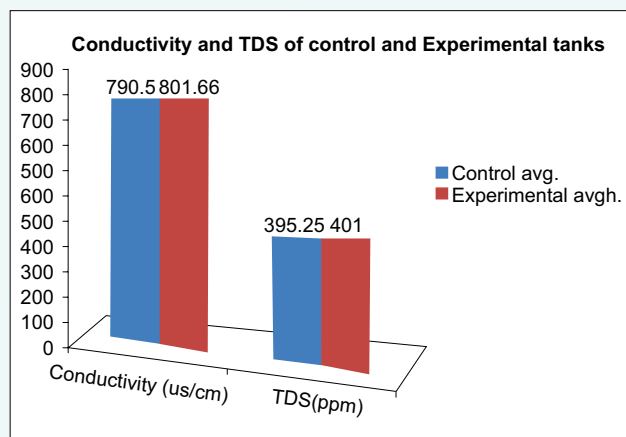


Fig. 45 Water quality parameters in experimental tanks

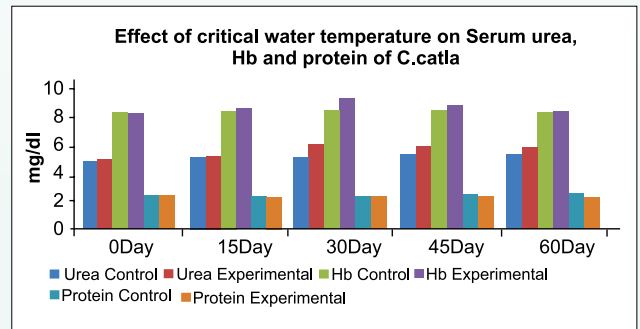
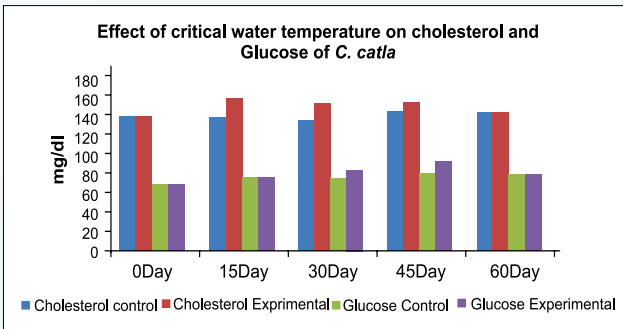
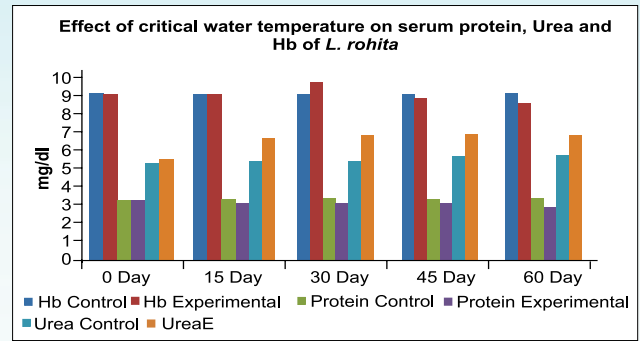
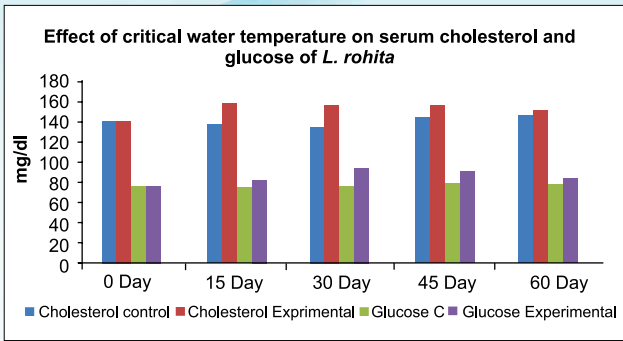


Fig. 46 Effect of critical water temperature on serum cholesterol, glucose, urea, Hb and serum protein

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



E*x-situ* conservation and repositories of the genetic resources in their native distribution are enlightend under section 9.0 of convention of Biological diversity. Such strategies are also emphasized in Biological Diversity Act, 2002 of India. The aquatic genetic resources are facing serious threats from the multiple stressors including natural and anthropogenic. As a result, number of species are heading towards depletion in numbers and sizes in some of their native distribution range. Hence, conservation of fish genetic resources of agrobiodiversity importance is a vital aspect for sustainable utilization of these resources. The objective of such research is to preserve the genetic material for information retrieval, regeneration of depleting germplasm

of conservation and aquaculture value, stock enhancement of wild relatives and populations. ICAR-NBFGP has been working in this area of research since its inception. The major activities of the institute have been as species-specific sperm cryopreservation protocol development for finfish species, tissue banking, and captive breeding of some fish species. Recent initiatives have brought success in capacity building for using stem cells as conservation tools and are promising as it can store diploid germplasm in contrast to the haploid storage through sperm. In the coming days, though sperm cryopreservation can be a useful aquaculture tool to alleviate the sperm related problems, however, stem cells are more promising for long-term conservation of germplasm.

Project: Development of surrogate broodstock for propagation of valuable fish germ lines

Period: April, 2014 – March, 2019

Personnel: SullipK.Majhi(PI)andLabrechai M. Chowdhury

Funding Support: Institutional, ICAR-NBFGR

Pluripotent stem cell transplantation is one of the promising assisted reproductive technologies for propagation of valuable genetic resources. This technique could play a pivotal role in the conservation of endangered fish species. The

objectives of the study were to standardize the protocol for efficient depletion of endogenous germ cells in recipient fish (*Cyprinus carpio*) and to develop surrogate broodstock through intra-gonadal germ cell transplantation that will generate unlimited donor-derived functional gametes.

The spermatogonial cells isolated from the young goldfish (*Carassius auratus*) were transplanted into gonads of adult common carps (*Cyprinus carpio*) by non-surgical (through common urogenital papilla) interventions, which had been severely depleted of endogenous germ cells by a combination of Busulfan (40 mg/kg BW; total 5 dosage) and high water

Table 11 Results of artificial insemination of *C. auratus* eggs with sperm derived from surrogate *C. carpio* fathers (transplanted with *C. auratus* germ cells).

Surrogate <i>C. carpio</i> fathers	Eggs derived from wild <i>C. auratus</i> mothers (n)	Fertilization (%) (n)	Hatching (%) (n)	Donor-derived germline transmission (%) (n)
#1	81	93.8 (76)	89.4 (68)	100 (68)
#2	96	90.6 (87)	93.1 (81)	100 (81)
#3	75	93.3 (70)	90.0 (63)	100 (63)
#4	88	96.5 (85)	90.5 (77)	100 (77)
#5	102	94.1 (96)	93.7 (90)	100 (90)
Control	79	92.4 (73)	93.1 (68)	NA

Table 12 Results of natural spawning trial between surrogate *C. carpio* fathers and mothers (both transplanted with *C. auratus* germ cells).

Surrogate <i>C. carpio</i> fathers	Surrogate <i>C. carpio</i> mothers (n)	Numbers of embryo collected (n)	Fertilization (%) (n)	Hatching (%) (n)	Donor-derived germline transmission (%) (n)
#1	#1	60	96.6 (58)	89.6 (52)	100 (52)
#2	#2	82	93.9 (77)	92.2 (71)	100 (71)
#3	#3	103	88.3 (91)	92.3 (84)	100 (84)
#4	#4	55	81.8 (45)	91.1 (41)	100 (41)
#5	#5	68	89.7 (61)	81.9 (50)	100 (50)
Control		95	88.4 (84)	86.9 (73)	NA



Fig. 47 Intra-papillar transplantation of donor cells into recipient gonads. A) The recipients were placed on to an operation platform and received a constant flux of aerated anesthetic water through the gills during the procedure, B) The donor cells were injected through the genital papilla and, C) Resuscitated in clean water. Scale bar indicates 2 cm.

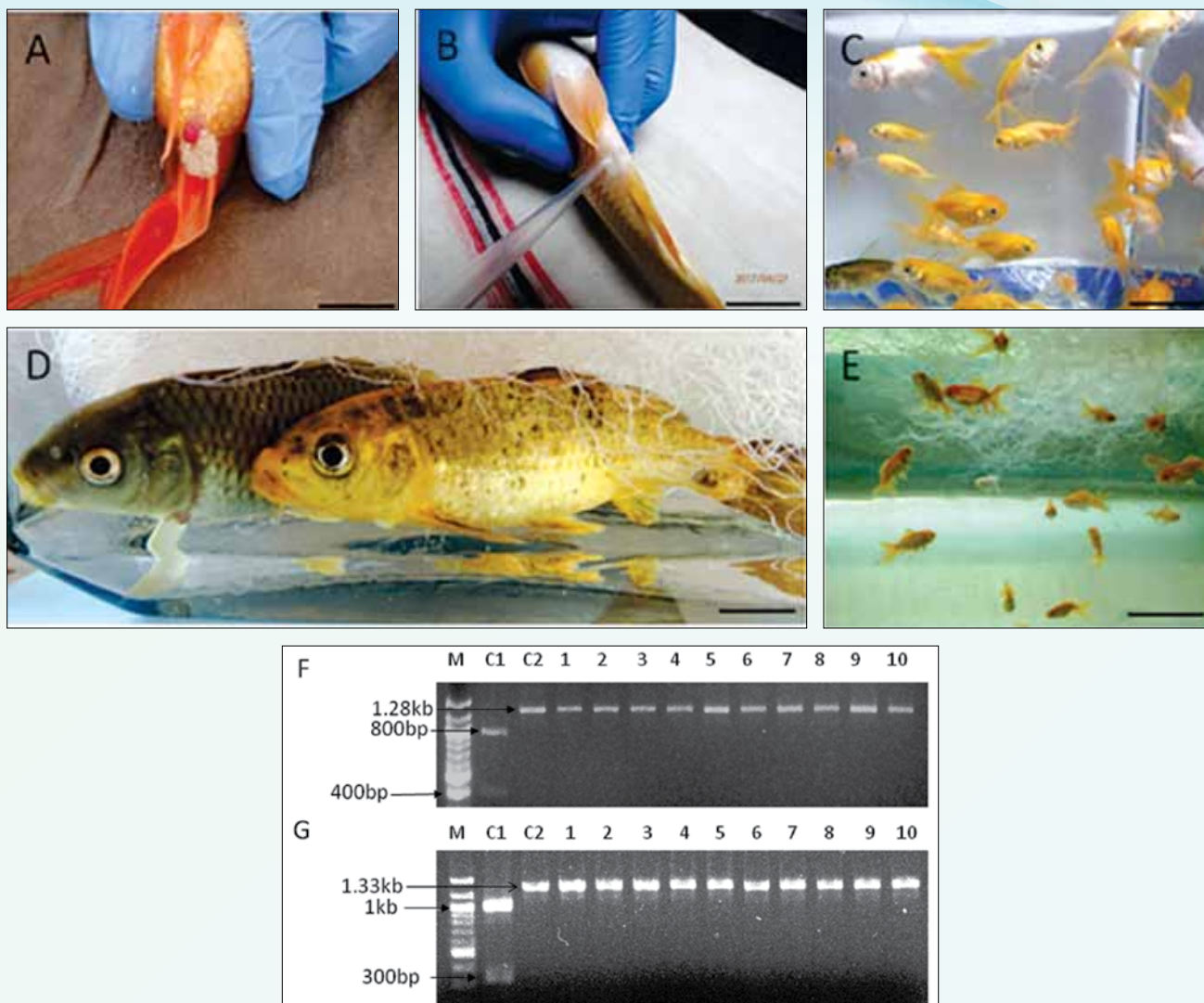


Fig. 48 Overview of steps involved in production of offspring from surrogate parents. A-C) Donor-derived spermatozoa were harvested from the surrogate fathers and artificially fertilized with the eggs derived from pure goldfish mother to produce surrogate progeny, D, E) The surrogate parents were coupled for natural spawning to generate the surrogate progeny, F, G) The molecular confirmation of surrogate progeny was done by using markers developed from RAG2 gene. Scale bar indicates 2 cm (A-E).

temperature (38 °C) treatments. The observation of the donor cells behavior inside the recipient gonads showed that transplanted gonial cells were able to migrate, colonize and undergo further differentiations to produce donor-derived gametes within 4-5 months from the transplantation. The presence of donor-derived gametes was confirmed by PCR in 90% of the recipients. These surrogate (common carp) parents were crossed through artificial fertilization and natural spawning to produce viable donor-derived (goldfish origin) progeny (Table 11 & 12 and Fig. 47 & 48).

Project: Establishment (Development & Characterization) of spermatogonial stem cells (SSC) from (endemic fishes of Western

Ghats) *Etroplus suratensis* and *Sahyadria denisonii*

Period: April, 2015 – March, 2018

Personnel: T. Raja Swaminathan (PI) and Charan Ravi

Funding Support: Institutional, ICAR-NBFGR

The testes of pearlspot are paired, elongated, tubular and thread like. Not enough mature testicular tissues would be harvested from a single fish which could be used in Fi-coll gradient separation of spermatogonial cells. Hence, we have taken another fish species, *Clarias dussumieri* for further experiments. Live adult *C. dussumieri* of 30-34 g body weight; 14-16 cm length (n=10), that were

captive bred and maintained in glass aquaria for the preparation of testes explant for SSC. Three primary cultures of *C. dussumieri* testes using explant method and dissociation methods (collagenase) and two primary cultures of *C. dussumieri* seminal vesicle, were carried out using dissociation methods (collagenase). Microscopic observation of culture consists of mixed population of somatic cells and spermatogonial cells including motile sperm. Twitching of the cell mass was observed from the cultures of *C. dussumieri* seminal vesicle 10 days after the preparation and the twitching was continued up to 20 days of culture. Monolayer of SSC of *C. dussumieri* was established and passaged for

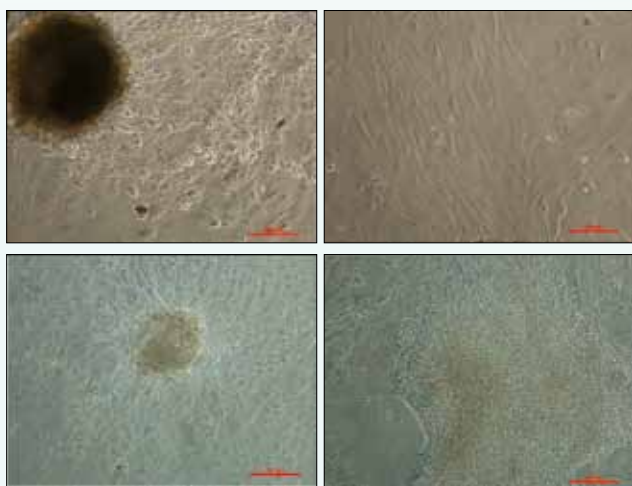


Fig. 49 Primary culture of *Clarias dussumieri* testis and seminal vesicle by explants and dissociation methods.

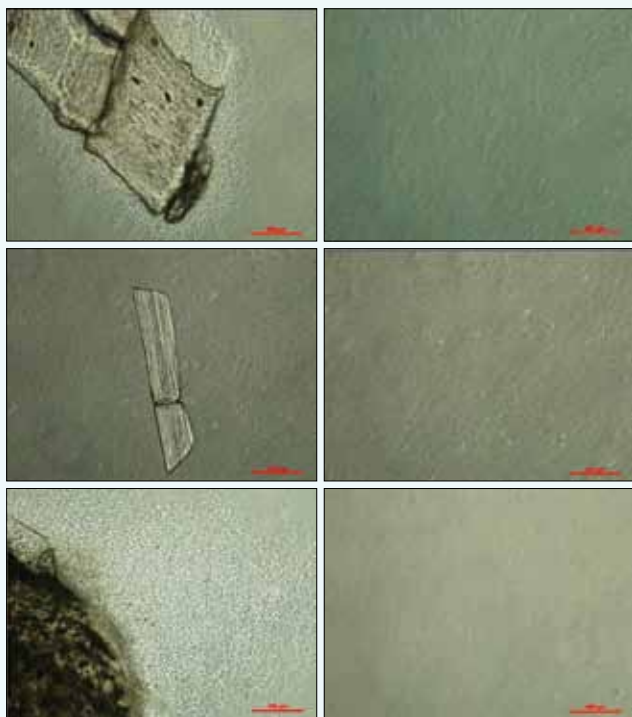


Fig. 50 Primary culture of caudal fin tissue of *Horabagrus brachysoma*, *Clarias dussumieri* and *Etroplus suratensis*.

5 times. Monolayers of sertoli cells of the testes of *C. dussumieri* were also established during the course of establishing SSC cells (Fig. 49). Primary cultures of caudal fin tissue of three endemic fish species of the Western Ghats viz., *C. dussumieri*, *E. suratensis* and *H. brachysoma* were carried out and the fin cultures of the respective fishes were deposited to NRFC at ICAR-NBFGR, Lucknow (Fig. 50) for future program on capacity building if somatic cell banking.

Project: National repository of fish cell lines in NBFGR, Phase II

Period: May, 2017 – May, 2020

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

Funding Support: Department of Biotechnology, Govt. of India

Eight new fish cell lines were deposited by researchers namely DrG (*Danio rerio* gill), DrRPE (*D. rerio* retina), and CSCVE (*Channa striatus* cardiovascular tissue), OST (*Channa striatus* thymus), CMP (*Cirrhinus mrigala* peritoneal), PHF (*Pangasianodon hypophthalmus* fin), TL (*Oreochromis niloticus* liver) and AFF (*Pterophyllum scalare* fin). These cell lines were found free from bacterial and fungal contamination. Authentication and characterization of these cell lines is under progress for assigning NRFC code, wherein DNA has been isolated from four cell lines with COI sequence information confirmed for two new cell lines.

In-vitro culture of testis-originated cells of *Clarias magur* was carried out using explant method and grown till 5th passages. Leibovitz-15 (L-15) growth media with 20% FBS was found optimum at 28 °C temperature for cell growth. Epithelial-like cells in morphology were observed which was confirmed by immunocytochemistry. Chromosome observations revealed diploid number of 50 chromosomes (Fig. 51). The species-specificity of cultured cells was confirmed by amplification of two mitochondrial markers, i.e. COI and 16S rRNA. Characterization of cell lines was undertaken during the period and 42 cell lines were revived and cryopreserved. Total 38 cell lines were re-authenticated by sequencing the COI gene. Chromosome preparation work was standardized and carried out for 18 cell lines with karyotyping finalized for two cell lines.

In-vitro toxicity estimation of heavy metal mercury chloride was assessed using AlamarBlue assay in three cell lines, viz., PC1L1Tr (*Pomacentrus caeruleus* liver), DT1F4Ex (*Dascyllus trimaculatus* fin) and DRG (*Danio rerio* gill). Similarly, *in-vitro* toxicity estimation of a newly introduced herbicide, tembotrione, was carried out using AlamarBlue assay in two cell lines, viz., PHF (*Pangasiodon hypothalmus* fin) and DT1F4Ex (*Dascyllus trimaculatus* fin). IC50 values were calculated using GaphPad Prism v6 software which was found to be 2014 and 1317 μ M, respectively, in the tested cell lines (Fig. 52).

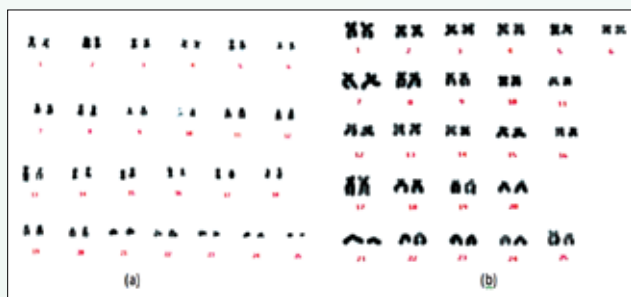


Fig. 51 Karyotype prepared from fish cell line (a) (CFEN2) of *Amphiprion sebae* (b) testis-derived cells of *C. magur*.

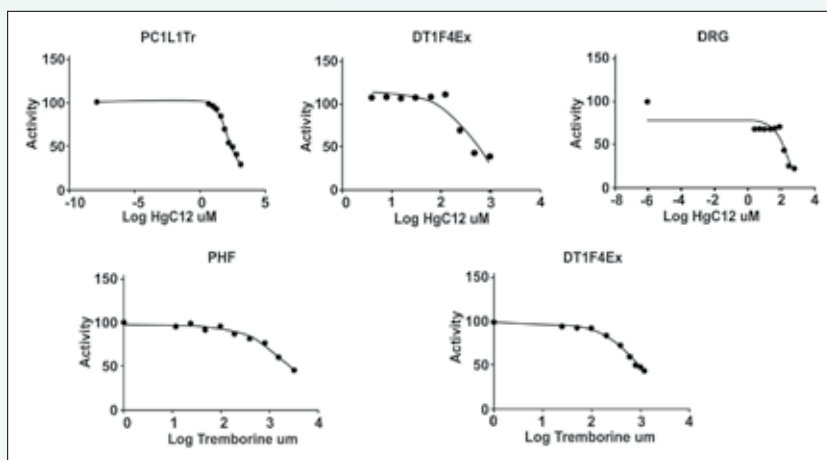


Fig. 52 Dose responsive inhibition curves of five cell lines (a) PC1L1Tr, (b) DT1F4Ex and (c) DRG treated with different doses of heavy metal Mercury chloride; and (d) PHF and DT1F4Ex treated with different doses of herbicide, Tembotrione.

As a part of the cell line exchange program, five fish cell lines from Access Centre at C. Abdul Hakeem College were transferred to NRFC, ICAR-NBFGR, while 18 cell lines from NRFC were transferred to Access Centre for storage and distribution purposes. Out of 18, 11 fish cell lines are currently being maintained successfully at the Access Centre. Seventeen cell lines were distributed to five research institutions for research purposes.

Project: Evolutional significance of hypothalamus-pituitary-gonadal axis in fishes, with special reference to Indian species

Period: November, 2016 – October, 2018

Personnel: Ajay K. Pandey (PI)

Funding Support: Institutional, ICAR-NBFGR

To have a database on hypothalamus-pituitary-gonad (HPG) axis, 456 references including Indian fishes were collected and documented. Gonadotropin releasing hormone (GnRH), the main regulator of reproduction in vertebrates, which appeared phylogenetically first in cnidarians (coelenterates with evolution of nervous system), is reported from molluscs, echinoderms and protochordates. With evolution of HPG axis, it plays pivotal role in neuroendocrine regulation of reproduction in chordates. GnRH has been reported from non-hypothalamus tissues also but its role appears to be autocrine/paracrine in nature.

Generally, the cytoarchitecture of hypothalamus of teleosts follows the similar pattern with neurosecretory cells forming nucleus preopticus (NPO), nucleus preopticus paraventricularis (NPP), nucleus lateralis tuberis (NLT) and nucleus preopticus basalis lateralis (NPBL). The neurosecretory cells of NPO and NLT contribute beaded axons in the matured females to form common hypophysial tract passing through infundibulum to the pituitary gland. The beaded appearance of the axons may probably be due to accumulation of neurosecretory substance. Since GnRH immunoreactivity is more confined in NLT cells, it appears to play important role in ovarian maturation of teleosts while neurosecretory cells of NPO registered enhanced activity during spawning peak suggesting its role in contraction of smooth muscle leading to the release of gametes. There exist reports that fishes lack portal blood circulation and neurons directly transfer the secretory materials through axons to the respective cells of pituitary gland. There are a

few reports of its existence in air-breathing Indian teleosts. Our observations revealed that hypothalamus differs considerably in location and distribution of neurosecretory cells in different sub-classes of fishes.

Though HPG axis of a few Indian teleosts have been documented, attempt is being made to compare the relative involvement of this axis with the reproduction of representing species including the observations made in *Labeo rohita*, *Tor putitora*, *Heteropneustes fossilis*, *Xenentodon cancila*, *Lates calcarifer*, *Hilsa kelee*, *Rastrelliger kanagurta*, *Megalaspis cordyla*, *Decapterus tabl*, *Decapterus russelli*, *Ariomma indica* and *Sphyraena obtusata*. Pituitary gland of these fishes possessed distinct stalk and was divisible into rostral pars distalis (RPD), proximal pars distalis (PPD) and pars intermedia (PI) arranged one after the other. Corticotrophs (ACTH cells) and lactotrophs (LTH-prolactin cells) were the predominant cell types in RPD whereas PPD comprises mainly somatotrophs (STH cells), gonadotrophs (GTH cells) and thyrotrophs (TSH cells). The cynophils (gonadotrophs) become major cell type of PPD in the matured specimens. Few chromophobic cells with feeble staining affinity were also seen distributed in all the three portions of pituitary gland. In the comparative study, 3-5 acid fuchsin +ve Herring bodies (HB) of varying sizes were encountered in anterior neurohypophysis (ANH) of matured specimens of *L. calcarifer*, however, such structure are rarely seen in the freshwater teleosts. Evolutionary and physiological significance of these structures are not known.

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

Period: June, 2017 – May, 2019

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

Funding Support: Science and Engineering Research Board (SERB)

Hydropower infrastructure transforms the local aquatic environment via alteration in flow, barriers, sedimentation and changes in nutrient adversely affecting downstream fishes like *Tor putitora* which is a 'flagship' species, inhabiting Himalayan Rivers.

The majority of critical riverine habitats of mahseer have been subjected to or are under the process of regulation for hydropower generation. In recent years, conservationists have expressed concern over its declining populations due to indiscriminate fishing besides severe adverse effects of dams. The purpose of this project is to gain insight into the basic biological responses, employing a suite of physiological and molecular tools in order to properly manage endangered mahseer populations in hydropower-impacted river system.

The current proposal is being executed at four hydroelectric project sites: Srinagar and Birahi Ganga (in Alaknanda basin), Tehri-I and Maneri Bhali-II (in Bhagirathi basin). Formal meetings were held with project officials, District Forest Officers and other regulatory authorities in Uttarakhand to discuss the scope of project, objectives and importance of the project in long term conservation goal of golden mahseer. Subsequently, written permissions were secured from Srinagar and Birahi Ganga project authorities to sample the species from different stretches along project sites.

Experimental fishing was carried out both in person, as well as, by using the expertise of local fisherfolk to determine the current stock aggregation and length-weight pattern of *Tor putitora* at all sites. Total 28 samples were collected at AHPC Srinagar site, 15 samples from Birahi HEP and 14 samples from THDC Tehri site. No sample could be collected around Maneri Bhali-II hydro-project at Uttarkashi. However, 17 samples were recorded at unobstructed Nayar stream at Devprayag and 18 samples were recorded at Satpuli. The length-weight relationship of fish has significant importance in studying the growth, gonadal development and general well-being of fish population. The *b* value was calculated here to assess whether the samples of *T. putitora* obtained were growing allometrically or isometrically. For all the samples clubbed together, the *b* value was 2.9 depicting the growth is almost isometric, the value less than 3 may be due to small sample size or due to the fact that fishes in these stretches are growing with slower weight increase relative to the length.

Field assessment was done to assess the area under influence at each project via site surveys, as well as by consulting project officials and previous Environmental Impact Assessment reports.

Accordingly, twelve sampling points were identified i.e., one upstream and downstream at each of the four hydroelectric project sites and four unobstructed flow sites in order to gather information on water quality and habitat alteration due to hydropower operations and infrastructure developments. Monthly data was collected starting October, 2017 and significant variations in habitat quality and water chemistry were observed between upstream reservoirs and downstream river stretch. Water temperature of the reservoir showed typically rapid warming-up (up to 24 °C) between Decembers to March owing to the low flow rate as the power plants were storing rather than generating electricity. Similarly, high pH (up to 8.3) was recorded in reservoirs during February-March which might be due to increased photosynthetic activity and decomposition of allochthonous matter with rise in temperature. The dissolved oxygen concentration reduced (up to 6.2 mg/l) in the dam reservoirs in comparison to downstream stretches (9.6 mg/l) as a result of suspended materials brought into the reservoirs by rain increases oxygen demand while oxygen production by photosynthesis is reduced by turbidity. Total alkalinity in downstream unobstructed flow showed wide range of fluctuations (40-105 mg/l) which is due to varied location, bottom deposits and season, while less variability was observed upstream (65-90 mg/l). Higher level of nitrates and phosphates in reservoirs was observed in post-monsoonal months (0.085 and 0.9 mg/l, respectively). This could be attributed to runoff after rainfall from nearby farmlands containing fertilizers and herbicides leading to increased concentration in reservoirs. The significant variation in the conductivity in upstream values was observed (59-240 µS/cm), which may

be due to dilution by influx of rain water and later the reduction in water level in the reservoirs due to evaporation with the start of dry season. A large accumulation of total solids in the reservoirs (105-339 mg/l) than unregulated river stretches (72-165 mg/l) was recorded, which may reduce light penetration and suppress photosynthetic activity leading to decrease in productivity of aquatic ecosystem.

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

Period: April, 2017- March, 2020

Personnel: Sharad K. Singh (PI), Lalit K. Tyagi and Akhilesh K. Yadav

Funding Support: Institutional, ICAR - NBFGR

It is envisaged that Best aquaculture management practices (BMP's) in barren and low crop productive land of Uttar Pradesh can be developed through the scientist-farmer's participatory mode. In the due course of time, the sustaining aquaculture productivity in these areas can be achieved through diversification of fish species in aquaculture, which is expected to improve income and quality of life of participating families and vulnerable sections of society. This change would need study of impact of indigenous resources based aquaculture-led integrated farming system, in improving rural livelihoods and enhancing social and economic empowerment of poor quality land. Survey was undertaken in the district of Lucknow for selection of suitable farmer's site. On different visits to the sites in the identified area, one of the lady farmer, Mrs. Sapana Devi, W/o Shri Santosh Kumar, Village & Post Sameshi, Mohanlalganj, District Lucknow owner



Fig. 53 Survey of beneficiary ponds

of defunct/un-operational government lease pond area (1.250 ha) agreed to provide (0.4 ha) area for carrying out project activities (Fig. 53). Soil sampling and analysis of the area was done. The soil parameters recorded were: pH (8.2-8.3), EC (0.2-0.3 dS/m),

organic carbon (0.20-0.30%), available nitrogen (4.5-6.0 mg/100g soil), available phosphorus (0.5-1.0 mg/100g soil), and potash (15.0-18.0 mg/100g soil). The water quality from nearest sources was optimal for aquaculture-led activities.

Program 4.5: Documentation of fish genetic resources of India



Documentation of all existing genetic resources of the country is essential for sustainable exploitation of the potential resources and also for safeguarding its stakes globally. The information is also required for fulfilling country's obligations towards international requirements such as Aichi's Biodiversity Targets under Convention on Biological Diversity (CBD) and State of World Aquatic Genetic Resources of CGREA under FAO. Keeping the importance of the subject in view, ICAR-NBFGR has

initiated strong efforts in cataloguing and documentation of fish genetic resources, since its inception. The generated data base becomes more important for strategic planning and decision making for management of Fish Genetic Resources (FGR). The institute is working to document FGR database on web interactive format with added information on genetics, genomics and diseases etc., for its wider use. This is a part of initiative to provide a single window framework for existing information.

Project: Information base on fish genetic resources of India.

Period: April, 2012 – March, 2018

Personnel: Ajey K. Pathak (PI), T. T. Ajithkumar, Mahender Singh, Poonam J. Singh, Rejani Chandran, Rajesh Dayal, Reeta Chaturvedi and Ravi Kumar

Funding Support: Institutional, ICAR - NBFGR

The Bureau continued its efforts towards collection and cataloguing of the fish genetic resources of India. The information base on fish genetic resources of India was restructured using MySQL database management system under the Linux operating platform. At present, the database holds the complete checklist information of 3055 species. Further, type specimen information for 987 fish species collected from the published sources was entered. On line web data sources like Catalog of Fishes and FishBase; as well as, off line sources like books and database sources were used to collect the information. The collected information was screened and compiled. Total 26 tables were designed to hold the records in the database. All the tables hold the information about fish. For populating compiled information on fish, a web based data entry interface integrated with data management ability was developed using Linux-Apache-MySQL-PHP (LAMP). To make the data entry enable for the selected users, an authentication module managed by the database administrator was developed. This module provides an interface that allows the user to register for data entry and viewing. After registration, the registered user can enter the data. The data entry section includes options like taxonomic lineage, biology, molecular information, patents and other information. After implementation of this section, the data on different parameters were entered by the users. The patented nucleotide information related to Zebra fish was compiled for 167 records and this information was enlisted for entry. To manage users and the records entered by users, a dashboard for administrator was developed. This dashboard is only accessible to the database administrator and the database administrator preserves the rights of user and data management.

A web interface for browsing information integrated with search and query tools was designed and implemented using the LAMP technology. This

web interface known as FGRBase: Fish Genetic Resource Information System includes set of query and search tools and browsing pages. In addition, it includes options *viz.*, home page, user guide, downloads, fish photo gallery, add new species, GIS occurrence map etc. The Home page option includes different query and search tools to retrieve the information from the database using value entered or selected by the user. All the query tools works in selective mode and at a time only one query can be fired to retrieve the information from the databases. All molecular databases developed at the Institute like HRGFish, FBIS, FishKaryome, FishMicrosat and FMir were also integrated and implemented to obtain the information for each species covered in the database. To integrate the spatial occurrence information of fish species, a spatial dataset on occurrence of fish species was developed under the ARCGIS environment and map was published (Fig. 54).

Species-specific information for each species of the mollusc reported from India was collected from the published sources. Information on 200 additional species totaling to 1750 species of mollusc representing 299 families, 66 order and 6 class out of the checklist of 3,827, was updated by populating the information on taxonomy, habitat, synonyms, common name, reference, author and year.

Transcription factors in 26 fishes were identified from the literature and 17 attributes/ parameters were finalized to collect the information. These attributes are species name, transcription factor name, family name, ensembl_ID, gene_ID, symbol, alias, full name, chromosome map location, gene orientation, gene length, gene position, transcripts, gene ontology, paralog, ortholog and cross reference. The transcriptional information on 26 fishes were manually curated and characterised by review of literature and open data sources like NCBI, Pfam, UniProt and TRANSFAC. The gene, genomic and gene ontology information of each species were retrieved and linked to the respective data sources based on ID. To accomplish this, a web interface of the database was designed and implemented using the LAMP technology and accessible at (<http://mail.nbfgr.res.in/fishtf/index.php>). Query tools were designed and implemented in the interface to retrieve the information from the database and facilitate link to other data sources in order to access the detailed information. The Hidden Markov Model (HMM)

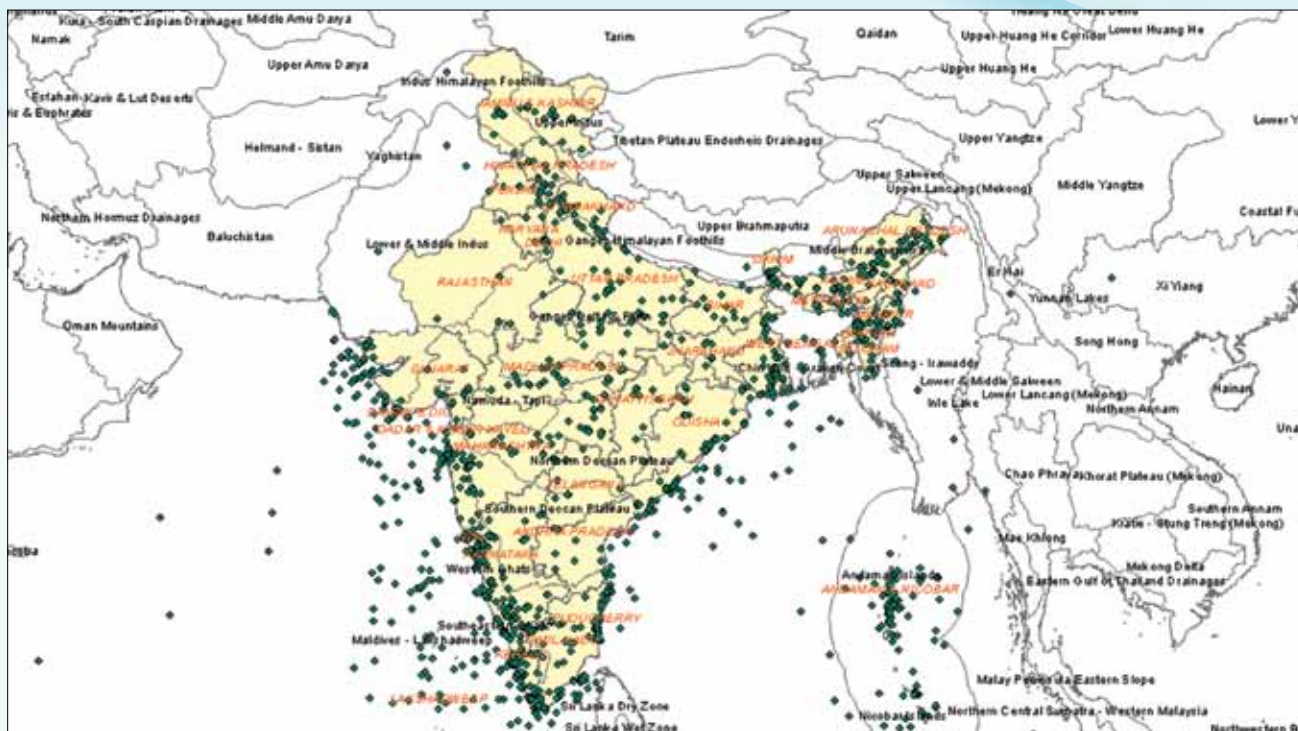


Fig. 54 Occurrence map of fish species in FGR database

profiling of the each classified transcriptional factor is being retrieved using the Pfam scan database (<https://www.ebi.ac.uk/Tools/pfa/pfamscan>). The output from the Pfam database is in compilation process for populating data in the database. The parameters of HMM profiling to be populated in the database are seq id, alignment start, alignment end, envelope start, envelope end, hmm acc, hmm name, hmm type, hmm start, hmm end, hmm length, bit score, E-value, significance and clan.

Project: Techno-legal analysis of policy issues and patents for strategic management of fish genetic resources.

Period: April, 2015 – March, 2018

Personnel: Poonam J. Singh (PI), Ajay K. Pandey, Amar Pal, Amit S. Bisht and Ravi Kumar

Funding Support: Institutional, ICAR -NBFGR

Exploring fish biodiversity through patent analysis for novel sequences for usable information retrieval

Total 746 patented protein sequences were screened of which 500 belong to cypriniformes. Total 486 patented protein sequences were screened for

disclosure of origin declaration in patent document and country guidelines for exchange and patenting for genetic resources of zebrafish. Patented and non-patented nucleotide, and protein sequences related to fish genetic resources were compiled for analysis of governance of digital sequence in public databases. This would help in providing a structured input for biopiracy that has been debated before the enactment of TRIPS where developing countries wanted share of their information and traditional knowledge.

A policy paper is under compilation for utilizing geographical Indications as a traditional specialty, especially for Northeast India using model of European Union for premium value addition. European Union has 46 such products registered under class 1.7 relating to fresh fish, molluscs and crustaceans. The analysis report is being compiled for potential Geographical Indications related to fish genetic resources that can be harnessed for innovation.

Project: Intellectual Property Management and transfer/ Commercialization of Agricultural Technology scheme (Up-scaling existing components i.e. Intellectual Property Right)

Period: April, 2017 - March, 2020

Personnel: Poonam J. Singh (PI and Nodal Officer)

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

The World Intellectual Property Organization (WIPO) has designated 26th April as World Intellectual Property Day. World Intellectual Property Day was celebrated on 26th April, 2017 at Prathamik Vidyalaya Ambedkar Zone-I, Lucknow (Fig. 55), which was also published at WIPO website.

A handholding cum training workshop on “Empowering Self Help Groups through Systemic Design Approach for Entrepreneurship & Sustainable Livelihood Incubation” was organized on 19th November, 2017 for raising awareness towards entrepreneurship and livelihood enhancement using systemic design strategies based on preliminary survey of Kalli Pashchim area near Lucknow.

Awareness workshop aimed at handholding and mentorship for potential Agri-startups using systemic design thinking approach by harnessing simplicity and mentoring towards innovation. The programme empowered women by imparting basic awareness on entrepreneurship which will be a core area for agriculture based business incubation in future. A total of five Self help groups (SHGs) with 16 women in each SHGs, participated in the programme. In order to develop entrepreneurial and financial skills among SHGs, an outreach programme on “Capacity building among women SHG members through Inclusive Financial Literacy for Entrepreneurship and Innovation” was organized in co-ordination with AWOKE India Foundation and Lucknow Management Association (LMA) on 17th January, 2018 at Pradhan Mantri Kaushal Vikas Yojna Kendra, Kali Paschim, Lucknow. The workshop empowered the existing SHGs of Kalli Pashchim village, Lucknow



Fig. 55 Celebrating World Intellectual Property Day with the theme 'Innovation for Improving Lives during Happy Innovation Hour' for Kids' at Pratamik Vidhalya, Ambedkar Zone-I, Lucknow.

1.Kids made a painting for the Chief Guest, Ms Swati Singh, Honble Minister of State, Govt. of Uttar Pradesh; 2. The creative painting showing power of creative hands showing future of kids was made for the Chief Minister of Uttar Pradesh; 3. Hon'ble Minister with kids; 4. Kids with their design on problems and their solution; 5 Kids participating exploring and understanding nature through microscope; 6. Kids with teachers and organisers at Ganga Aquarium, ICAR-NBFGR; 7. Kids observing fishes; 8. Enthusiasm among kids and 9. Kids with awareness materials at Ganga Aquarium.

by imparting basic awareness on financial literacy. The women also discussed how their skills can be used for creating entrepreneurship avenues. A total of 40 women registered with government SHGs, participated in the programme.

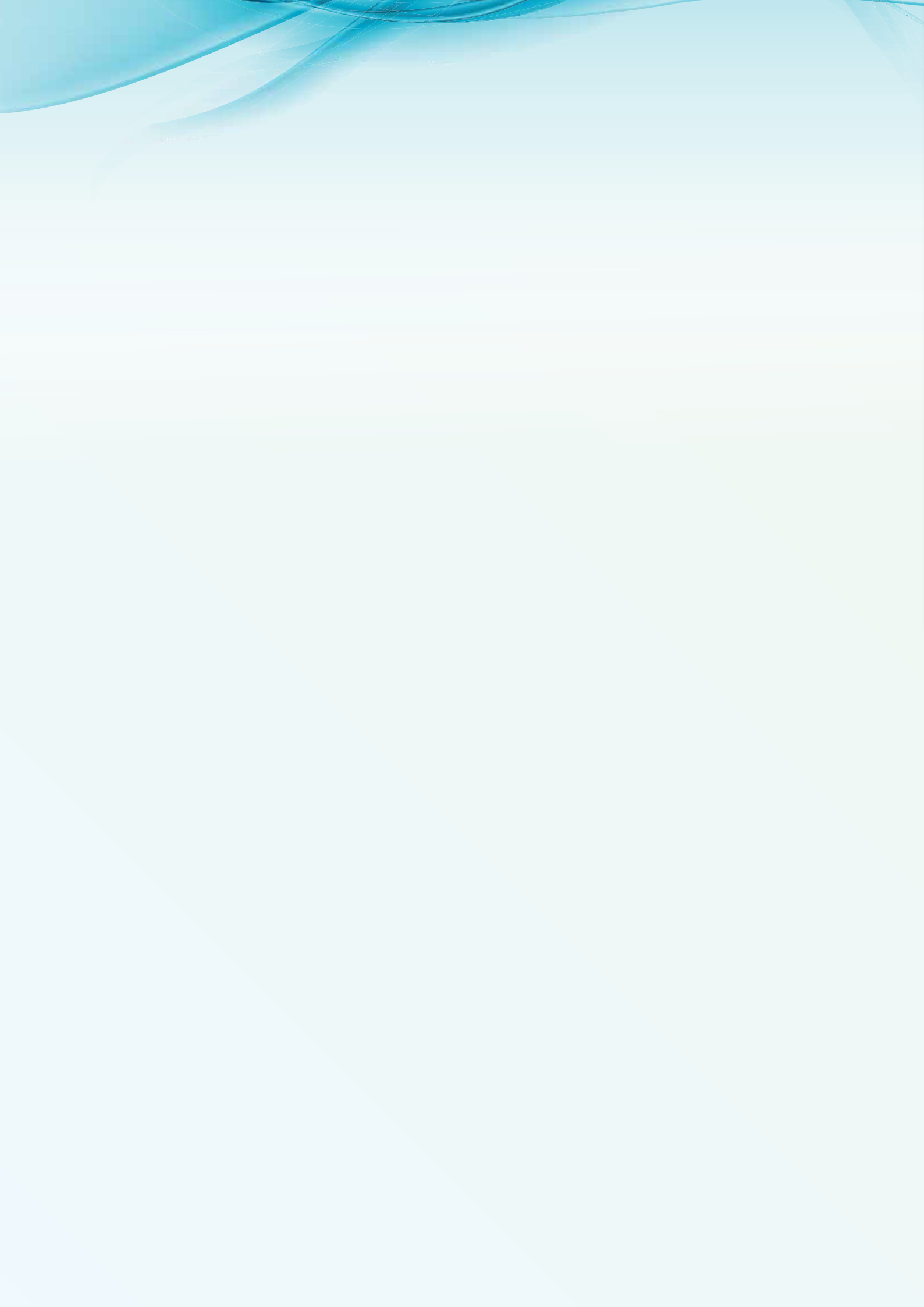
As a creative case study, the women were imparted skills for making a terrarium with locally available materials. The women used their traditional skills to make toys like fish, beads and huts. Fish scales were reused to make decorative flowers. The terrariums were marketed by Aaryish depending on orders. This was a small initiative to teach women how to make things that are custom made. Within a month of the

workshop, the women displayed their terrariums at an exhibition inaugurated by the Mayor of Lucknow, who also appreciated the efforts of the SHGs (Fig. 56).

Orientation Programme on IP Management and Creativity in Agriculture Fisheries were provided to the visiting undergraduate students of I. T. M University, Gwalior, Madhya Pradesh on 22nd July, 2017 and Collage of Fisheries Science, Sri Venkateswara Veterinary University, Muthukur, Andhra Pradesh on 9th August, 2017. A postcard communication series was started for SHGs community for answering queries related to entrepreneurship and IP, starting with 140 self-addressed postcards.



Fig. 56 Row A: Primary interaction with Self Help Groups, training handholding and mentoring; Row B: Preparation of terrariums by SHGs and exhibiting terrariums made of locally available materials at Sibtainabad Imambara for display; Row C: Designs created by locally available materials; Row D: The final products and Row; E: Mentoring for Financial Inclusion.



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



Exotic diseases are one of the major risks to aquaculture and indigenous germplasm. Under the law and international obligations, diagnostic and reportings is an important need for effective surveillance and prevention of outbreaks. ICAR-NBFGR established it's capacity and is leading the program in this direction. Trans-boundary movement of live fish species is an age old practice, which has been intensified during last few decades with the advent of globalisation. Despite the abundant fish diversity available in the country, alien species have been imported in India intentionally or un-intentionally with specific objectives of

broadening the stocking base for aquaculture, fisheries development in lakes, sport fisheries, and ornamental trades. Besides this, there are reports of clandestine introduction of some dangerous fishes. Though number of precautionary measures are already in vogue to control and check the spread of alien fish species in Indian open waters, still, there has been some instances indicating abrupt appearance and expansion of aliens in open waters. Hence, there is stringent need to have a Risk-Benefit Assessment model for alien fish species to control unregulated introduction of fish species across the borders.

Project: Development of an immune marker and understanding host - *Aphanomyces invadans* interaction using macrophage cell line

Period: April, 2014 - March, 2018

Personnel: Neeraj Sood (PI), Pravata K. Pradhan and Chinmayee Muduli

Funding Support: Institutional, ICAR-NBFGR

To understand the molecular response of fish macrophage to oomycete pathogen, the response of catla macrophage cell line against *Aphanomyces invadans* was examined at different time intervals after infection, using real-time PCR. The pro-inflammatory cytokine genes, interleukin-1 β (IL-1 β) and tumor-necrosis factor alpha (TNF α) showed up-regulation following infection with *A. invadans* zoospores. The class II Major Histocompatibility (MHC II) gene, involved in immune responses to exogenous antigens, was down-regulated in the presence of *A. invadans*. The down-regulation of MHC II gene appears to serve as a form of immune evasion, as the MHC II plays a crucial role in the recognition of exogenous antigens. However, MHC I gene was unchanged. The Mx gene encoding the antiviral protein and complement component C3 gene did not show any change in expression in response to oomycete pathogen. The supernatant from 53 hybridomas was checked for reactivity with catla macrophages. However, none of the hybridomas was found to have reactivity with catla macrophages.

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

Period: May, 2016 – May, 2019

Personnel: Neeraj Sood (PI), Pravata K.

Pradhan and Vindhya Mohindra

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

A trilateral consortium involving research institutes in India, Bangladesh and United Kingdom funded by DBT-BBSRC-DFID, is working on key diseases of carps and shrimps encountered in Asia viz., infection with *Aphanomyces invadans* and white spot disease, respectively. Under the project, the focus is to develop understanding of the host-pathogen interactions in dynamic disease situation, studying the socio-economic impacts of two diseases, as well as, role of the pond environment in regulating occurrence of disease outbreaks.

At ICAR-NBFGR, Lucknow, the focus is on infection with *A. invadans* which is responsible for heavy mortalities among Indian major carps during winter months. For socio-economic analysis, the work focused on carp farming areas. A total of 17 villages from five different blocks of Maharajganj were visited to conduct the field work and a total of 150 questionnaires, 15 in-depth interviews, 10 photo diaries and one budget diary were completed in the field work. All the interviews and photo diaries were translated in English and the data is being analysed. For epidemiological studies, 248 farms were randomly selected out of a total of 358 farms in Maharajganj district of Uttar Pradesh. The selected farmers were contacted through letters. The information about diseases encountered during the ongoing growing season, as well as, risk factors was collected from 198 farmers in a questionnaire. The data is being analyzed.

RNASeq of experimentally infected muscle tissue samples at advanced stages of infection was carried out for transcriptome analysis (Fig. 57). Preliminary analysis of the results indicated that about 40-50% of



Fig. 57 Sequential sampling of susceptible rohu and resistant common carp following experimental infection of *Aphanomyces invadans*

the reads mapped to the host genome whereas, 0.02-0.07% of the remaining reads mapped to the pathogen genome. Further analysis is in progress.

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

The National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) is currently being implemented in 16 States and 3 Union Territories through 24 collaborating partners. The objectives of the ongoing surveillance programme are to rapidly detect new and emerging pathogens, to know the occurrence and distribution of endemic pathogens and improve the disease reporting to international organizations.

Infection with Tilapia Lake Virus (TiLV), an emerging disease is considered as a threat to global tilapia industry. During last year, mortalities in farmed tilapia were recorded in two states, West

Bengal and Kerala. The diseased fish exhibited lethargy, inappetence and skin erosions with heavy mortality. TiLV infection was confirmed on the basis of amplification and sequencing of segment 3 of TiLV, histopathology, infection of fish cell line and bioassay (Fig. 58). Phylogenetic analysis of the partial sequences of segment 3 of the TiLV revealed that North 24 Parganas (MF502419) and South 24 Parganas (MF582636) of West Bengal showed 97.2% similarity with Israel (KJ605629.1), whereas, Ernakulam, Kerala (MF574205) showed 96.4% similarity. In histopathology, typical syncytial giant cells in liver and congestion of the blood vessels along with haemorrhages in sections of brain tissue were observed. The filtered tissue homogenate prepared from liver and brain of affected tilapia produced cytopathic effects in CFF cell line derived from *Pristolepis fasciatus*. The disease was successfully reproduced in naive tilapia following injection of culture supernatant from infected cell line and TiLV was successfully re-isolated from experimentally infected tilapia (Fig. 58). This is the first report of TiLV from India.

Two cell lines from brain (OnLB) and liver (OnLL) from Nile tilapia, *Oreochromis niloticus* were developed and characterized for the efficient propagation of TiLV and have been sub-cultured for more than 45 times with OnLL submitted to NRFC, ICAR-NBFGR for further dissemination (Fig. 59).

Samples of ornamental fish, salmon, fish feed, squid and oyster sauce received from Animal Quarantine and Certification Services were screened

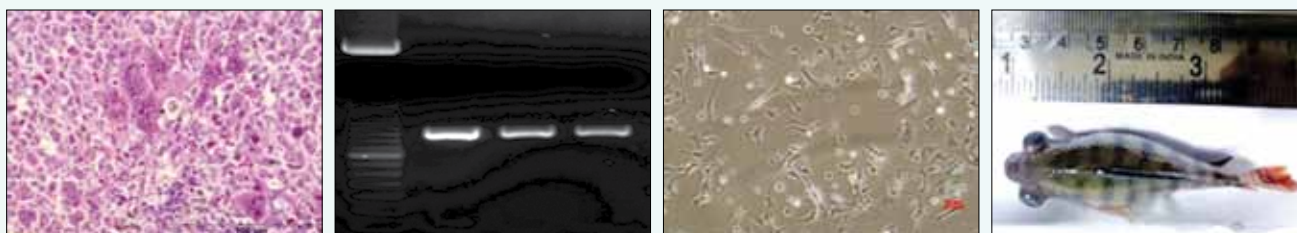


Fig. 58 Diagnosis and confirmation of TiLV infection through histopathology, PCR amplification, infection of fish cell line and bioassay



Fig. 59 Monolayer of Liver cells (OnLL) and Brian cells (OnLB) from *Oreochromis niloticus* at passage 25 after 4 days of seeding

for the desired OIE-listed pathogens. Positive controls were given to collaborating centers as per their requirement.

Sub-project 1: Surveillance of freshwater fish and shellfish diseases in Uttar Pradesh and Haryana

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

Period: February, 2013 – September, 2019

Funding Support: National Fisheries Development Board, Hyderabad

Under ICAR-NBFGR component of NSPAAD project, activities including routine pathogen screening from both archived samples and newly surveyed samples were carried out. The archived samples of tilapia and Indian major carps were screened for

Tilapia Lake Virus (TiLV) and found to be negative. Further, goldfish samples (n=58) collected from aquarium shops of different places of Lucknow were screened for infection with cyprinid herpesvirus-2. Two samples were found to be positive in first step whereas, additional five samples were found to be positive in nested PCR. Infection with *Thelohanellus qadrii* and *Myxobolus mrigalhitae* was observed in gills of *Labeo rohita* from a farm in Lucknow. Awareness about disease surveillance was created among fish farmers during training programmes organised at ARTU, Chinhat, on the occasion of Institute Foundation day and World Fisheries Day. Moreover, for obtaining the baseline disease status in finfish hatcheries, a survey was carried out in different hatcheries of Maharajganj and Kushinagar districts of Uttar Pradesh (Fig. 60). Apart from these, entry and validation of data in National Aquatic Animal Disease Database was done with different component such



Fig. 60 Survey of hatcheries at Maharajganj and Kushinagar district

as baseline information (n= 976 farms), biological information of finfish (n=271), biological information of shrimps (n=12) and disease outbreaks (n=24).

Sub-Project 2: Surveillance programme for aquatic animal diseases of ornamental fishes in the states Kerala and Tamil Nadu
Period: April, 2013 – March, 2018
Personnel: T. Raja Swaminathan (PI) and V.S. Basheer
Funding Support: National Fisheries Development Board, Hyderabad

A total of 120 ornamental fish samples were collected from Kerala (Ernakulam, Thrissur, Allapuzha, Kottayam, and Kollam) and Tamil Nadu (Chennai and Madurai). Ornamental fish disease management consultation was given to 12 ornamental fish farmers and 8 antibiotic sensitivity tests were carried out to find the correct antibacterial agent to treat the diseased fish. Tilapia Lake Virus (TiLV) infection was reported from farmed tilapia mortalities in Kerala with >85% mortality. TiLV infection was confirmed on the basis of RT-PCR, sequencing of segment 3 of TiLV, histopathology, infection of fish cell lines and bioassay. TiLV was isolated from the diseased tilapia using species-specific cell lines, viz., Nile tilapia (*Oreochromis niloticus*) cell lines from brain (OnLB) and liver (OnL) and continuously propagated in these cells for 20 passages. Ornamental fish samples (n=120) collected from Kerala and Tamil Nadu were screened for important OIE pathogens viz., Koi Herpes Virus (KHV) and Spring Viraemia of Carp (SVC) and all samples were found to be negative.

Project: Network project on assessment of anti microbial resistance in fisheries and aquaculture
Period: October, 2016 – March, 2020
Personnel: Gaurav Rathore (PI), Chandrabhusan Kumar, Anutosh Paria, Chinmayee Muduli, Satyendra M. Srivastava and Vikash Sahu

Funding Support: Institutional, ICAR-NBFGR

Network of AMR has been established with ICAR-Fisheries research institutes by nomination of project working group from Director's of each of the eight partners. Launch workshop of the network was held in March, 2018, wherein technical details of the

project were finalized in consultation with partners. A Manual on Standard Operating Procedures for AMR is under process of preparation.

Project: Risk and benefit assessment modeling for exotic species
Period: April, 2017 – March, 2019
Personnel: Kripal Dutt Joshi (PI), V.S. Basheer, Aditya Kumar, Satyendra M. Srivastava and Vikash Sahu

Funding Support: Institutional, ICAR-NBFGR

Reviewed the status of alien fish species in the country from all available literature, reports, online search and the institute database, to assess the magnitude of invasion and to evolve appropriate policy prescription. The major contents were related to introduction, expansion of alien species in different natural waterbodies, pathways of alien species and their impacts on native fish species. Despite the abundant fish diversity available in the country, 500 alien species (14.14%) have also been introduced in the country till date with specific objectives of species diversification in aquaculture, sport, ornamentation and control of mosquito larvae. The present list of introduced fish species in India comprised food fishes (29), sport (2), mosquito control (3) and the rest were ornamental fishes.

It was observed that most of the inland open water resources including rivers, wetlands and reservoirs of the country are reportedly invaded by few resilient alien species. Hardy and resilient alien species namely *Oreochromis niloticus*, *O. mossambicus* and *Cyprinus carpio* have now prominently established in many of the inland open waters of the country. Furthermore, some late arrived species like *Pterygoplichthys* spp. and *Clarias gariepinus* are also in the process of establishment in open waters and reported from some wetlands. The potential source for appearance of the alien species in inland open waters are ornamental fish trade, rapid expansion of aquaculture, fish farming in flood-prone areas and un-authorized import from neighbouring countries. The indiscriminate introductions of species are suspected for likely adverse impacts on sensitive native fish species, spread of unknown diseases and threat to the recipient aquatic ecosystems.

Review of available literature showed that most of the introduced species in Indian waters survived

well in the new environments, as per their specific biological adaptability traits. But some others, particularly those introduced in coldwater habitats, failed to succeed because of variations in thermal regime. In all, the majority of the introduced fishes proved useful in augmentation of fish production from ponds, promotion of sport fishery, and control of mosquito larvae and diversification of species for ornamental fish industry. The introduced grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*) and common carp (*Cyprinus carpio*) are compatible with Indian major carps and helpful in augmentation of fish production from ponds with optimum utilization of available food from different trophic niches. As a result, the introduced carp species got wider adoption by the fish farmers under poly-culture system. However, some other species i.e. *Pterygoplichthys* spp. are adversely impacting ecosystem and native species. The introduction of exotic fishes has brought about a wide array of problems including extirpation of indigenous species. The exotics compete with the indigenous species for food, habitat and may even prey upon them, introduce new parasites and diseases, result in the production of hybrids and cause genetic “erosion” of indigenous species and alteration of the physico-chemical nature of aquatic ecosystems. The potential risks not only affect the biodiversity, but also the socio-economic aspects of the human community that depend on aquatic ecosystem for their sustenance.

Considerable precautionary measures are already in place to control and check the spread of alien fish species in Indian open waters, still, there have been some instances indicating abrupt appearance and extension of aliens in open waters. The invasion pressure to open waterbodies intensified under depleted habitat conditions. The deteriorated riverine habitats and depleted waters are invaded by alien fish species. It was reportedly found that the exotic fish comprised 2.46 to 5.35% of the total species of the river Ganga and its tributaries. The instance of maximum invasion of exotics was recorded 93.0% of the total fish catch in the river Yamuna at Etawah in Uttar Pradesh.

Project: Deciphering *Aphanomyces invadans* genome to understand its mechanism of infection in fishes
Period: April, 2015 – March, 2018

Personnel: Pravata K. Pradhan (PI), Vindhya Mohindra, Neeraj Sood and Rajeev K. Singh
Funding Support: Institutional, ICAR-NBFGR

The hybrid assembly of PacBio reads and Illumina paired-end reads was generated using different assemblers, namely MaSuRCA, CISA and Scaffold builder. Whole-genome assembly of the PacBio reads only was done using the Canu assembler. Out of different assemblers used MaSuRCA assembly provided the total length of 71,359,239 which was comparable with the reference *Aphanomyces invadans* genome available at EBI (71,402,472).

Contigs generated by individual assemblers were aligned with the RNASeq data of different stages (zoospores, germinated zoospores and mycelium) of *A. invadans* and the alignment statistics of different assemblers revealed that maximum number of reads mapped with CANU assembly followed by MaSuRCA and CISA assembly. Selected genome assemblies were checked for gene set completeness using BUSCO against fungal and stramenophiles database. Out of all the assemblies, in MaSuRCA, the gene completeness was found to be maximum (i.e. 85.5 and 89.8 against Fungi_ODB9 and alveolata_stramenophiles_ensembl, respectively) and therefore, it was used for further downstream analysis.

Using Augustus, a total of 19,732 genes were predicted against 18,622 genes (FALCON assembly using PacBio data only) and 20,816 genes in EBI. Secretome analysis indicated a total of 916 proteins as putative secretory proteins. BlastP analysis of the predicted secretome (n=916) against the PHI base protein database, revealed 33 secretory proteins having significant similarity with PHI base.

Project: ICAR-Consortia Research Platform on Vaccines & Diagnostics

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

Period: August, 2015 - March, 2020

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

Funding agency: ICAR, New Delhi

Experiment was conducted to assess the efficacy of inactivated germinated zoospores of *Aphanomyces invadans* as antigen in conjunction with and without adjuvant Montanide ISA 763, in providing protection against *A. invadans* infection. The experimental rohu *Labeo rohita*, (n=160, 74±12g) were divided in 4 groups (C, A, G and GA) with 40 fish in each group. The fish in groups i.e., C, A, G and GA were injected intraperitoneally with PBS, adjuvant emulsified with PBS, inactivated germinated zoospores, and inactivated germinated zoospores emulsified with adjuvant, respectively. After 21 days of immunization, the fish were given a booster dose as above. After 7 days of the booster dose, the fish were challenged with zoospores of *A. invadans* to determine the relative percent survival (RPS). The results revealed that all the fishes in C, A and G group succumbed to infection (0% RPS), although there was delayed mortality in fish from A and G groups in comparison to the C group. However, the fish in GA group showed significantly higher ($p<0.05$) protection (66.7% RPS).

The antibody response of rohu in all the fish groups was determined by indirect ELISA, before and after challenge with zoospores of *A. invadans*. Pre-challenge, antibody level was higher in GA group compared to all other groups, but, the difference was statistically significant only with respect to control group ($p<0.05$). After challenge with *A. invadans* zoospores, antibody level was significantly higher in GAH group at 14 DPI in comparison to all other groups ($p<0.05$).

Pooled sera samples from the fish of different groups were analyzed by western blot analysis and peptides recognized by the sera are shown. A strong reaction was observed at around 54 kDa against pooled sera of GA, while in case of sera from G group, faint bands of 54 kDa were recognized. No bands were observed with sera of A and C group. Analysis of antiprotease activity revealed that before challenge, the antiprotease activity of fish in different groups did not show any significant difference ($p>0.05$). However, following challenge with *A. invadans* zoospores, the antiprotease activity of fish in all the groups including fish in GAD group was significantly lower ($p<0.05$). The histopathological examination of the muscle tissue (Fig. 61) revealed that fishes of GA group did not show any gross lesions, although there were well developed granulomas and extensive mononuclear cell infiltration restricted to the site of injection, whereas

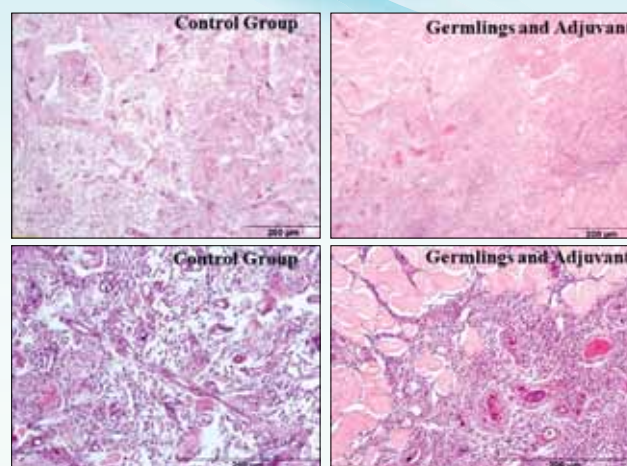


Fig. 61 Histopathological examination of muscle tissue in control and immunized rohu

in other groups, there was extensive myonecrosis with proliferating hyphae.

Project: All India Network project on Fish Health

Period: July, 2017 – March, 2020

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

Funding Support: ICAR, New Delhi

The efficacy of commonly used aquaculture chemicals and antifungal drugs against *Aphanomyces invadans* was studied *in vitro*. The selected chemicals and drugs included CIFAX, iodine solution, sodium thiosulfate and clotrimazole. The different doses of the above products were evaluated for their effect on production of zoospores, germination of spores (Fig. 62) and growth of hyphae of *A. invadans* (Fig. 63). The results indicated that CIFAX up to 100 ppm did not have effect on production of zoospores and their subsequent germination. Hence, in the subsequent experiment, five different concentrations i.e. 100, 200, 500, 1000 and 10000 ppm of CIFAX were used. It was found that there was sporulation, as well as, germination up to 200 ppm of CIFAX. Sporulation was not observed with higher concentration of CIFAX i.e. 500 ppm and above. There was a decrease in production of zoospores with iodine solution, in comparison to control at 1 ppm, but substantial reduction was observed with higher concentration i.e. only at 10 ppm. At a concentration of 100 ppm, there was complete inhibition of zoospore production.

However, the germination of spores could not be observed at conc. of 1 ppm and above. Further, it was found that the hyphal growth was inhibited at a concentration of 1 ppm iodine solution following treatment for 36 hrs. Different concentrations of sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$) (1, 10, 100 and 500 ppm) resulted in reduction in number of spores but the complete inhibition of sporulation was observed at the highest tested dose of 500 ppm. The antifungal drug, clotrimazole was found to be effective in reducing the number of spores produced at a dose as low as 0.1 ppm and complete inhibition in sporulation was observed at 1 ppm. However, inhibition in germination and hyphal growth were observed at concentration of 1 ppm.

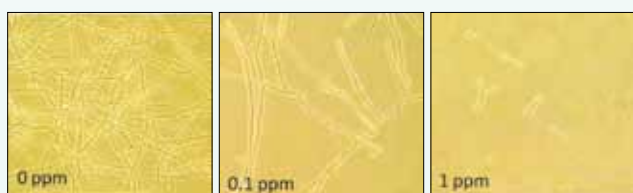


Fig. 62 Representative figure of effect of antifungal agents on germination of zoospores of *A. invadans*

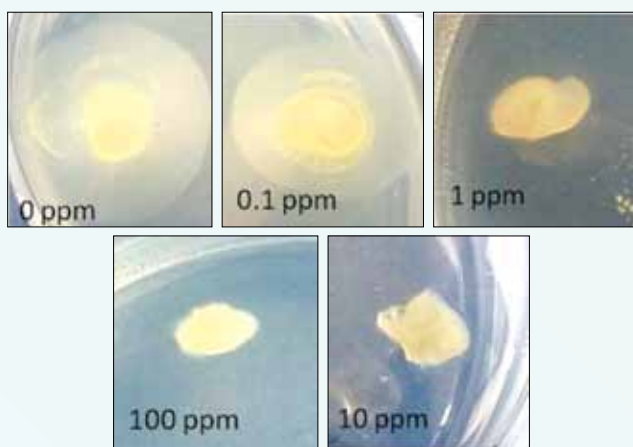


Fig. 63 Representative figure of effect of antifungal agents on growth of *A. invadans*

Project: Development of vaccines and diagnostic kit for the management of goldfish Herpesviral Hematopoietic necrosis disease in India

Period: April, 2017 – March, 2022

Personnel: T. Raja Swaminathan (PI)

Funding Support: ICAR-National Fellow Project

A new cell line, FtGF (Fantail goldfish fin), which consists of predominantly fibroblastic cells with diploid number of chromosome ($2n=104$), was developed

from caudal fin of fantail goldfish. It grows in L-15 medium with 10% FBS at growth temperature of 28 °C. The virus titer was estimated at $10^{7.8 \pm 0.26}$ TCID₅₀ ml⁻¹, at 28 °C which is a high incubation temperature and much higher than any earlier reported titer for cyprinid herpesvirus 2 (CyHV-2) in other studies. An experimental infection of naive goldfish using supernatant from infected FtGF cells caused 100% mortality and CyHV-2 infection in the challenged fish was confirmed by the amplification of DNA polymerase gene, histopathology and transmission electron microscopy (Fig. 64). A new primer (F 5' TCA GAT GGT CTT GGA TCT GCT 3' R 5' GAA CTT TTG CAC GTG ATA GGC 3') was designed in Primer3 v.0.4.0 (<http://bioinfo.ut.ee/primer3-0.4.0/>) to amplify the 932 bp partial sequence of major capsid protein (MCP) gene of CyHV-2 from the sequence present in GenBank (Accession No. NC019495) for the specific detection of CyHV-2. The specificity of the newly designed primer was evaluated by testing different fish viral nucleic acid viz., Spring Viraemia of Carp Virus (SVCV), Cyprinid Herpesvirus-3 (CyHV-3, also called as Koi Herpesvirus, KHV), Viral Nervous Necrosis Virus (VNNV) etc. The sensitivity was evaluated by testing the different concentration of CyHV-2 DNA ranging from 20 ng to 20 pg/μl. Another set of nested primer (IF 5' CCC GTC TGA GAA AGT GCT TC 3' IR 5' AAG GCG CTT GGG AAG TAG AT 3') was also designed to amplify 331 bp product from low concentration of CyHV-2 DNA. The gene coding for CyHV-2 major capsid protein (CyHV-2-ORF92) was amplified from genomic DNA of Indian isolate of cyprinid herpesvirus 2 by PCR with gene-specific primer set designed for eukaryotic expression vector. Forward and reverse primers were designed based on the nucleotide sequence of CyHV-2 available in GenBank (Accession No. JQ815364). The sequence of the primers with the restriction sites and the corresponding annealing temperatures used to amplify the capsid gene are given in Table 13.

The gene encoding for open reading frame (ORF) of the major capsid protein gene (MCP) of CyHV-2, approximately 3.789 Kb in length, was amplified by PCR using gene-specific primers. The MCP gene has to be cloned into a eukaryotic expression vector, pcDNA3.1 (Invitrogen), behind the early cytomegalovirus promoter, for yielding pcDNA3.1 - CyHV2MCP. Juveniles of goldfish will be used in challenging experiment to evaluate the efficacy of DNA vaccine.

Table 13 Details of primers used to amplify the major capsid gene of CyHV-2.

Primer	Product size	Sequence (5'-3')	Annealing temp.
CyHV2-ORF92 EF	3789 bp	CGGAATTCCCACCATGTCTAGTCAACAGTACAT <i>EcoRI</i>	60°C
CyHV2-ORF92 ER		CCCAAGCTTGGGTAAACAGAGTGATTGGGAT <i>Hind III</i>	60°C

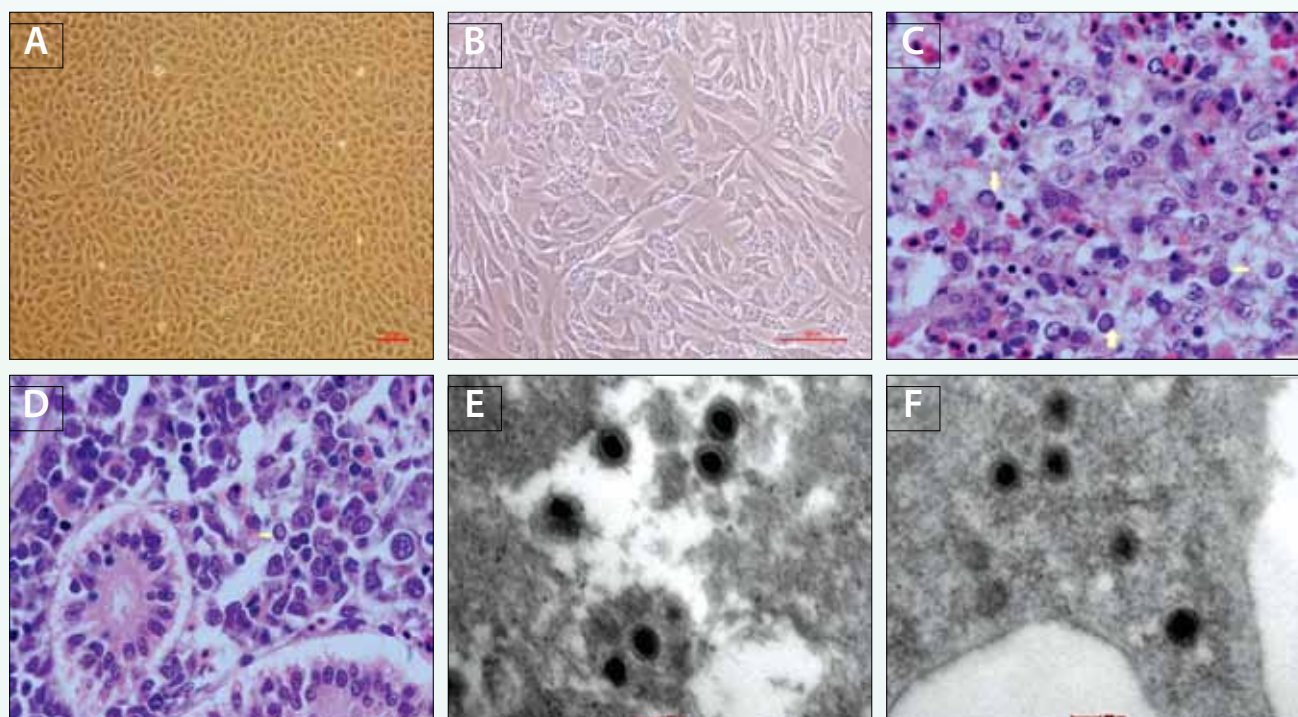


Fig. 64 Experimental infection of naive goldfish using supernatant from infected FtGF cells and its confirmation: **a.** FtGF cells inoculated with sterile L-15 medium as negative control; **b.** FtGF cells inoculated with CyHV-2 suspected tissue homogenate showing cytopathic effects; **c.** Histopathological lesions of affected liver of an experimentally challenged goldfish with the CyHV-2 infected cell culture fluid; **d.** Histopathological lesions of affected kidney of an experimentally challenged goldfish with the CyHV-2 infected cell culture fluid; **e.** Demonstration of mature CyHV-2 particles in the affected liver tissue in goldfish by Transmission electron microscope and **f.** Demonstration of mature CyHV-2 particles in the affected gill tissue in goldfish by Transmission electron microscope

Project: Anti-viral cytotoxic T-cell response in goldfish, *Carassius auratus* to cyprinid herpes virus 2 (CyHV-2) infection and comparative immune gene expression with rohu, *Labeo rohita*

Period: July, 2016 – March, 2018

Personnel: Sweta Das (PI) and T. Raja Swaminathan (Supervisor)

Funding Support: Science and Engineering Research Board (SERB)

Goldfishes were collected from commercial shops and kept in plastic buckets with proper aeration and feeding. The fish were injected with 200 µl of viral extract previously collected from cell culture

supernatant. After two weeks, blood was collected with anticoagulant and preceded with density gradient centrifugation using HiSep (Himedia). Briefly, blood was collected aseptically with anticoagulant after one week of intraperitoneal injection with CyHV2 extract. The cell count was 1.32×10^6 cells/mL as counted in a haemocytometer. The cells were visualized under inverted microscope after Giemsa staining. Majority of cells (80-90%) were monocytes and lymphocytes. After a week of acclimatization, the cells were stimulated with 10 mg/ml phytohaemagglutinin or PHA (Himedia) for 72 hours. Remarkably more increase in lymphocyte population was noticed than monocytes with PHA stimulation.

Goldfish fin (GF) cells were cultured in 96-well plate for overnight. Then the cells were infected in triplicate with CyHV2 cell culture extract previously

collected from infected cells along with PBS control. The results showed no significant difference in CyHV2 infected and PBS control GF cells in all the three experimental samples (infected leukocyte, uninfected leukocyte and no leukocyte control) at 2nd and 5th day of assay. Significant increase ($p < 0.05$) in cell density was observed on 4th day between virus infected and control GF cells. This signifies there was CyHV2 specific cell-mediated lymphocyte proliferation at 4th day of infected goldfish fin cells and CyHV2 specific leukocytes interaction.

Leukocytes from kidney (stimulator cells) tissue of healthy goldfish were collected by taking head kidney tissue in PBS. The tissues were homogenized and filtered through a cell strainer of 100 μm . Then the cells were diluted with PBS and leukocytes were collected using density gradient centrifugation with HiSep as described above. The cells were stained with Giemsa and visualized under inverted microscope. Primers were designed from few immune genes and expressions were checked in CyHV2 infected tissues (kidney, liver, spleen, gill and blood) of goldfish and compared with uninfected control tissues.

Project: Identification and characterization of novel viral etiology from undiagnosed

disease outbreaks of fishes using meta-genomic and meta-transcriptomic approaches

Period: June, 2017 – June, 2019

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

Funding Support: Science and Engineering Research Board (SERB)

Standardizations were carried out for optimal enrichment of virion particles and for removal of non-viral nucleic acids in the samples. Samples were digested with different concentrations of DNase1 and RNase to remove non-viral nucleic acids but no significant improvement was observed on increasing concentrations of nucleases. Initial concentration i.e. 60 u/ml DNase1 and 700 u/ml RNase A/T1 mix was able to successfully remove non-viral nucleic acids except rRNA molecules. No effect of increasing nucleases concentrations were observed on rRNA removal. Standardizations are also being performed for optimal representation of virus genomes during metagenomic library preparation. Currently 4 samples have been out-sourced for metagenomic sequencing on Illumina NextSeq platform.

WORKSHOPS/ SYMPOSIA/ TRAININGS/ MEETINGS ORGANIZED

Workshops and Symposia

International Symposium on Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture

An International Symposium on Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture was organised during 20-21 April, 2017 in collaboration with the Aquatic Biodiversity Conservation Society, Lucknow and National Surveillance Programme for Aquatic Animal Diseases. Shri Ashutosh Tandon, Hon'ble Minister of Technology and Medical Education, Govt. of Uttar Pradesh, inaugurated the symposium. Shri Tandon while inaugurating the symposium, briefed about 'Namami Gange', the flagship programme of Government of India to tackle pollution, conservation and rejuvenation of River Ganga. He also informed about the commitment of the Government of Uttar Pradesh to reduce water/river pollution in the state and expressed hope that by preventing water pollution, the fishers/farmers would be benefited. Hon'ble Minister also visited the Ganga Aquarium in the premises of ICAR-NBFGR and appreciated that it is open for public and school children towards creating awareness about conservation of fish diversity. In his presidential address, Dr. Joykrushna Jena, Deputy Director General

(Fisheries Science), ICAR, New Delhi stressed on the challenges faced by the aquaculture industry in the Asian region, particularly due to huge losses by disease outbreaks. He briefed about the ongoing National Surveillance Programme for Aquatic Animal Diseases, selective breeding programmes for increasing disease resistance in fishes and some of the new initiatives regarding Antimicrobial resistance programme. Dr. Jena emphasized that the presence of aquatic animal health expertise in the country and support by the international collaboration, is capable of meeting the challenges emerging due to aquatic animal diseases. Prof. Kenton Lloyd Morgan, Emeritus Professor, University of Liverpool, United Kingdom, as Guest of Honour, highlighted the important role of epidemiology in sustainability of the aquaculture. Dr. Kuldeep K. Lal, Convener of the Symposium and Director, ICAR-NBFGR, Lucknow briefed about the active role of ICAR-NBFGR in training farmers on fish culture, conservation and fish health management. Over 200 distinguished aquatic animal health scientists, technocrats, policy makers, students and entrepreneurs from all over the country and overseas participated in this symposium. On this occasion, an exhibition was also organised for the benefit of participants.



Shri Ashutosh Tandon, Hon'ble Minister of Technology and Medical Education, Govt. of U.P. inaugurating the symposium



Dr. J. K. Jena, DDG (Fisheries Science), ICAR, New Delhi addressing the symposium.



A view of the participants



Hon'ble Minister visiting the Exhibition

Annual Review Meeting of National Surveillance Program for Aquatic Animal Diseases

An Annual Review Meeting of the National Surveillance Program for Aquatic Animal Diseases was organised during 16-18 April, 2017 at the Institute. The meeting was chaired by Dr. Joykrushna Jena, Deputy Director General (Fisheries Science), ICAR, New Delhi whereas, Prof. Kenton L. Morgan, Emeritus Professor of Epidemiology, Institute of Veterinary Science, University of Liverpool, U.K and Dr. Iddya Karunasagar, Sr. Consultant, FAO, were the Guests of Honour on this occasion. All the partners presented their work done under the NSPAAD programme which was reviewed by the experts. Over 100 participants including Principal Investigators, Co-investigators and research scholars of collaborating centers attended the meeting.



Dr. Kuldeep K. Lal, Director speaking at the annual review meeting of the NSPAAD

3rd Review Workshop of ICAR-Consortium Research Platform on Genomics

The 3rd Review Workshop for ICAR-Consortium Research Platform (CRP) on Genomics was held during 26-27 July, 2017 at ICAR-NBFGR, Lucknow. Dr. J. K. Jena, Deputy Director General (Fisheries & Animal Science), ICAR, New Delhi chaired the

workshop whereas, Dr. A. K. Shasany, CSIR-CIMAP, Lucknow and Dr. Sridhar Sivasubbu, CSIR-IGIB, New Delhi were members of reviewing committee for evaluating progress of the projects. Dr. Kuldeep K. Lal, Director, ICAR-NBFGR and PIs and Co-PIs of nine participating institutes under CRP-Genomics were present at the workshop. Dr. Jena, in his opening remarks, recapitulated the launch and review of proposals of CRP-Genomics by Former DG, ICAR, Dr. S. Ayyappan and 2nd review meeting, chaired by Dr. T. Mohapatra, DG, ICAR. The PIs of all the participating institutes presented progress of work done under their projects. The objectives of the consortium, i.e., to bring different agricultural domains together at the same platform of genomics and develop human resources in National Agricultural Research System, was appreciated and substantial accomplishment towards this direction was recognised. Genome information generated under this platform can be used for development of marker panel in different species and to develop a link with industry for its practical application in field. Dr. Jena thanked both the members of experts committee for their constructive suggestions and felt that CRP-Genomics is heading on a right path.



Dr. J.K. Jena, DDG (Fisheries & Animal Sciences), ICAR, New Delhi chairing the review workshop of ICAR CRP Genomics

Launch Workshop of the Bioersity International and ICAR-NBFGR collaborative project

The Bioersity International and ICAR-NBFGR collaborated on the project, "Towards responsible agriculture for preserving sustainable aquatic ecosystems: assessment of impact of agriculture effluents on aquatic food webs" was officially launched on 7th February, 2018 at ICAR-NBFGR, Lucknow in presence of Dr N.K. Krishna Kumar, Regional Representative, South and Central Asia, Bioersity International, New Delhi; Dr J. K. Jena, Deputy Director General (Fisheries Science), ICAR, New Delhi and Dr Kuldeep K. Lal, Director, ICAR-NBFGR, Lucknow. On this occasion, Dr. Lal welcomed the guests and apprised the audience about the need and purpose of the project. Dr. Jena expressed that sustainability of aquatic ecosystem is dependent upon prevailing agricultural/industrial practices in the adjoining areas. Speaking on this event, Dr. Krishna Kumar stressed on the significance of ecology in relation to economics. He told its relevance in current scenario when biodiversity, industry, environmentalist and beneficiaries have to jointly address the issue of sustainability.



A group photo on the occasion of launch workshop

Launch Workshop of Network Program on Antimicrobial Resistance (AMR) in Fisheries

The Launch Workshop of 'Network Programme on Antimicrobial Resistance (AMR) in Aquaculture & Fisheries' was organized at the Institute on 24th March, 2018. Dr. H. Rahman, Regional Representative for South Asia, International Livestock Research Institute (ILRI), New Delhi was the Chief Guest on the occasion whereas, Dr. J.K. Jena, DDG (Fisheries & Animal Sciences), ICAR, New Delhi presided over. Dr. R.K. Singh, Director, ICAR-IVRI, Bareilly and Dr. Rajesh Bhatia, Former Regional Technical Advisor, FAO, were the Guests of Honour. Dr. Kuldeep



Dignitaries releasing the draft SOPs for Network Programme on AMR in fisheries

K. Lal, Director, ICAR-NBFGR, Lucknow in his welcome address, informed that all the eight fisheries research institutes would be partners in the Network Programme on AMR in Aquaculture & Fisheries, with ICAR-NBFGR, Lucknow as the Lead Centre. The dignitaries released the draft Standard Operating Procedures (SOPs) for Network Programme on AMR in Fisheries, which would serve as guiding document for operational framework.

Training programs for Capacity Development

Epidemiology School on Aquatic Animal Diseases

An Epidemiology School on Aquatic Animal Diseases was organized at ICAR-NBFGR, Lucknow for scientists involved in the National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) during 24-28 April, 2017. The programme was led by Prof. Kenton L. Morgan, Emeritus Professor of Epidemiology, Institute of Veterinary Science, University of Liverpool, U.K., who is an Internationally recognised Aquatic Animal Epidemiologist and involved in the NSPAAD from beginning of the programme. A total of 21 researchers from 8 institutes from all over the country involved in the NSPAAD programme attended the training programme. The programme was aimed at providing training on basic and practical aspects of epidemiology. Some of the topics covered under the programme were: study designs, population surveys, estimation of disease frequency, questionnaire design, bias and confounding, identification of risk factors for disease from observational studies using univariable analysis with an introduction to multivariable analysis, introduction to modelling and simulation and introduction to clinical trials and outbreak investigation.

Training workshop on 'Applications of Single Molecule Real Time (SMRT) Sequencing and Bioinformatics Analysis'

A training workshop on 'Applications of Single Molecule Real Time (SMRT) Sequencing and Bioinformatics Analysis' was organised at the Institute in collaboration with Imperial Life Sciences Pvt. Ltd., Gurugram India, & Pacific Biosciences, California, USA during 25-26 July, 2017. The workshop was aimed at enhancing the capacity and knowledge of scientists, providing latest information about SMRT sequencing technology, its application in various areas of genomic research and bioinformatics analysis, thereof. The workshop was inaugurated by Chief Guest, Dr. Sudhir Raizada, ADG (Inland Fisheries), ICAR, New Delhi who emphasised on the use of latest technologies that can enhance the aquaculture production of the country. Dr. Kuldeep K. Lal, Director, ICAR-NBFGR welcomed the guests and highlighted the importance of SMRT technology and its application in fisheries research. Ms. Camille Cyncynatus, Director Sales, Pacific Biosciences, South Asia, emphasized the importance of SMRT technology and various prospects of research that can be carried out on this platform. Dr. Vindhya Mohindra, Coordinator of the program thanked the guests



Dr. Sudhir Raizada, ADG (Inland Fisheries), ICAR, New Delhi inauguration the Training Workshop on applications of SMRT sequencing and bioinformatics analysis



Guest resource persons and participants of training workshop

and participants. A total of 47 scientist/researchers attended the workshop, which included 39 from ICAR and 8 from universities and ICMR institutes.

Joint training programme for shrimp farmers by ICAR-NBFGR-NACA-INFOFISH and MPEDA

A training programme on 'Current Issues, Practices and Innovations in Shrimp Culture in India' was organised for shrimp farmer training program at Nellore during 29-30 August, 2017. The training programme was conducted jointly by ICAR-NBFGR-NACA-INFOFISH and MPEDA in which 280 farmers from 11 states participated. Dr. Yuan Derun, Coordinator, Education and Training Programme, NACA shared his experiences and innovations with the participants on shrimp farming. NACA also arranged a resource person, Dr. Suthep Puttipayawonga for



Joint training programme for shrimp farmers



Dr. Kuldeep K. Lal, Director addressing during Human Resource Development week programme

discussions and lecture on Shrimp Nursery in Thailand for the benefit of the participants. In addition to the lectures, NACA resource persons also participated with other resource persons in the panel discussion answering queries of the farmers.

Human Resource Development Week on ‘Skill and Competency Enhancement’

A Human Resource Development Week on ‘Skill and Competency Enhancement’ was organized at ICAR-NBFGR, Lucknow during 6-10 November, 2017. The programme was inaugurated by Dr. A.D. Pathak, Director, ICAR-Indian Institute of Sugarcane Research, Lucknow as Chief Guest of the function. Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, Lucknow in his welcome address explained that the programme is aimed at enhancing the skills and competency through need based lectures and hands-on exercises for all categories of staff members. Apart from staff members from headquarters, those from PMFGR Centre, Kochi also participated through Skype and 9 scientists from the local ICAR institutes, ICAR-Indian Institute of Sugarcane Research and ICAR-Central Institute of Subtropical Research, Rehmankheda, Lucknow also attended the programme. A three day special training capsule was also designed and conducted for the Skilled Support Staff of the Bureau. During the programme, there were lectures by external and internal resource persons, as well as, hands on training sessions on Writing a winning project proposal and communication skills, Team building, ERP purchase requisitions, Positivity in management, GFR rules, Awareness on vigilance matters, and hands on sessions on ERP and computer applications. Dr. A.K. Vyas, Astd. Director General, HRD, ICAR, New Delhi was the Chief Guest during the valedictory session on 10th November, 2017, and Dr. Vindhya Mohindra, Course Director and Nodal Officer, HRD, presented a brief report of the training programme and activities by the HRD cell. A training manual, as a ready reference for the participants from Skilled Support Staff category, was also released during the valedictory function and certificates were presented to 18 trainees.

Training programme on ‘Fish taxonomy’

A training programme on conventional fish taxonomy was organised at PMFGR centre, ICAR-NBFGR, Kochi during 25-30 November, 2017. Prof. Venkataramani, Adjunct Professor, KUFOS, Kochi



Prof. Venkataramani conducting a session on fish taxonomy

was the Chief Resource Person. Total fourteen participants including scientists, technical staff and students attended the training programme. Theory and practical sessions on various aspects of taxonomy and systematics were covered during the session. Training programme was very useful for the participants to get enriched on various aspects on classical taxonomy.

Training programme on ‘Integrative Taxonomy and Systematics in Freshwater Fishes’

A training programme on ‘Integrative Taxonomy and Systematics in Freshwater Fishes’ was organised at ICAR-NBFGR, Lucknow during 5-10 February, 2018. The training was aimed at capacity development of the partner researchers/scholars from North-Eastern region and scientists of the Institute in fish taxonomy and systematics. A team of three resource persons led by renowned taxonomist, Prof. W. Vishwanath, Dean, School of Life Sciences, Manipur University, imparted training for three days in conventional taxonomy and



Guests, resources persons and participants of training on integrative taxonomy and systematics in freshwater fisheries

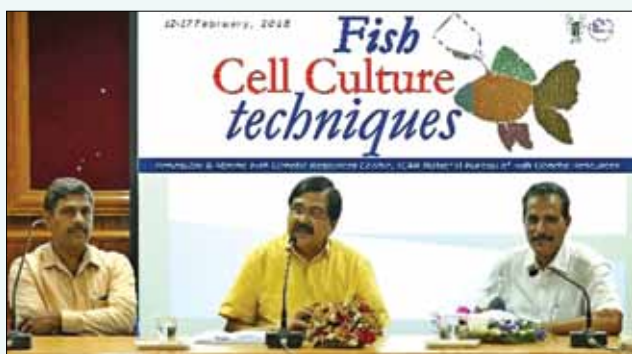


A hands on session led by Prof. W. Vishwanath

systematics of freshwater fishes. Besides, scientists from ICAR-NBFGR served as the resource persons for molecular taxonomy. The resource persons conducted full technical sessions including demonstrations and guiding hands-on practice by the trainees.

Training programme on 'Fish Cell Culture Techniques'

A training programme on 'Fish Cell Culture Techniques' was organised at PMFGR, ICAR-NBFGR, Kochi during 12-17 February, 2018. The training programme was inaugurated by Dr. A. Gopalakrishnan, Director, ICAR-Central Marine Fisheries Research Institute, Kochi who emphasized on the importance and different applications of cell culture. Beside the scientists of the Institute, two guest faculties, Dr. Sanil, N.K. and Dr. R. S. Krupesha Sharma from ICAR CMFRI, Kochi gave invited lectures on different topics, like, disease management in cage aquaculture and viral diseases in marine cage culture during the training programme.



Dr. A. Gopalakrishnan, Director, ICAR-CMFRI, Kochi addressing the participants of training on fish cell culture techniques



A hands of training session on fish cell culture

Hands-on training on 'Fish Cell Culture Techniques: Cell Line Development and Applications'

A training programme on 'Fish Cell Culture Techniques: Cell Line Development and Applications'

was organised during 5-9 March, 2018. The training programme was inaugurated by Dr. A.K. Singh, Former Director, ICAR-Directorate of Cold Water Fisheries Research, Bhimtal. In his address, Dr. Singh emphasized upon the need to learn cell culture techniques and its applications to various stakeholders. Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, Lucknow welcomed the participants and briefed about the importance of cell culture and utilize facilities available at ICAR-NBFGR, Lucknow for their research applications. Dr. Ravindra Kumar, Course Director of the training program gave an overview of development of fish cell culture and briefed about the National Repository of Fish Cell Lines (NRFC) facility at ICAR-NBFGR, Lucknow. Eight participants from various parts of the country participated in the program.

Training Program on Genome Sequencing

A training program 'Genome Sequencing: Methods and Applications' was organized by the Institute during 12-17 March, 2018. The programme aimed at developing trained manpower in the field of genomics. It was designed to be accessible for early stage researchers, as well as, senior researchers, who have only basic knowledge in the field of genomics. A total of 18 participants from various institutes/universities/departments attended the training which was inaugurated by Dr. S.K. Barik, Director, CSIR-National Botanical Research Institute, Lucknow. The course exposed participants to recent advances/platforms in sequencing technologies, and their applications in functional and structural genomics. Participants were given demonstrations for steps involved in genome sequencing with third generation sequencer PacBioRSII and Sanger Sequencing, bioinformatic analysis and automation in bacterial identification. Genome databases developed by ICAR-NBFGR were also explained. Dr. M. Sudhakar, Director, CMLRE, Kochi, presided over the Valedictory session and gave certificates to the participants.

Workshop on 'Good Food Habits for Women' to Commemorate the Mothers' Day

The Women Cell of ICAR- NBFGR, Lucknow organized a Workshop on 'Good Food Habits for Women' to commemorate the Mothers' Day on 20th May, 2017. The workshop was intended to spread awareness on nutrient values of different food and good eating habits, which will not only improve



Workshop on 'Good Food Habits for Women'

nutritive well being, but also prevent deficiency diseases. Dr. Anjali Gupta, Institute Doctor gave a lecture on nutrient values of different food and good eating habits. All the women staff of the institute and the family members of the staff were invited for the same. A total of 50 women participants attended the workshop. Participants were given an opportunity to exchange and discuss their point of views.

Awareness program on 'Sexual Harassment of Women at Workplace'

An awareness program on 'Sexual Harassment of Women at Workplace' was conducted on 3rd August, 2017 where all the staff and research scholars of the institute participated. Dr. Sunita H. Khurana, Director, Institute of Secretariat Training and Management, New Delhi was invited as the speaker. She highlighted the importance and need for providing safe working environment for women. She threw light on what constitutes sexual harassment and redressal mechanism in such cases. The talk was followed by a discussion session where she also interacted with the staff on this subject.



Dr. Sunita H. Khurana, Director, ISTM, New Delhi addressing the staff

Important Days and Celebrations:

National Fish Farmers' Day Celebrated

The Institute celebrated National Fish Farmers' Day on 10th July, 2017. Dr. Kuldeep K. Lal, Director of the Institute highlighted that this day is observed every year throughout the country among fisheries institutions and organisations in the memory of scientific achievement of successful induced breeding of carp fishes, which was established by Dr. H. L. Chaudhary and his colleagues in Odisha, way back in 1957. Major highlight of the day was scientist and fish farmers interaction. On the occasion, quality carp seed and fish medicines were distributed to the adopted fish farmers of Mera Gaon Mera Gaurav programme. More than 60 farmers and officials participated in the programme. Scientific films on fisheries and aquaculture were shown to the farmers during the day. Several scientists of the Institute and officials of



National Fish Farmers' Day Celebration

the U.P. State Fisheries Department delivered lectures to the farmers. Progressive farmers also shared their success story.

Agriculture Education Day Celebrated

The Agriculture Education Day was celebrated on 3rd December, 2017 at ICAR-NBFGR, Lucknow. On the occasion, various events for school children were organized which included, drawing, painting and essay competition, under three categories of students. Total 101 school children representing 18 schools of Lucknow participated in these events. The themes of the events were relevant to today's environmental awareness and societal needs, such as, Indian Village Fair, Save Rivers and Digital India in Education. The students, along with their parents and teachers, visited the Ganga Aquarium located at the ICAR-NBFGR campus. The students interacted with the scientists and two lectures were delivered on this occasion, one

on 'Agriculture for higher income' by Dr. Achal Singh and another on 'ICAR in Agriculture Education' by Dr. L.K. Tyagi. The celebrations and activities were structured to provide an opportunity to the students to visit the Institute with fun and interest, so as to create awareness on various aspects of biodiversity and agricultural education.

ICAR-NBFGR celebrated '34th Foundation Day' and 'Farm Innovators Day'

The Bureau celebrated its '34th Foundation Day' and 'Farm Innovators Day' on 12th December, 2017. Dr. A.S. Ninawe, Advisor, Department of Biotechnology, Ministry of Science and Technology, Govt. of India, New Delhi and Dr. S.D. Singh, Former Assistant Director General (Inland Fisheries), ICAR, New Delhi, graced the occasion as Chief Guest and Guest of Honour, respectively. In his welcome address, Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, Lucknow apprised about the salient achievements of the Institute. A total of 45 invited progressive aqua farmers, entrepreneurs, students of 11 schools of Lucknow and aqua-trainees of tribal community from Madhya Pradesh participated in the programme. The Chief Guest and Guest of Honour addressed the staff and the farmers on this occasion and congratulated them for their achievements. An interactive session was also organized to solve the problems of the aqua-farmers on

different aspects of aquaculture and fish conservation by scientists of the Institute. The farmers also visited ICAR-NBFGR farm and aquarium facilities.

On this occasion, Annual Institute Awards for the year 2016-17 were presented to the ICAR-NBFGR staff members for their performance in various categories. Selected fish farmers from various districts of Uttar Pradesh were also awarded on the occasion for their achievements in fish farming. The awardees in various categories were: Dr. Mahender Singh, Sr. Scientist, Best Scientist; Dr. Akhilesh K. Mishra, Sr. Technical Officer and Shri Om Prakash, Technical Officer, Best Technical Staff; Mr. Ram Sakal Chaurasia, Personal Assistant, Best Administrative Staff; Mr. Sidhnath, SSS, Best Support Staff and Smt. Kalawati Devi, Shri Ghasita Ram, Shri Jitendra Pratap Singh, Shri Rajesh Verma and Shri Aasif Siddiqui, Best Fish Farmers; Dr. Ajay Kumar Singh, Assistant Chief Technical Officer and Mr. Swapan Debnath, Assistant, appreciation certificates.

International Women's day celebrated

ICAR-NBFGR, Lucknow celebrated International Women's Day on 8th March, 2018. Dr. Ravindra Kumar, Director In-Charge, wished all the women staff on this day and thanked them for their contribution to the Institute. The event was graced by the Chief Guest, Dr. Mandakini Pradhan, Professor and Head, Department of Maternal and Reproductive Health,



Agriculture Education Day Activities



Foundation Day Celebration



Presentation of Annual institute awards

Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow who spoke on the importance of educating women. She also stressed that women need to take active part in decision making, especially, those issues that concern them directly, instead of being dependant on family. The Chief Guest also shared some of her personal experiences as a doctor on women empowerment. Dr. Vindhya Mohindra, Chairperson, Women’s Cell, ICAR-NBFGR, Lucknow spoke on the importance of Women’s contribution in the society. A debate competition on the topic ‘*Naari Sashaktikaran ke liye shiksha hi ekmatra madhyam hai*’, was organised in which 16 participants spoke and placed their views on role and importance of education in empowering women.

Lembucherra, Tripura; Dr. A.K. Sahu, Former Principal Scientist, ICAR-CIFA, Bhubaneswar; Dr. Manas Das, Former Principal Scientist, ICAR-CIFRI, Barrackpore; Dr. Nirmalendu Saha, Professor of Department of Zoology, North Eastern Hill University, Shillong and Dr. P. Praveen, Assistant Director General (Marine Fisheries), ICAR, New Delhi participated as expert members of the RAC. Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, Lucknow apprised the RAC about the Institute’s achievements in research, extension, capacity development and infrastructure development during last one year. The Member Secretary, RAC, Dr. G. Rathore, Principal Scientist and Head, Fish Health Management Division, ICAR-NBFGR, Lucknow presented the action taken report on the recommendations of RAC held during 2017.

Important Meetings:

Research Advisory Committee (RAC) Meeting

The RAC meeting of the Institute was held during 23-24 February, 2018 under the Chairmanship of Dr. George John, Former Advisor, Department of Biotechnology, Govt. of India and Former Vice Chancellor, Birsa Agricultural University; Dr. J.R. Dhanze, Consultant, COE-FAB Project, College of Fisheries, Central Agricultural University,



RAC Meeting Chaired by Dr. George John

The Heads of the Divisions/In-charges of units also gave presentations on significant achievements under different projects of the respective divisions/units. The RAC reviewed progress of all the ongoing research programmes of the Institute and provided significant inputs to improve the research programmes. The Chairman emphasised the importance of time series data in predicting outcomes in future. Expert members gave valuable suggestions to improve upon the research programmes of the Institute. In his concluding remarks, the Director thanked the RAC for the valuable recommendations and guidance and assured that the institute would strive hard to meet the expectations of all the stakeholders.

Annual Institute Research Committee (IRC) meeting

The annual Institute Research Committee meeting for the year 2016-17 was held at ICAR-NBFGR, Lucknow during 30th March - 1st April, 2017 which was chaired by Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, Lucknow. In his introductory remarks, the Chairman IRC appreciated the efforts of the scientists and other members of the Institute for undertaking good research, extension and capacity development activities at the institute during the year 2016-17. The Chairman opined that research programmes should be undertaken on the basis of identified thematic areas only and each new project should clearly visualize and plan for not only the methodology and technical activities in detail, but also its output and outcome. After chairman's address, progress reports of projects were presented by the respective PIs. After presentation of progress report of on-going research projects, the new concept proposals for the research projects were presented, discussed and approved with desired modifications.



Annual IRC Meeting

Institute Management Committee Meeting

The 32nd annual meeting of Institute Management Committee (IMC) was organised on 30th January, 2018.



Institute Management Committee Meeting

Celebration of Independence Day

The Institute celebrated the Independence day with full enthusiasm on 15th August, 2017. Dr. Kuldeep K. Lal, Director, ICAR-NBFGR, Lucknow hoisted the National flag in the presence of staff members of the Bureau. Director appreciated the efforts made by the Bureau in the past and highlighted future plans in his address. On this occasion, a cultural programme was organised in which large number of the staff and children of the ICAR-NBFGR family participated.

Republic Day Celebrated

A flag hoisting ceremony was observed on the Republic Day on 26th January, 2018. Dr. Kuldeep K. Lal, Director hoisted the National Flag in the presence of other staff members of the Bureau. In his address, he highlighted the achievements of ICAR-NBFGR during the year 2017. He emphasized upon the need to keep updated with recent developments in the fisheries sciences and society as a whole and adapt research programmes in accordance with the emerging needs of the society. Dr. Lal also informed the staff that the Institute has undertaken several initiatives, to comply with the recent efforts of the Govt. of India towards digitization. The programme was followed with a small cultural programme in which large number of children of the ICAR-NBFGR family participated.



Dr. Kuldeep K. Lal, Director addressing on Republic Day

EXTENSION ACTIVITIES

Training Programmes for Skill Development of Beneficiaries under Pradhan Mantri Krishi Sichayee Yojana (PMKSY):

The Institute organised a series of special short-term training programmes on 'Fish Culture-cum-Horticulture' for skill development of beneficiaries under PMKSY - Watershed Development, Shri Upendra Tiwari, Hon'ble Minister of State (Independent Charge), Land and Water Resources, Government of U.P. inaugurated one such training programme on 23rd January, 2018. Hon'ble Minister also visited Ganga Aquarium and Fish Farm of the Institute. Shri Chandra Prakash Tripathi, Secretary, Department of Irrigation and Water Resources, Govt. of U.P. and CEO, U.P. State Level Land Development Agency also shared his views on the new initiatives taken by the Govt. of U.P. on the occasion. Dr. K. K. Lal, Director, ICAR-NBFGR, Lucknow, in his welcome address, apprised the dignitaries about various activities undertaken by the Institute for the benefit of stakeholders. Total five training programmes were conducted in which 135 participants were trained as per the details given below:

S. N.	District	Duration	Total no. of participants
1.	Mahoba, U.P.	18-22 December, 2017	35
2.	Lucknow, U.P.	09-11 January, 2018	30
3.	Pilibhit, U.P.	23-27 January, 2018	35
4.	Bareilly, U.P.	13-17 March, 2018	35
	Total		135



Hon'ble Minister Shri Upendra Tiwari delivering the inaugural address during Training programme on skill development under PMKSY



Participants and staff with Hon'ble Minister

Special Training Programme for Skill Development in Re-Circulatory Aquaculture System:

The Institute organised two special short-term training programmes on 'Re-Circulatory Aquaculture System' during 15-17 February, 2018 and 07-09 March, 2018. Total 97 participants from U.P. were trained in these programmes towards skill development in Re-Circulatory Aquaculture System. The programmes were sponsored by the National Fisheries Development Board, Hyderabad.



Inaugural function of the training on Re-circulatory Agriculture System



Field visit during training



A demonstration session on inducement of brooders

Training Programme on Cryopreservation of Fish Gametes for Fisheries Department Officials of Kerala

A training programme on 'Cryopreservation of fish gametes' was conducted for fisheries department officials of Kerala at the National Fish Seed Farm, Polachira, Tiruvalla. A total of nine officials of Fisheries Department, Kerala attended the training programme. Theory classes were conducted on aspects of cryopreservation of fish gametes and its application,

followed by practical session on selection of brooders and inducement of brooders with synthetic hormones, collection of milt, checking motility, activity of different extenders and cryoprotectant. Fertilisation trials were conducted using cryopreserved sperm. The participants appreciated the efforts of ICAR NBFGR and utility of the training programme.

Tribal Sub-Plan (TSP) Scheme Activities

TSP Team: L.K. Tyagi (Nodal Scientist), Sharad K. Singh, A.K. Yadav, S.K. Singh and A.S. Bisht

Under the Tribal Sub-Plan scheme of the Govt. 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. During the year under report, four training programmes on fish culture, conservation, and breeding and livelihood opportunities for tribals in fisheries, were organised as per the details given below:



A practical session during training

S.N.	District	Duration	Venue	Total no. of participants
1	Ashok Nagar dist., M.P.	11-14 December, 2017	ARTU, ICAR-NBFGR, Lucknow	33
2	Lalitpur dist., U.P.	03-06 January, 2018	ARTU, ICAR-NBFGR, Lucknow	36
3	Kamrup (Rural) dist., Assam	15-17 February, 2018	Aquaculture & Biodiversity Center, Dept. of Zoology, Gauhati University, Guwahati	29
4	Dima Hasao dist., Assam	27-29 March, 2018	Haflong Govt. College, Haflong, Assam	30
	Total			128



Glimpses of training programmes organised for tribal farmers

Awareness Programme on Livelihood Opportunities in Fisheries for Tribal Farmers:

An awareness programme on 'Livelihood Opportunities in Fisheries for Tribal Farmers' was organised at Kushi village of Kamrup (Rural) district, Assam in collaboration with Department of Zoology, Gauhati University, Guwahati. Total 90 tribal farmers including tribal women attended the awareness programme and got benefitted. Dr. K. K. Lal, Director, ICAR-NBFGR, Lucknow while chairing the programme, explained about the initiatives taken by the Institute towards supporting tribal beneficiaries for livelihood enhancement. Prof. Jatin Kalita, Head, Department of Zoology and Dean, Faculty of Science, Gauhati University, Prof. Dandadhar Sarma, Professor, Department of Zoology, Gauhati University and Dr. L.K. Tyagi, Principal Scientist, ICAR-NBFGR,



A view of the participating tribal farmers

Lucknow also spoke on the occasion and informed about various livelihood opportunities for livelihood development in the fisheries based enterprises and the joint initiative taken by the ICAR-NBFGR and Gauhati University for tribal development activities.

Technological and Infrastructure Support for tribal farmers:

Two programmes on technological and infrastructure support for selected tribal farmers for taking up/strengthening fisheries based enterprises towards enhancing their livelihoods initiated in Assam in collaboration with Dept. of Zoology, Gauhati University, Guwahati and Haflong Govt. College, Haflong, Assam. Five tribal beneficiaries selected in Dimali, Salbari and Batakuchi villages, Kamrup (Rural) dist., Assam. Format were prepared and baseline socio-economic data of beneficiaries was



Awareness programme for tribal farmers organised in Assam



Few ponds of tribal beneficiaries for technological & infrastructure support in Assam

collected. Renovation of selected tribal beneficiaries is in progress. Similarly, four tribal beneficiaries selected in Naben and Longmailai villages, Halflong dist., Assam and baseline survey and pond renovation is in progress.

Mera Gaon Mera Gaurav Programme

The Institute undertook a number of activities under the Govt. of India programme 'Mera Gaon



Distribution of quality fish seed to the beneficiary farmers of selected villages under Mera Gaon Mera Gaurav programme



Integrated aquaculture at a selected farmer's pond

Mera Gaurav'. Quality fish seed (10 lakh) were distributed to beneficiary farmers of selected villages on Fish Farmer Day (10th July, 2017). Farmers also received Soil Health Card (26 farmers) of their pond in collaboration of ICAR-CSSRI, Lucknow Center and ICAR-NBFGR, Lucknow on World Soil Day (5th December, 2017) programme at ICAR-NBFGR, Lucknow. Major aquaculture activities in the ponds of adopted aquaculture farmers were integration like duck-cum-fish farming and fodder-led grass carp aquaculture. Aquaculture related on the spot scientific advisory was also given to the farmers.

Fish Seed Production

The production of quality fish seed of carps was continued to cater to the need of quality fish seed in this region, as well as, for R&D purpose. Over 700.0 lakhs spawn of Indian major carps, minor carps and exotic carps were produced. Demonstration of induced breeding technique and other aquaculture activities was also continued to the participants of various short term training programmes organised at the Institute.

Media programmes (TV, Radio, etc.) for serving stakeholders:

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

08/05/2017	Doordarshan, Lucknow	Integrated Farming	Krishi Darshan
18/05/2017	DD Kisan Channel, New Delhi	Fish Culture	Subject expert interaction programme in Hello Kisan (Live)
24/05/2017	All India Radio, Lucknow	Fish culture	Vigyan evam Kisan Programme
20/12/2017	All India Radio, Lucknow	Clipping regarding PMKSY- Watershed training programme 18-22 Dec, 2017 for Publicity	Coverage for publicity
24/12/2017	All India Radio, Lucknow	Jalkrishi aur Matsya Talab mein samayik prabandhan	Telecasted in Vigyan evam Kisan Programme on dated 24-12-2017
24/01/2018	National Voice	PMKSY-Watershed Training Programme coverage recording on 23/01/2018	Telecasted in National Voice News programme on 24/01/2018
27/02/2018	ETV Uttar Pradesh	PMKSY-Watershed Training Programme	Recording for ETV Uttar Pradesh Annadata programme

Other Farmer Advisory Services

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

RESEARCH PROJECTS

Institutional Projects

No	Project Title	Personnel	Period
Molecular Biology & Biotechnology Division			
1	Stress tolerance response in cultivable freshwater fish species	S.K. Srivastava (PI), Ravindra Kumar and Murali S.	April, 2017 - March, 2018
2	Systematic review and evolutionary study of Indian Clupeiform fishes	Mahender Singh (PI), T.T. Ajithkumar, Teena Jayakumar, T.K. and A.K. Mishra	April, 2017 - March, 2019
Fish Conservation Division			
3	Participatory programme on exploration and characterization of fish germplasm resources and indigenous knowledge in North-Eastern region of India	Lalit K. Tyagi (Coordinator), Vindhya Mohindra and Rajeev K. Singh	October, 2012 - September, 2017
4	Outreach activity on fish genetic stocks, Phase II NBFGR HQ Component PMFGR Center Component	Kuldeep K. Lal (Project Coordinator), Rajeev K. Singh (Co-coordinator and Lead Centre PI) Vindhya Mohindra, Sangeeta Mandal, Rejani Chandran, Achal Singh, Amar Pal, R.S. Sah and Rajesh Kumar (Personnel HQ) P.R Divya (PI), V.S. Basheer, A.K. Pandian and Charan Ravi (Personnel PMFGR Center)	April, 2014 - March, 2019
5	Signatures of natural selection and genomic diversity in important freshwater fish species, <i>Tor putitora</i> and <i>Clarias magur</i>	Vindhya Mohindra (PI) and Trivesh S. Mayekar	April, 2014 - March, 2018
6	Establishment of mapping and marker panel for first generation linkage map in Indian Catfish, <i>Clarias magur</i>	Rajeev K. Singh (PI), Santosh Kumar, R.S. Sah, Rajesh Kumar and Vikash Sahu	April, 2014 - March, 2018
7	Exploration for fish diversity assessment and traditional ecological knowledge in lower Mahanadi basin	Lalit K. Tyagi (PI), Sangeeta Mandal, Trivesh S. Mayekar, Rejani Chandran, A.S. Bisht and Sanjay K. Singh	April, 2016 - March, 2019
8	Evolutionary significance of hypothalamus-pituitary-gonadal axis in fishes, with special reference to Indian species	A.K. Pandey (PI)	November, 2016 - October, 2018

No	Project Title	Personnel	Period
9	Development of surrogate broodstock for propagation of valuable fish germplines	S.K. Majhi (PI) and Labrechai Mog Chowdhury	April, 2014 - March, 2018
10	Exploration and assessment of fish diversity of mid-Himalayan tributaries and wetlands of Ganga River System	K.D. Joshi (PI), A.K. Pathak, Santosh Kumar, Rajesh Dayal, Ajay K. Singh and Ravi Kumar	April, 2017 - March, 2019
Fish Health Management & Exotics Division			
11	Development of an immune marker and understanding host - <i>Aphanomyces invadans</i> interaction using macrophage cell line	Neeraj Sood (PI), P.K. Pradhan and Chinmayee Muduli	April, 2014 - March, 2018
12	Deciphering <i>Aphanomyces invadans</i> genome to understand its mechanism of infection in fishes	P.K. Pradhan (PI), Vindhya Mohindra, Neeraj Sood and Rajeev K. Singh	April, 2015 - March, 2018
13	Exploring the variation in immunological and disease susceptibility against <i>Aeromonas hydrophila</i> in two different stocks of Indian catfish <i>Clarias magur</i>	Gaurav Rathore (PI), Chinmayee Muduli, Rajeev K. Singh, Anutosh Paria and Ranjana Srivastava	November, 2016 - March, 2019
14	Risk and benefit assessment modelling for exotic species	K.D. Joshi (PI), V.S. Basheer, Aditya Kumar, S.M. Srivastava and Vikash Sahu	April, 2017 - March, 2019
15	Network project on assessment of anti microbial resistance in fisheries and aquaculture	Gaurav Rathore (PI), Chandrabhusan Kumar, Anutosh Paria, Chinmayee Muduli, S.M. Srivastava and Vikash Sahu	December, 2017 - March, 2020
Peninsular & Marine Fish Genetic Resources Centre, Kochi			
16	Establishment (Development & characterization) of spermatogonial stem cells (SSC) from (endemic fishes of Western Ghats) <i>Etroplus suratensis</i> and <i>Sahyadria denisonii</i>	T. Raja Swaminathan (PI) and Charan Ravi	April, 2015 - March, 2018
17	Exploration and cataloguing of the fish diversity from marine island ecosystems and Cauvery River basin Sub project-1: Survey and collection of fishes from Cauveri River basin	V. S. Basheer (PI), T. Raja Swaminathan, Charan Ravi and Rajool Shanis C. P.	April, 2016 - March, 2019
	Sub project-2: Survey and Collection of fishes from Marine Islands (Andaman & Lakshadweep)	T. T. Ajithkumar (PI), A. K. Pandian and Teena Jayakumar T. K.	April, 2016 - March, 2019
Fish Genetic Resource Documentation Unit			
18	Information base on fish genetic resources of India	A.K. Pathak (PI), T. T. Ajithkumar, M. S. Verma, Poonam J. Singh, Rejani Chandran, Rajesh Dayal, Rita Chaturvedi and Ravi Kumar	April, 2012 - March, 2018
19	Techno-legal analysis of policy issues and patents for strategic management of fish genetic resources	Poonam J. Singh (PI), A.K. Pandey, Amar Pal, A.S. Bisht and Ravi Kumar	April, 2015 - March, 2018

ICAR Plan fund

No	Project Title	Personnel	Scheme	Period
1	Network project on agricultural bioinformatics and computational biology: Sub Project: Construction of physical map of <i>Clarias magur</i>	Ravindra Kumar (PI), Basdeo Kushwaha, Mahender Singh, A. K. Pathak and Murali S.	ICAR-IASRI	April, 2017 - March, 2020
2	ICAR CRP-Genomics: De-novo gene sequencing of anadromous Indian Shad <i>Tenuulosa ilisha</i> (Hamilton, 1822)	J. K. Jena (Coordinator) Vindhya Mohindra (PI), Rajeev K. Singh, Basdeo Kushwaha and Labrechai Mog Chowdhury	ICAR-CRP	April, 2015 - March, 2020
3	ICAR CRP-Agrobiodiversity: National network on agro-biodiversity management: On-Farm evaluation of prioritized fish genetic resources for conservation aquaculture	Kuldeep K. Lal (PI), S. K. Majhi, Santosh Kumar, Ajay K. Singh, T. T. Ajithkumar, Aditya Kumar and Charan Ravi	ICAR-CRP	April, 2017 - March, 2020
4	ICAR CRP-Vaccines & Diagnostics: Evaluating the effect of immunization on protection against infection with <i>Aphanomyces invadans</i>	P.K. Pradhan (PI), Neeraj Sood and Chandra Bhushan Kumar	ICAR-CRP	October, 2017 - March, 2020
5	All India network project on fish health	P.K. Pradhan (PI), Gaurav Rathore, Neeraj Sood and Anutosh Paria	ICAR	April, 2017 - March, 2020
6	Intellectual property management and transfer/ commercialization of agricultural technology scheme (Up-scaling existing components i.e. Intellectual property right)	Poonam J. Singh (PI)	ICAR Plan, NAIF	April, 2017 - March, 2020

External funded projects

No	Project Title	Personnel	Funding Agencies	Period
1	Whole genome sequencing and development of allied genomic resources in two commercially important fish- <i>Labeo rohita</i> and <i>Clarias batrachus</i>	J.K. Jena (Coordinator) Basdeo Kushwaha (PI), Ravindra Kumar and Mahendra Singh	DBT, Govt. of India	September, 2013 - March, 2018
2	Characterization and DNA barcoding of fishes from Mizoram	Mahender Singh (PI) and W. Vishwanath (PI, Manipur University)	DBT, Govt. of India (Twining Project for NE)	December, 2014 - December, 2017
3	National repository of fish cell lines in NBFGR, Phase II	Basdeo Kushwaha (PI), Ravindra Kumar, Murali S., Akhilesh K. Mishra and Vijay Kumar	DBT, Govt. of India	May, 2017 - May, 2020

No	Project Title	Personnel	Funding Agencies	Period
4	Development of biotechnological approach for production of <i>Clarias magur</i> (Hamilton, 1822) spermatozoa for aquaculture	S.K. Majhi (PI) and Santosh Kumar	DBT, Govt. of India	January, 2018 - December, 2020
5	National surveillance programme for aquatic animal diseases Sub project I: Surveillance of freshwater fish and shellfish diseases in Uttar Pradesh and Haryana Sub project II: Surveillance programme for aquatic animal diseases of ornamental fishes in the states Kerala and Tamil Nadu	J.K. Jena (Coordinator), Kuldeep K. Lal (Co-coordinator), Neeraj Sood (PI), P.K. Pradhan, T. Raja Swaminathan and Gaurav Rathore P.K. Pradhan (PI), Neeraj Sood, Aditya Kumar and Gaurav Rathore T. Raja Swaminathan (PI) and V.S. Basheer	NFDB NFDB NFDB	February, 2013– September, 2019 February, 2013– September, 2019 April, 2013 - March, 2018
6	Poverty alleviation through prevention and future control of the two major socio-economically/important diseases in Asian aquaculture	Neeraj Sood (PI), P.K. Pradhan and Vindhya Mohindra	DBT- BBSRC	May, 2016 - May, 2019
7	Exploring our wetlands: Establishing DNA barcodes for finfishes and shellfishes of Ramsar sites in Kerala	P.R. Divya (PI)	KSCS&T	January, 2016 - January, 2019
8	Molecular taxonomy and phylogeny of Cones (Cone snails) and Strombs (Mollusca, Gastropoda) of the Indian coast	Laxmilatha P. (PI), Ranjit L. (ICAR- CMFRI) and A. Kathirvel Pandian (Co-PI)	DBT, Govt. of India	November, 2015 - November, 2018
9	Development of vaccines and diagnostic kit for the management of goldfish Herpesviral Hematopoietic necrosis disease in India	T. Raja Swaminathan (PI)	ICAR- National Fellow Project	April, 2017 - March, 2022
10	Towards responsible agriculture for preserving sustainable aquatic ecosystems: assessment of impact of agriculture effluents on aquatic food webs	Kuldeep K. Lal (Coordinator), Rajeev K. Singh (PI), Lalit K. Tyagi, Aditya Kumar, Achal Singh and Chandra Bhushan Kumar	Bioversity Inter- national	January, 2018 - December, 2018
11	Setting up of marine ornamental fish village: Way forward to promote livelihood to mangrove dwellers and marine biodiversity conservation at Maharashtra	Kuldeep K. Lal (Coordinator), T.T. Ajithkumar (PI), Charan Ravi and Lalit K. Tyagi	UNDP- Mangrove Cell, Maharashtra	March, 2018 - February, 2021

Post-Doctoral Schemes

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

PUBLICATIONS

Research papers

International

1. Behera, B.K., P.K. Pradhan, T.R. Swaminathan, N. Sood, P. Paria, A. Das, D.K. Verma, R. Kumar, M.K. Yadav, A.K. Dev, P.K. Parida, B.K. Das, K.K. Lal and J.K. Jena, 2018. Emergence of Tilapia Lake Virus associated with mortalities of farmed Nile Tilapia *Oreochromis niloticus* (Linnaeus, 1758) in India. *Aquaculture*, 484: 168–174.
2. Biswal, J.R., R. K. Singh, N. Dutta, A. Pathak, K.K. Lal, V. Mohindra, R.S. Sah and J.K. Jena, 2017. The complete mitochondrial genome of Olive barb, *Systomus sarana sarana* (Hamilton, 1822) and its phylogenetic status. *Mitochondrial DNA Part B: Resources*, 2: 940–942.
3. Divya, B.K, P. Yadav, P. Masih, R. K. Singh and V. Mohindra, 2017. *In-silico* characterization of Myogenic Factor 6 transcript of Hilsa, *Tenuulosa ilisha* and putative role of its SNPs with differential growth, *MetaGene*, 13: 140–148.
4. Divya, P.R., J. Linu, C. Mohitha, A. Kathirvelpandian, P. Manoj, V.S. Basheer and A. Gopalakrishnan, 2017. Deciphering demographic history and fine scale population structure of cobia, *Rachycentron canadum* (Pisces: Rachycentridae) using microsatellite and mitochondrial markers, *Marine Biodiversity*, DOI.org/10.1007/s12526-017-0817-x.
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7. Iliyas, R., N.S. Nagpure, P. Srivastava, A.K. Pathak, R. Kumar, V. S. Baisvar, M. Singh and B. Kushwaha, 2017. HRE Finder: A Tool for Quarrying Hypoxia-Response Element in Genomic Sequences. *International Journal of Current Microbiology and Applied Sciences*, 6 (7): 1580 -1586.
8. Kumar, A., Charan R., T.I. Chanu, S. Mishra, U. Kumar and P.C. Das, 2017. Effect of Different Weaning Strategies on Survival and Growth of Endangered Fish Pengba, *Osteobrama belangeri*. *International Journal of Pure and Applied Bioscience*, 5(5):951-957.
9. Kumar, R., B.K. Pandey, U.K. Sarkar, N.S. Nagpure, V.S. Baisvar, P. Agnihotri, A. Awasthi, A. Mishra and N. Kumar, 2017. Population genetic structure and geographic differentiation in butter catfish, *Ompok bimaculatus*, from Indian waters inferred by cytochrome b mitochondrial gene. *Mitochondrial DNA Part A: DNA Mapping Sequencing and analysis*, 28(3): 442-450.
10. Kumar, R., V. S. Baisvar, B. Kushwaha, G. Waikhom and N. S. Nagpure, 2017. Cytogenetic investigation of *Cyprinus carpio* (Linnaeus, 1758) using giemsa, silver nitrate, CMA3 staining and fluorescence in situ hybridization. *The Nucleus*, 60(1): 1-8.
11. Kumar, A., P.K. Pradhan, P.C. Das, S.M. Srivastava, K.K. Lal and J.K. Jena, 2017. Growth performance and compatibility of pacu, *Piaractus brachypomus* with Indian major carps in polyculture system. *Aquaculture*, doi:10.1016/j.aquaculture. 2018.02.052.
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13. Maisnam, M., S. Chandra, K.K. Lal, R.K. Singh and V. Mohindra, 2017. Characterization of threatened endemic fish *Osteobrama belangeri* (Valenciennes) and related species from Northeast India based on morphological and molecular analysis. *Mitochondrial DNA Part A. DNA Mapping Sequencing and Analysis*, 2:1-14.
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15. Majhi, S.K. and S. Kumar, 2017. Generation of Viable Progeny from Dead Brooders of Endangered Catfish *Clarias magur* (Hamilton, 1822), *Heliyon* 3: e00434.
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21. Paria, A., M. Makesh, A. Chaudhari, C.S. Purushothaman and K.V. Rajendran, 2018. Molecular characterisation, ontogeny and expression analysis of melanoma differentiation-associated factor 5 (MDA5) from Asian seabass, *Lates calcarifer*. *Developmental and Comparative Immunology*, 78: 71-82.
22. Pradhan, P.K., N. Sood, M.K. Yadav, P. Arya, D.K. Chaudhary, U. Kumar, C.B. Kumar, T.R. Swaminathan and G. Rathore, 2018. Effect of immunization of rohu *Labeo rohita* with inactivated germinated zoospores in providing protection against *Aphanomyces invadans*. *Fish and Shellfish Immunology*, 78: 195-201.
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10. Kumar, A., S. Kumar and C.B. Kumar, 2017. पेंगबा (आस्टियोब्रामा बेलांगिरी) का प्रेरित प्रजनन. *Matsyalok* (6th issue), Published by ICAR-NBFGR, Lucknow. p. 17-18.
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Books

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Book chapter/ technical bulletin

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2. Baiswar, V.S., R. Kumar, B. Kushwaha, M. Singh and Murali S, 2017. मत्स्य आनुवंशिकी में परा उत्पत्तिमूलक (ट्रांसजेनिक) तकनीक द्वारा उत्पन्न मत्स्य प्रजाति पर संक्षिप्त प्रकाश. *Matsyalok* (6th issue),

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18. Singh, S.K., 2017. लवणग्रस्त मृदा आधारित तालाबों में जलकृषि : एक पर्यावरण सौहार्द पहल. *Matsyalok* (6th issue), Published by ICAR-NBFGR, Lucknow. p. 21-26.
19. Srivastava, S.M., 2017. स्वादिष्ट भोजन के लिए पतरा मछली. *Matsyalok* (6th issue), Published by ICAR-NBFGR, Lucknow. p. 14.
20. Tyagi, L.K., 2017. सर्दियों में मत्स्य तालाब का सामयिक प्रबंधन. *Matsyalok* (6th issue), Published by ICAR-NBFGR, Lucknow. p. 27-28.

Proceedings

1. Neeraj, S., P.K. Pradhan, G. Rathore, T.R. Swaminathan, Charan R., R. Chaturvedi, S. Chandra, R. Kumar and K.K. Lal. 2017. Proceedings of the International Symposium on Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture, ICAR National Bureau of Fish Genetic Resources, Lucknow, India, from 20-21 April 2017 p208.

राजभाषा प्रकाशन

1. सिंह एस. के., 2017. लवणग्रस्त मृदा आधारित तालाबों में जलकृषि: एक पर्यावरण सौहार्द पहल।
2. मत्स्य लोक (षष्ठम् अंक): पृष्ठ 21-26।
3. सिंह एस. के., अखिलेश कुमार यादव एवं के. के. लाल, 2018. पुनर्चक्रिय जलकृषि पद्धति (री-सर्कुलेशन एक्वाकल्चर सिस्टम)। प्रशिक्षण पाठ्यक्रम संकलन, निदेशक, भाकृअनुप-राष्ट्रीय मत्स्य आनुवंशिक संसाधन ब्यूरो, लखनऊ द्वारा प्रकाशित (फरवरी व मार्च अंक 2018): 40 पृष्ठ।
4. सिंह एस. के., अखिलेश कुमार यादव एवं संजय कुमार सिंह, 2017. व्यवसायिक कार्प मत्स्य पालन द्वारा आय अर्जन, किसान ज्योति 6(1): 93-98।

Participation in Seminar/Symposia/Workshop/ Training/Meetings

Abroad:

Dr. Vindhya Mohindra, Principal Scientist and Head, Fish Conservation Division participated in the International Conference on Plant and Animal Genome, Asia 2017 (PAG ASIA 2017) in Seoul, South Korea and presented the poster on “Draft genome of the anadromous Indian shad, *Tenuulosa ilisha*” during 29-31 May, 2017.

Dr. Pravata K. Pradhan, Principal Scientist and Dr. T. Raja Swaminathan, Principal Scientist and National Fellow attended the 10th Symposium on Diseases in Asian Aquaculture (DAA10) held in Bali, Indonesia during 28th August to 1st September, 2017. Also attended parallel meeting on Tilapia Lake Virus organized by World Fish on 29th August 2017 at Bali, Indonesia.

Dr. Pravata K. Pradhan, Principal Scientist attended “Emergency Regional Consultation for Prevention and Management of TiLV in Asia-Pacific”, at Guangzhou, PR China during 27-28 September, 2017.

In India:

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

- 2nd Meeting of Coordination Committee for Uttar Pradesh on Doubling Farmers’ Income By March-2022 on 5th April, 2017 at ICAR-Indian Veterinary Research Institute, Izatnagar.
- EFC and revision of cadre strength of scientific staff meeting at SMD, New Delhi during 6-7 April, 2017.
- Meeting with Vice-Chancellor, Kerala Agricultural University, Kerala on 28th April, 2017.
- Seventh meeting of Expert Committee meeting on Agro-biodiversity at National Biodiversity Authority, Chennai on 9th May, 2017.
- Technical Coordination Committee for National Brood Stock Bank on 18th May, 2017 at Krishi Bhawan, New Delhi.
- Meeting of Deep Sea Mission at Central Marine Living Resources and Ecosystem (CMLRE), Kochi on 23th May, 2017.
- Visit to Fisheries Department, Telangana and Meeting with Commissioner Fisheries and officials on 25th May, 2017.
- “Eighth Meeting of Expert Committee on Agro-biodiversity” on 1st August, 2017 at NBA, Chennai.
- Forty fourth meeting of Expert Committee on Access and Benefit Sharing on 8th August, 2017 at NBA, Chennai.
- Review Meeting on National Surveillance Programme for Aquatic Animal Diseases on 18th August, 2017 at NFDB, Hyderabad.
- Workshop on “Reshaping Agricultural Research Education and Extension Systems Management for 2030” during 31st August - 1st September, 2017 at ICAR-NAARM, Hyderabad.
- “India-EU Dialogue Seminar on the Use of Veterinary Medicines and Anti Microbial Resistance” on 15-16 November, 2017 at New Delhi.
- 11th IFAF during 21-24 November, 2017 at Kochi, Kerala.
- Policy Dialogue on Mainstreaming Biodiversity into Inland and Cold Water Fisheries during 28-29th November, 2017 at ICAR- NAARM, Hyderabad.
- Forty Sixth Meeting of Expert Committee on Access and Benefit Sharing on 21st December, 2017 at NBA, Chennai.
- To attend International Biodiversity meeting with DDG (Fisheries Science) on 12th January 2018 at New Delhi.
- World Wetlands Day Programme at NIO, Goa organized by Goa State Biodiversity Board (GSBB), Goa on 2nd February, 2018 and invited lecture on the invasive alien species and surveillance program on exotic pathogens.
- Technical Advisory Committee Meeting of National Surveillance Programme for Aquatic Animal Diseases on 16th February, 2018 at DAHDF, Krishi Bhawan, New Delhi.
- Keynote Address in the 4th International Conference on Environment and Ecology at Dept.

of Zoology, Gauhati University, Guwahati on 15th February, 2018.

- Expert Consultation at Bihar Animal Sciences University, Patna on 6th March, 2018.
- Directors Conference during on 8-9 March, 2018 at NASC Complex, New Delhi.
- Meeting on National Surveillance Programme for Aquatic Animal Diseases on 12th March, 2018 at New Delhi.

Dr. Ravindra Kumar, Principal Scientist and Head, Molecular Biology and Biotechnology Division participated in following activities:

- International Symposium on 'Aquatic animal health and epidemiology for sustainable Asian aquaculture' at ICAR-NBFGR, Lucknow during 20-21 April, 2017.
- 17th and 18th Advisory (Expert) Committee meetings of the Agriculture and Allied Sector Division of Council of Science and Technology, Uttar Pradesh on 07th July, 2017 and 17th October, 2017 at Vigyan Bhawan, Lucknow.
- Workshop on 'Single Molecule Real Time (SMRT) sequencing and bioinformatics analysis' at ICAR-NBFGR, Lucknow during 25-26 July, 2017.
- Workshop on 'Flow Cytometry: Single tool for versatile applications' at ICAR-NBFGR, Lucknow on 24th August, 2017.
- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during November 21-24, 2017 at Kochi.
- Plenary Session on 'Pharmaceutical and Biotechnology: Investing Today for a Better Tomorrow' of UP Investors Summit 2018 on 21st February, 2018 at Indira Gandhi Pratishthan, Lucknow.
- Launch Workshop of 'Network Programme on Antimicrobial Resistance (AMR) in Fisheries' at ICAR-NBFGR, Lucknow on 24th March, 2018.
- Meeting for Identification of Research Priorities chaired by DG, UP Council of Agricultural Research at Lucknow on 12th March, 2018.

Dr. Vindhya Mohindra HOD, Fish Conservation Division participated in following activities:

- National Seminar on "Strategies, Innovations, Sustainable Management and Enhancing Coldwater Fisheries and Aquaculture at ICAR-DCFR, Bhimtal during 22-24 September, 2017.

- Scientific Advisory Committee Meeting of the Centre of Excellence on Fisheries and Aquaculture Biotechnology (CoE-FAB) at CAU, Agartala on 8th October, 2017.
- Workshop on ICAR-NASF project at CIFRI at Central Inland Fisheries Research Institute, Barrackpore, West Bengal, 24-26 October, 2017.
- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during 21-24 November, 2017 at Kochi.
- Training on Policy Workshop on Big Data Analysis in Agriculture at ICAR-NAARM, Hyderabad during 8-9 February, 2018.
- DNA fingerprinting meeting at ICAR-NBPGR, New Delhi, chaired by DG, ICAR and Secretary DARE on 12th February, 2018.
- CRP-Genomics review meeting at Krishi Bhawan, New Delhi, Chaired by DG, ICAR and Secretary DARE on 6th March, 2018.
- Final Basin-wide (National) workshop on Strategic Basin Planning for Ganga river basin in India supported by Ministry of Water Resources, River Development & Ganga Rejuvenation, Govt. of India and conducted by the consultant Deltares-AECOM at Shangri La's Eros Hotel, Connaught Place, New Delhi on 20th March, 2018.

Dr. Gaurav Rathore, Head, Fish Health Management and Exotics division participated in following activities:

- International Symposium on "Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture", organised by Aquatic Biodiversity Conservation Society, Lucknow, in collaboration with ICAR-NBFGR at Lucknow during 20-21 April, 2017.
- Strategy Planning Workshop on "Aquatic Animal Diseases Surveillance in India", organised by ABCS in collaboration with ICAR-NBFGR and NSPAAD at NBFGR, Lucknow on 22nd April, 2017.
- School on "Aquatic Animal Epidemiology", at ICAR-NBFGR, Lucknow during 24-28 April, 2017.
- Aqua Aquaria, 2017 and delivered a talk on "Research advancements in Shrimp health Management", organized by MPEDA, Kochi at Mangalore during 14-15 May, 2017.

- Meeting for SFC corrections and submission of Scheme 32 at Fisheries Division, ICAR, KAB-II, New Delhi during 22-23 May, 2017.
 - Meeting for SFC presentation of Scheme 32 at ICAR, Krishi Bhawan, New Delhi during 18-20 June, 2017.
 - FAO-ICAR Meeting on 'Operational Mechanism of Indian Network for Fisheries and Animal Antimicrobial Resistance (INFAAR) and made a presentation on "Criteria for expanding membership of INFAAR" and "Operational mechanism of INFAAR in Fisheries", organized by FAO and ICAR, New Delhi at ICAR-CIFE, Mumbai on 14th July, 2017.
 - Workshop on "Single Molecule Real Time (SMRT) Sequencing and Bioinformatics Analysis" at ICAR-NBFGR organized jointly with ILS, Haryana and Pacific Biosciences, USA, during 25-26 July, 2017.
 - Workshop on "Flow Cytometry: Single Tool for Versatile Application" organized by ICAR-NBFGR and Thermo Fisher Scientific at ICAR-NBFGR, Lucknow, on 24th August, 2017.
 - Joint Training programme for shrimp farmers at Nellore and delivered a talk on Biosecurity for Shrimp Diseases relevant of Asian Aquaculture., organized by MPEDA, NACA and ICAR-NBFGR on at Nellore, Andhra Pradesh on 30th August, 2018.
 - Development of Soft Skills for Attaining Excellence in Science organised by NAAS at ICAR-IISR, Lucknow on 12th September, 2017.
 - Delivered a talk on "Steps to generate indent in ERP for purchase of items for research use". In Human Resource Development Week on "Skill and Competency Enhancement", organized at ICAR-NBFGR during 6-10 November, 2017.
 - EU-India dialogue seminar on "Use of Veterinary medicines and anti-microbial resistance" and delivered a talk on Surveillance of Antimicrobial Resistance (AMR) in microorganisms associated with fisheries and aquaculture in India, Export-Inspection Council, Ministry of Commerce and Industry, New Delhi during 15-16 November, 2017.
 - Delivered an invited talk on "Automation in Bacterial Identification during training programme on Genomics", In Training course on Genome Sequencing: Methods and applications, Organized at ICAR-NBFGR, during 12-17 March, 2018.
 - Made a presentation on "Sampling Strategy for Network Programme" on AMR in Fisheries., during launch workshop Organized at ICAR-NBFGR, Lucknow on 24th March, 2018.
 - Delivered a talk on "Standard operating Procedures for Network Programme on AMR in Fisheries" during launch workshop, Organized at ICAR-NBFGR, Lucknow on 24th March, 2018.
- Dr. A.K. Pandey, Principal Scientist participated in following activities:
- International Symposium on Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture, during 20-21 April, 2017 at ICAR-NBFGR, Lucknow.
 - Conclave on Education-2025: Students First on 22th April, 2017 at Confederation of Education Excellence (CEE), Crowne Plaza Hotel, Rohini, New Delhi.
 - Brain Storming Session on Safety and Health in Disaster Management on 28th April, 2017 at International Institute of Disaster Management, Gomti Nagar, Lucknow.
 - National Seminar on "Agriculture Research and Education in Relation to Development of Integrated Agriculture: Challenges and Solution" on 14th June, 2017 at ICAR-Indian Institute of Sugarcane Research and Uttar Pradesh Council of Agricultural Research, Lucknow.
 - Workshop on Flow Cytometry: Single Tool for Versatile Application on 24th August, 2017 at ICAR-National Bureau of Fish Genetic Resources & Thermo-Fisher, Lucknow.
 - Conclave on Transforming India Through Civic Education on 2nd September, 2017 at Confederation of Education Excellence (CEE) at New Delhi.
 - Workshop on Development of Soft Skills for Attaining Excellence in Science on 12th September, 2017 at National Academy of Agricultural Sciences (NAAS), Lucknow Chapter & ICAR-Indian Institute of Sugarcane Research, Lucknow.
 - National Seminar on Strategies, Innovations and Sustainable Management for Enhancing Coldwater Fisheries and Aquaculture during 22-24 September, 2017 organised by Zoological Society of India, Gaya & Coldwater Fisheries Society of India. ICAR-Directorate of Coldwater Fisheries Research, Bhimtal (Nainital).
 - International Conference & EXPO on Agriculture & Veterinary Sciences: Research and Technology for Sustainable Impact at Centre for Good Governance, Department of International Development & World Bank and Professor

Jayashankar Telangana State Agricultural University, Hyderabad during 23-25, October, 2017.

- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during 21-24 November, 2017 at Kochi.
- National Symposium on Biodiversity and Natural Resources for Sustainable Development & 37th Annual Session of the Academy of Environmental Biology organised by Academy of Environmental Biology (AEB), Lucknow & Department of Zoology, Chaudhary Charan Singh University, Meerut during 24-26 November 2017.
- XVI-AZRA International Conference on Applied Zoological Research for Sustainable Agriculture and Food Security organised by Applied Zoologists Research Association (AZRA), Bhubaneswar & Department of Entomology & Applied Zoology, at Institute of Agricultural Sciences, Banaras Hindu University (BHU), Varanasi during 9-11 February, 2018.
- 30th All India Congress of Zoology (AICZ) and National Seminar on Advances in Zoology for Sustainable Development organised by Zoological Society of India, Gaya & Department of Zoology, Kurukshetra University, Kurukshetra during 15-17 February, 2018.
- National Conference on Agricultural Sciences and Sustainable Environment (ASSE-2018) organised by Society for Scientific & Social Development & Shobhit University, Meerut on 24th February, 2018.
- International Conference on Current Challenges and Future Perspectives in Science, Technology and Social Humanities organised by Society of Life Sciences, Satna & School of Life Sciences, Dr. B.R. Ambedkar University, Agra from 26-28 February, 2018.

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

- Third International Large Rivers Conference organised by NIH, Roorkee and University of Natural Resources, Vienna, Austria at India Habitat Centre, New Delhi during 18-21 April 2017. Delivered lecture on Invasion of Resilient exotic fishes in the Ganga river system.
- International Symposium on 'Aquatic animal health and epidemiology for sustainable Asian

aquaculture' at ICAR-NBFGR, Lucknow during 20-21 April, 2017.

- Workshop on "Biodiversity and Sustainable Tourism" organised by U.P. Biodiversity Board, Lucknow at Shri LB Shastri Ganna Sansthan Dalibagh, Lucknow on the occasion of World Diversity Day on 22nd May, 2017.
- National Level Steering Committee Meeting for Introduction of Exotic Fish Species, at Krishi Bhawan, Ministry of Agriculture & Farmers Welfare, New Delhi on 18th July, 2017.
- National Level workshop on Stakeholders Consultation for Formulation of National Inland Fisheries & Aquaculture Policy at BAMETI, Patna Bihar on 22nd July, 2017.
- National Conference on Environmental Science and Technology organised by the School of Earth and Environmental Sciences, Central University of Himachal Pradesh, Kangra, H.P. on 24th August, 2017. Delivered an invited lecture on "Environmental flow for management of river ecology and fisheries: A case study of Ganga river system".
- National Seminar on Strategies, Innovations and Sustainable Management for Enhancing Coldwater Fisheries and Aquaculture organised by ICAR-Bhimtal at Bhimtal from 22-23 September, 2017. Also delivered invited lecture on "Status of coldwater fish diversity in India and strategies for conservation" on 23rd September, 2017.
- Workshop on Blue Revolution: Prospects and Opportunity for Doubling Farmers and Fishers Income on 23rd October, 2017 at PHD Chamber of Commerce and Industry, Gomti Nagar, Lucknow.
- Workshop on "Strategic Basin Planning for Ganga river basin in India" held at New Delhi during 15-16 November, 2017.
- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during 21-24 November, 2017 at Kochi.
- India Water Impact Summit organised by IIT, Kanpur during 4-7 December 2017 at Vigyan Bhawan, New Delhi.
- Meeting for identification and prioritization of research projects at UPCAR, Lucknow for funding, as Institute Representative on 12th March, 2018.
- Meeting of U.P. Fisheries Development

Corporation on development of Pangassius hatchery at Gomati hatchery on 13th March, 2018 at Pradeshik Cooperative Dairy Federation, Lucknow.

- Final Basin-wide (National) Workshop on Strategic Basin Planning for Ganga river basin in India supported by Ministry of Water Resources, River Development & Ganga Rejuvenation, Govt. of India and conducted by the consultant Deltares-AECOM at Shangri La's Eros Hotel, Connaught Place, New Delhi on 20th March, 2018.

Dr. V.S. Basheer, Principal Scientist and In-charge, PMFGR Center, ICAR-NBFGR, Kochi participated in following activities:

- Brainstorm meeting on "Deep Sea Mission" at Centre for Marine Living Resources and Ecology (CMLRE), Kochi on 23rd May, 2017.
- Meeting on "International legally binding under the United Nations Convention on the law of the Sea (UNCLOS)" at MoES-CMLRE, Kochi on 20th June, 2017.
- National consultation on Intensification of *Macrobrachium rosenbergi* culture in India" during 28-29 July, 2017 at NCAAH, CUSAT, Kochi.
- Delivered an invited talk on "Fish Genetic resources and its conservation" in a joint initiative of Indo-US collaboration funded by USAID "Feed The Future - India Triangular Training (FTF-ITT)" programme on "Recent Trends in Harvest and Post-Harvest Technologies in Fishery" during 12-26 September, 2017 at ICAR-CIFT, Kochi.
- Delivered an invited talk on "Cryopreservation and Gene banking" in a DBT sponsored National training in Molecular Biology and Biotechnology for Fisheries Professionals" on 26th December, 2017 at ICAR-CMFRI, Kochi.
- Delivered an invited talk on "Use of molecular markers for identification of fishes" in "International seminar on Molecular biology" held during 8-9 January 2018 at Farooq College, Calicut, Kerala.
- 82nd meeting of the Institute Management Committee of ICAR-CMFRI on 11th January, 2018 at ICAR-CMFRI, Kochi.
- 83rd meeting of the Institute Management Committee of ICAR-CMFRI on 19th March, 2018 at ICAR-CMFRI, Kochi.
- Delivered an invited talk on "Exotic fishes in Aquaculture" in an International Workshop cum training programme on "Fisheries and

Aquaculture" sponsored by African Asian Rural Development Organisation (AARDO), Govt. of India on 22th March, 2018 at ICAR-CMFRI, Kochi.

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

- International Symposium on "Aquatic animal health and epidemiology for sustainable Asian aquaculture" at ICAR-NBFGR, Lucknow during 20-21 April, 2017.
- Workshop on "Single molecule real time (SMRT) sequencing and bioinformatics analysis" held at ICAR-NBFGR, Lucknow during 25-26 July, 2017.
- Symposium on "Flow-cytometry single tool for versatile applications" held ICAR-NBFGR, Lucknow on 24th April, 2017.
- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during 21-24 November, 2017 at Kochi.

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

- International Symposium on 'Aquatic animal health and epidemiology for sustainable Asian aquaculture' at ICAR-NBFGR, Lucknow during 20-21 April, 2017.
- Strategy Planning Workshop on Aquatic Animal Diseases Surveillance in India organized by ABCS in collaboration with ICAR-NBFGR and NSPAAD on 22nd April, 2017.
- Meeting with Chief Executive, National Fisheries Development Board, Hyderabad at National Fisheries Development Board, Hyderabad on 18th August, 2017.
- Development of Soft Skills for attaining Excellence in Science by NAAS at ICAR-IISR, Lucknow on 12th September, 2017.
- Review of NFDB-funded projects by Secretary, DADF at National Fisheries Development Board, Hyderabad on 20th September, 2017.
- External examiner for viva voce of M.F.Sc. student at GADVASU, Ludhiana on 22nd September, 2017.
- 10th Symposium on Diseases in Asian Aquaculture at Fish Health Section, Asian Fisheries Society on 28th September, 2017.
- Meeting of the Board of Studies (Biotechnology), Department of Zoology, HNB Garhwal University, Srinagar on 10th October, 2017.

- Vigilance Awareness Meeting at village Devariya, Lucknow organized by ICAR-NBFGR on 1st November, 2017.
- Review meeting of Fishery Related matters convened by DADF at Tagore Chamber, Scope Complex, New Delhi organized by National Fisheries Development Board, Hyderabad on 10th November, 2017.
- World Fisheries Day organized by National Fisheries Development Board, DADF on 21st November, 2017

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

- International Symposium on "Aquatic animal health and epidemiology for sustainable Asian aquaculture" at ICAR-NBFGR, Lucknow during 20-21 April, 2017.
- 7th meeting of Technical Advisory Committee (TAC) constituted for overall monitoring and supervision of National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) at Krishi Bhawan on 2nd August, 2017.
- Review meeting of CRP on Vaccines and Diagnostics held during 6-7 October, 2017 at IVRI, Bengaluru.
- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during 21-24 November, 2017 at Kochi.
- 8th meeting of TAC constituted for overall monitoring and supervision of NSPAAD at Krishi Bhawan on 16th February, 2018.
- Review meeting regarding progress of National Surveillance Programme for Aquatic Animal Diseases by Secretary, DADF at Krishi Bhawan on 12th March, 2018.

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

- International Symposium on "Aquatic animal health and epidemiology for sustainable Asian aquaculture" at ICAR-NBFGR, Lucknow during 20-21 April, 2017.
- Agriculture advisory committee meeting as invited specialist at Door Darshan, Lucknow on dated 20th May, 2017 and 30th July, 2017.
- Crop weather watch group workshop and several meeting during April to July 2017 at UPCAR, Lucknow.

- Meeting organized by Dr. U.C. Goswami on Revamping of Agricultural Education in the state of U.P. on dated 24th August, 2017 at Directorate of U.P. State Agriculture, Lucknow.
- Sankalp se Sidhi programme organized by KVK ICAR-IISR, Lucknow on 29th August, 2017.
- Delivered invited/special lecture along with Dr. A. K. Yadav, CTO, ARTU, Chinhat in Kisan Goshti at Mathura, U.P. during 22-25 September, 2017.
- Workshop on Blue Revolution: Prospects and Opportunity for Doubling Farmers and Fishers Income on 23rd October, 2017 at PHD Chamber of Commerce and Industry, Gomti Nagar, Lucknow.
- Delivered invited/special sensitization lecture on नीलतिमा से हरितिमा के द्वारा कृषि व्यवसाय के अवसर on dated 21st December, 2017 at the U.P. Agri Business Workshop organized at Gomti hotel, Lucknow.
- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during 21-24 November, 2017 at Kochi.
- Delivered invited/special lecture and participated along with Shri Sanjay Kumar Singh, STO, ARTU, Chinhat in Exhibition cum Mela in ICAR-CISH, Lucknow on सुनियोजित कृषि विकास केन्द्र के अन्तर्गत उद्यान विविधिकरण द्वारा किसानों की दुग्नी आय ।

Dr. T. Raja Swaminathan, Principal Scientist and National Fellow attended the following activities:

- Visited and examined the sites proposed by M/s Anandha Enterprises Pvt. Ltd., Bhimavaram and M/s BMR group for setting up SPF Shrimp Broodstock Multiplication Centre (BMC) at Bhimavaram on 04.04.2017 and Nellore on 05.04.2017 as a member of the Technical and Inspection Committee to assist the Project Screening Committee constituted for this purpose.
- Visited and examined the site proposed by M/s Vaishnavi Aquatech, Surat, Gujarat for setting up SPF Shrimp Broodstock Multiplication Centre (BMC) at Dehgam, Gujarat on 30.05.2017 as a member of the Technical and Inspection Committee to assist the Project Screening Committee constituted for this purpose.
- Inspected quarantine facility of M/S Anandha Enterprises Pvt. Ltd., Bhimavaram for import of Asian Seabass from Australia at Uppada, West Godavari Dt. A.P. on 11th July, 2017.

- Inspected the Ornamental Fish Quarantine Facility, Government of Karnataka, Bangalore on 23rd August, 2017.
- Delivered a lecture on TiLV at International Workshop on “Tilapia the future fish” at Tamil Nadu Fisheries University, Chennai Campus on 21st August, 2017.
- NaCSA 24th Governing Council meeting at Visakhapatnam during 27-28 March, 2018.

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

- International Symposium on "Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture", organised by Aquatic Biodiversity Conservation Society, Lucknow, in collaboration with ICAR-NBFGR at Lucknow during 20-21 April, 2017.
- Attended Scientific Advisory Committee meeting of the Krishi Vigyan Kendra, Unnao on 13th October, 2017.
- Review Meeting of the Research programme on exploration of fish germplasm resources of NE region held at Department of Zoology, Gauhati University, Guwahati on 1st November, 2017.
- World Fisheries Day organized by National Fisheries Development Board, DADF on 21st November, 2017.
- Participated and delivered lecture on 'ICAR in Agriculture Education' for school students during Agriculture Education Day programme on 3rd December, 2017 at ICAR-NBFGR, Lucknow.
- Launch Workshop of the project 'Towards responsible agriculture for preserving sustainable aquatic ecosystems: assessment of impact of agriculture effluents on aquatic food webs' held at ICAR-NBFGR, Lucknow on 7th February, 2018.
- 4th International Conference on Environment and Ecology (ICEE, 2018) held at Department of Zoology, Gauhati University, Guwahati during 13-14 February, 2018.
- Delivered lecture on 'Livelihood opportunities for tribal farmers in fisheries' during training programme for tribal farmers at Department of Zoology, Gauhati University on 15th February, 2018.
- Delivered an invited talk on 'Modern technology of fish farming and fisheries business' in a training programme for office-bearers of fishing cooperative societies at Indira Gandhi Institute of Cooperative Management, Lucknow on 15th March, 2018.

Dr. T.T. AjithKumar, Principal Scientist attended the following activities:

- International Symposium on "Aquatic animal health and epidemiology for sustainable Asian aquaculture" at ICAR-NBFGR, Lucknow during 20-21 April, 2017.
- Brainstorming meeting on Deep Sea Mission held at the Centre for Marine Living Resources and Ecology (CMLRE), Ministry of Earth Sciences, Kochi on 23rd May, 2017.
- Expert committee meeting on Invasive alien species held at the National Biodiversity Authority, Chennai during 29 - 30 June, 2017.
- Nominated by the Director, ICAR-NBFGR, to sign MoU with the Dept. of Fisheries, Telangana for collaborative works on conservation of fish genetic resources in Nagarjuna Sagar dam on 18th July, 2017.
- Consultation meeting on farming system for Nutrition” held at M S Swaminathan Research Foundation, Chennai during 5-10 August, 2017.
- Attended the technical committee meeting on the establishment of signature stall held at the Marine Products Export Development Authority (MPEDA), Kochi during on 30th August, 2017.
- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during 21-24 November, 2017 at Kochi.
- Attended the taxonomy training on Marine Fishes held at the NBFGR - PMFGR Centre, Kochi during 25-30 November, 2017.
- Workshop on potential and viability of culturing endemic and exotic species for aquaculture held at the ICAR-CIBA on 29th December, 2017.
- Advance training in aquaculture nutrition and feed technology held at the ICAR - CIBA during 3- 12 January, 2018.
- Meeting chaired by the Additional Principal Chief Conservator of Forests, Govt. of Maharashtra and presented the project proposal on “Setting-up of marine ornamental fish village: Way forward to promote livelihood to mangrove dwellers and marine biodiversity conservation at Ratnagiri / Maharashtra coast held at Mumbai on 6th February 2018.

- Delivered Keynote address on Ornamental aquaculture: Measure towards biodiversity conservation in the International Conference on Biodiversity and Sustainable Resources Management held at the University of Madras, Chennai on 12th March, 2018.
- Meeting on Exotic fishes held at ICAR - CIBA Chennai on 29th December, 2017

Dr. Charan, R., Scientist participated in “Karnataka Mathsya Mela 2017” at Bengaluru during 8-11 December, 2017.

Dr. V.S. Basheer, Dr. T. Raja Swaminathan, Dr. T.T. AjithKumar, Dr. Charan R. and Ms. Teena Jayakumar T.K., attended “International Symposium on Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture”, ISAAHE during 20-21 April 2017, ICAR-NBFGR, Lucknow.

Dr. V.S. Basheer, Dr. T. Raja Swaminathan, Dr. Divya, Dr. T.T. AjithKumar, Dr. Charan, Ms. Teena Jayakumar T.K. and Dr. Rajool Shanis attended the 11th Indian Fisheries & Aquaculture Forum (IFAF) Symposium at Kochi during 21-24 November, 2017.

Ms. Teena Jayakumar T.K. attended the International Symposium ‘SAFARI 2’ on Remote Sensing for Ecosystem and Fisheries held during 15-17 January 2018 at ICAR CMFRI.

Ms. Teena Jayakumar T.K. attended summer School on “Advanced Methods for Fish Stock Assessment and Fisheries Management” during 12.07.2017 - 01.08.2017 at ICAR-CMFRI, Kochi.

Dr. P.R. Divya attended the training programme on “Next Generation Sequencing workshop at ICAR-NBFGR, Lucknow during 24th July to 1st August, 2017.

Dr. Rajool Shanis attended the training programme on “Microbiological examination of Seafood” at ICAR-CIFT, Kochi during 1-7 August, 2017.

Dr. T.T. Ajith Kumar attended training on “Advances in Aquaculture Nutrition” at ICAR-CIBA during 3-12 January, 2018.

Dr. A. Kathirvelpandian and Ms. Teena Jayakumar T.K. attended training programme on “Integrative Taxonomy and Systematics in Freshwater Fishes” during 5-10 February, 2018 at ICAR-NBFGR, Lucknow.

Dr. V.S. Basheer and Ms. Teena Jayakumar T.K. attended training workshop “Hermit Crabs” at Department of Aquatic Biology & Fisheries, Kerala University, Thiruvananthapuram during 19-21 February, 2018.

Dr. Achal Singh, Principal Scientist attended the following activities:

- International Symposium on "Aquatic animal health and epidemiology for sustainable Asian aquaculture" at ICAR-NBFGR, Lucknow during 20-21 April, 2017.
- Workshop on “Flow cytometry: A tool for versatile Application” organised by ICAR-NBFGR and Thermo fisher scientific, at NBFGR, Lucknow on 24th August, 2017.
- Workshop on “Development of Soft skills for Attaining Excellence in Science” organised by National Academy of Agricultural Science (NAAS), Lucknow chapter at IISR, Lucknow, on 12th September, 2017.
- Delivered lectures on “Polynomial models in prediction of mango yield cv. Langra (*Mangifera indica* L.)” at Baba Saheb Bhimrao Ambedkar University, Lucknow on 28th October, 2017.
- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during 21-24 November, 2017 at Kochi.
- Delivered lecture on observance on Vigilance Awareness Week in the village level gosthi at village Chhoti Deoria, Lucknow on 1st November, 2017.
- Participated and delivered lecture on "प्रबंधन में उच्च गुणवत्ता के लिए सकारात्मक-इन्टेलिजेन्स" in the Institute HRD week program “Competence Enhancement week for NBFGR employee” on 8th November, 2017.
- Training on Policy Workshop on Big Data Analysis in Agriculture at ICAR-NAARM, Hyderabad during 8-9 February, 2018.

Dr. Sullip Kumar Majhi, Principal Scientist attended the following activities:

- International Symposium on "Aquatic animal health and epidemiology for sustainable Asian aquaculture" at ICAR-NBFGR, Lucknow during 20-21 April, 2017.
- International Symposium on Culture-Based Fisheries in Inland Open Waters organised by ICAR-Central Inland Fisheries Research Institute during 9-11 June, 2017 at Barrackpore, West Bengal.

- Workshop on “Flow cytometry: A tool for versatile Application” organised by ICAR-NBFGR and Thermo fisher scientific, at NBFGR, Lucknow on 24th August, 2017.
- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during 21-24 November, 2017 at Kochi.
- National Symposium on Use of Reproductive Technologies and Production Improvement in Livestock Species Aiming to Socio-economic Development of Rural Mass organised by Indian Society for Study of Animal Reproduction during 9-11 February, 2018 at Kolkata.
- Workshop on “Single Molecule Real Time (SMRT) sequencing and bioinformatics analysis” Jointly organised by NBFGR, ILS and Pacific Biosciences during period 25-26 July, 2017 at NBFGR, Lucknow.
- Modern genomic tools and breeding strategies for biotic and abiotic stress management in Sugarcane during period 25 October-3 November, 2017 at Indian Institute of Sugarcane Research, Lucknow.
- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during 21-24 November, 2017 at Kochi.
- Taxonomy training on Marine Fishes during 25-30 November, 2017 at PMFGR Centre, ICAR-NBFGR, Kochi.

Dr. Santosh Kumar, Scientist attended the following activities:

- International Symposium on "Aquatic animal health and epidemiology for sustainable Asian aquaculture" at ICAR-NBFGR, Lucknow during 20-21 April, 2017.
- Workshop on “Flow cytometry: A tool for versatile Application” organised by ICAR-NBFGR and Thermo fisher scientific, at NBFGR, Lucknow on 24th August, 2017.
- One day training on “Development of Soft Skills for Attaining Excellence in Science” organised by ICAR-IISR on 12th September, 2017 at ICAR-IISR, Lucknow.
- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during November 21-24, 2017 at Kochi.
- National Seminar on “Healthy Soil for Healthy Life” organised by ICAR-IISR at ICAR-IISR, Lucknow on 5th December, 2017.
- Training on Integrative Taxonomy and Systematics in Freshwater Fishes organized by ICAR-NBFGR during the period 5-10 February, 2018 at ICAR-NBFGR, Lucknow.

Dr. Trivesh Suresh Mayenkar, Scientist attended the following activities:

- International Symposium on ‘Aquatic animal health and epidemiology for sustainable Asian aquaculture’ at ICAR-NBFGR, Lucknow during 20-21 April, 2017.

Dr. Anutosh Paria, Scientist attended the following activities:

- Workshop on “Single Molecule Real Time (SMRT) sequencing and bioinformatics analysis” Jointly organised by NBFGR, ILS and Pacific Biosciences during period 25-26 July, 2017 at ICAR-NBFGR, Lucknow.
- Workshop on “Flow cytometry: A tool for versatile Application” organised by ICAR-NBFGR and Thermo fisher scientific, at ICAR-NBFGR, Lucknow on 24th August, 2017.
- National workshop on “Revisiting Foundation Course for Agricultural Research Service (FOCARS): Reflections and Feedback of Trained Scientists”, at ICAR-NAARM, Hyderabad during 15-16 March, 2018.
- Launch workshop on “Network programme on Assessment of Antimicrobial Resistance (AMR) in Microorganisms Associated with Fisheries and Aquaculture in India”, ICAR-NBFGR, Lucknow, 24th March, 2018.

Mr. Chandra Bhusan Kumar, Scientist attended the following activities:

- Participated in the annual review meeting of National Surveillance Programme for Aquatic Animal diseases, held at ICAR-NBFGR, Lucknow, India during 18-19 April, 2017.

- Presented poster in the “International Symposium on Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture” held at the ICAR-NBFGR, Lucknow, India during 20-21 April, 2017.
- Strategy Planning Workshop on Aquatic Animal Diseases Surveillance in India organized by ABCS in collaboration with ICAR-NBFGR and NSPAAD on 22nd April, 2017.
- Training school on “Aquatic Animal Epidemiology” organized under National Surveillance Programme for Aquatic Animal diseases by the ICAR-NBFGR, Lucknow, India during 24-28 April, 2017.

Mr. Aditya Kumar Scientist attended the following activities:

- International Symposium on ‘Aquatic animal health and epidemiology for sustainable Asian aquaculture’ at ICAR-NBFGR, Lucknow during 20-21 April, 2017.
- Training school on “Aquatic Animal Epidemiology” organized under National Surveillance Programme for Aquatic Animal diseases by the ICAR-NBFGR, Lucknow, India during 24-28 April, 2017.
- Workshop on “Flow cytometry: A tool for versatile Application” organised by ICAR-NBFGR and Thermo fisher scientific, at NBFGR, Lucknow on 24th August, 2017.
- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during November 21-24, 2017 at Kochi.
- Taxonomy training on Marine Fishes during period 25-30 November, 2017 at PMFGR Centre, NBFGR, Kochi.
- Training programme on ‘Fish Cell Culture Techniques: Cell Line Development and Applications’ during 5-9 March, 2017 at ICAR-NBFGR, Lucknow.

Dr. Sangeeta Mandal, Scientist attended the following activities:

- Taxonomy training on Marine Fishes during period 25-30 November, 2017 at PMFGR Centre, ICAR-NBFGR, Kochi.
- Training course on ‘Integrative Taxonomy and Systematics in Freshwater Fishes’ organized by NBFGR, Lucknow during 12-17 March, 2018.

- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during 21-24 November, 2017 at Kochi.
- International Symposium on “Aquatic animal health and epidemiology for sustainable Asian aquaculture” at ICAR-NBFGR, Lucknow during 20-12 April, 2017.
- Workshop on “Single Molecule Real Time (SMRT) Sequencing and Bioinformatics Analysis” jointly organised by NBFGR, ILS and Pacific Biosciences during 25-26 July, 2017 at ICAR-NBFGR.
- Workshop on “Flow Cytometry: A tool for versatile application” organised by ICAR-NBFGR and Thermo fisher scientific, at ICAR-NBFGR, Lucknow on 24th August, 2017.
- Training on “Development of Soft skills for Attaining Excellence in Science” organised by ICAR-IISR on 12th September, 2017 at ICAR-IISR, Lucknow.

Ms. Chinmayee Muduli, Scientist attended the following activities:

- International Symposium on “Aquatic animal health and epidemiology for sustainable Asian aquaculture” at ICAR-NBFGR, Lucknow during 20-21 April, 2017.
- Trainingschool on “Aquatic Animal Epidemiology” at ICAR-NBFGR, Lucknow during 24-28 April, 2017.
- Workshop on “Flow cytometry: A tool for versatile Application” organised by ICAR-NBFGR and Thermo fisher scientific, at NBFGR, Lucknow on 24th August, 2017.

Technical Personnel

Dr. S.M. Srivastava, Chief Technical Officer attended the following activities:

- Training on “Basic Microbiological Techniques for Studying Microbes in Microbiology” at ICAR-Indian Agricultural Research Institute, New Delhi from 24-31 July, 2017.
- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during 21-24 November, 2017 at Kochi.

Dr. Ajay K. Singh, Assistant Chief Technical Officer attended the following:

- “Integrative Taxonomy and Systematics in Freshwater Fishes” during 5-10 February, 2018 at ICAR-NBFGR, Lucknow
- “Advanced Training in Aquaculture Nutrition and Feed Technology” conducted by ICAR-Central institute of Brackishwater Aquaculture, Chennai during 3-12 January, 2018 at Chennai.

Mrs. Reeta Chaturvedi, Senior Technical Officer attended the following activities:

- Regional (North-III) Workshop on Institutional Digital Repository for National Digital Library of India organized by the Main Library, IIT (BHU), Varanasi and Indian Institute of Technology, Kharagpur during 2-3 June, 2017.
- Certificate Course in Android Application Development at NIELIT, Vibhuti Khand, Gomti Nagar, Lucknow during 12 June-24 July, 2017.

Mr. Subhash Chandra, Senior Technical Officer attended the following activities:

- Regional (North-III) Workshop on Institutional Digital Repository for National Digital Library of India organized by the Main Library, IIT (BHU), Varanasi and Indian Institute of Technology, Kharagpur during 2-3 June, 2017.
- National Conference of “Relevance of Ranganathan Philosophy in Digital India ” organized by the Department of Library and Information Science, Babasaheb Bhimrao Ambedkar University, Lucknow and Society for Promotion of Libraries (SPL), Uttar Pradesh during 12-13 August, 2017.

Mr. Amit Singh Bisht, Senior Technical Officer attended the following activities:

- Training programme “National Training programme on Mushroom Cultivation Technology” at ICAR-Directorate of Mushroom Research, at Solan, Himachal Pradesh during 12-18 July, 2017.
- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during

21-24 November, 2017 at Kochi.

Mr. Ravi Kumar, Senior Technical Officer attended the following activities:

- Training Programme “Certificate Course in Android Application Development” at NIELIT, Lucknow during 12-24 July, 2017.
- Training Programme “ Application of Remote Sensing and GIS in Natural Resource Management” at ICAR-Indian Institute of Soil and Water Conservation at Dehradun during 18-27 September, 2017.

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

- Seminar on Biodiversity & Sustainable Tourism on the occasion of “International Day for Biological Diversity” Organized by Uttar Pradesh State Biodiversity Board, Lucknow at Auditorium of Lal Bahadur Shastri Ganna Sansthan, Lucknow on 22nd May, 2017.
- Kisan Kalyan Mela, Matsya Palan Goshti and Celebration of Champaran Satyagrah Centenary Year” at Mahatma Gandhi Central University, Motihari, Bihar during 12-19, April, 2017.
- 11th Indian Fisheries and Aquaculture Forum: Fostering Innovations in Fisheries and Aquaculture organised by Asian Fisheries Society: Indian Branch, Mangalore & ICAR-Central Institute of Fisheries Technology, Kochi during 21-24 November, 2017 at Kochi.
- Rastriya Krishi Unnati Mela inaugurated by Hon’ble Prime Minister Shri Narendra Modi Ji at IARI Mela Ground, Pusa, New Delhi during 16-18 March, 2018.
- Training program on “Soft Skills and Personality Development for Technical Staff” at ICAR-National Academy of Agriculture Research Management (NAARM), Hyderabad during 15-24 June, 2017.

Administrative Personnel

Shri Ram Sakal Chaurasia attended the Specialized training programme on “Enhancing efficiency and behavioural skills” for Stenographer Grade-III, PA, PS and PPS of ICAR Hqs/Institute (Batch-VI) held at NBSS&LUP, Regional Centre, Kolkata during 5-11 January, 2018.

LIBRARY AND INFORMATION SERVICES

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

Resource Development

The library has total collection of 7579 books and 2655 bound volumes of journals and other reference materials. In addition to these, 38 journals were received on gratis/exchange basis.

Library Automation

The Library is operating in fully automated environment. The various activities of library have been computerized using Web Centric LSEase Library Management Software Package, Version 7.0. The records of books, journals, maps, etc. were entered in the database. Barcoding of books, periodicals and maps for automated circulation is under active process. Online Public Access catalogue is made available for the library users.

Information and Reference Services

The Library continued information and reference services to its users including locating materials, using the Online Public Access Catalogue (OPAC), using computers to access information, and using

basic reference sources. Access to ICAR- Consortium for e-Resources in Agriculture (CeRA) journals on agriculture and allied subjects continued through J-Gate Plus platform. The users of the library extensively used the Consortium for e-Resources in Agriculture (CeRA) to access the full text online journals and e-books. In addition to online access to CeRA, the library is providing Document Delivery Services to various institutions.

Technical Reports and Reprography Services

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

Exchange Services

The Library continued exchange relationship and resource sharing with leading National and International Research Institutes and Development organizations. To keep abreast of the activities of the Bureau, the library sent the NBFGR Annual Report 2016-2017 and other publications to various institutions and organizations including Universities, State Fisheries Departments, FFDA's, Krishi Vigyan Kendras, Entrepreneurs and Fish Farmers.

STAFF ACTIVITIES

New Joining

Scientist		Date of Joining
1	Dr. Anutosh Paria joined as scientist on transfer from ICAR-IIAB, Ranchi	05.06.2017

Administrative		Date of Joining
1	Shri Darvesh Kumar joined as Administrative Officer on transfer from ICAR-IISR, Lucknow.	26.12.2017

Relieving

Administrative		Date of Relieving
1	Shri Abhishek Rana, Administrative Officer was relieved from ICAR-NBFGR Lucknow to join as Sr. Administrative Officer at ICAR-CTCRI, Thiruvananthapuram, Kerala.	24.03.2018
Technical		Date of Relieving
1	Shri Rajool Sanis C.P., Technical Assistant was relieved from ICAR-NBFGR, Lucknow to join as Assistant Professor.	20.01.2018

Promotions

Scientist		Promotion w.e.f.
1	Dr. Achal Singh Sr. Scientist to Principal Scientist	28.09.2015
2	Dr. Satish Kumar Srivastava, Sr. Scientist to Principal Scientist	27.06.2016
3	Dr. T.T. Ajith Kumar, Sr. Scientist to Principal Scientist	12.08.2016
4	Dr. Rajeev Kumar Singh, Sr. Scientist to Principal Scientist	29.10.2016
5	Dr. Sullip Kr. Majhi, Sr. Scientist to Principal Scientist	04.11.2016
6	Dr. Mahender Singh, Sr. Scientist to Principal Scientist	05.11.2016
7	Dr. T. Raja Swaminathan, Sr. Scientist to Principal Scientist	22.11.2016
Technical		Promotion w.e.f.
1	Mrs. Reeta Chaturvedi, Sr. Technical Officer to Assistant Chief Technical Officer	26.12.2016
2	Shri Rama Shankar Sah, Sr. Technical Officer to Assistant Chief Technical Officer	30.08.2017
3	Shri Sanjay Kr. Singh, Technical Officer to Sr. Technical Officer	12.06.2015
4	Shri Gulab Chand, Technical Assistant to Sr. Technical Assistant	01.08.2016

MACP

Administrative		Date of MACP
1	Smt. Kaneez Fatima, 3 rd MACP	30.07.2017

Retirement

Scientist		Date of Retirement
1	Dr. Rehana Abidi, Pr. Scientist	28.07.2017 (Voluntary)

Technical		
1	Shri Anil Kumar Mishra, ACTO	31.05.2017
2	Shri Madan Lal, Sr. T.A	30.06.2017
3	Shri Ved Prakash, STO	31.07.2017
4	Shri Shree Ram, T.A	31.08.2017
5	Shri Pool Chand Jaiswar, T.A.	31.10.2017

Institute Management Committee (IMC)

32 nd meeting of the Institute Management Committee was held on 30.01.2018. The composition of the IMC are as under:		
1	Director ICAR-National Bureau of Fish Genetic Resources, Lko.	Chairman
2	Director of Fisheries Govt. of Uttar Pradesh, Lucknow-226007	Member
3	Director of Fisheries Govt. of Bihar, Patna, Bihar	Member
4	Dr. S. Shyama Professor & Director College of Fisheries, Penangad, Kochi, Kerala	Member
5	Shri Babu Ram Nishad Lucknow, U.P.	Member
6	Shri Manoj Kashyap Shahjahanpur, U.P.	Member
7	Dr. Gopi Krishna Pr. Scientist & Head ICAR-CIBA, Chennai	Member
8	Dr. K.V. Rajendran Pr. Scientist & Head ICAR-CIFE, Mumbai	Member
9	Dr. U.K. Sarkar Pr. Scientist & Head ICAR-CIFRI, Barrackpore	Member
10	Dr. Sunil Archak Pr. Scientist ICAR-NBPGR, New Delhi	Member
11	Dr. P. Pravin ADG (M.Fy.) ICAR, New Delhi	Member
12	AF&AO ICAR-NBFGR	Member
13	Administrative Officer ICAR-NBFGR	Member-Secretary

Staff Position

	Research Management/ Director	Scientist	Administrative	Technical	SSS
Sanctioned	01	41	21	38	20
In position	01	34	20	30	18

DISTINGUISHED VISITORS

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

Shri Ashutosh Tandon, Hon'ble Minister of Technology and Medical Education, Govt. of Uttar Pradesh, Lucknow

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

Shri Upendra Tiwari, Hon'ble Minister for Land and Water Resources (Independent Charge), Govt. of Uttar Pradesh, Lucknow

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

Dr. George John, Ex Advisor DBT, Govt. of India & Ex VC, BAU; New Delhi

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

Dr. A.K. Sahu, Former Principal Scientist, ICAR-CIFA, Bhubaneswar, Odisha

Prof. J.R. Dhanze, Consultant, COE-FAB Project, College of Fisheries, CAU, Lembucherra, Agartala Tripura

Dr. Nirmalendu Saha, Department of Zoology, N-E Hill University, Shillong, Meghalaya

Dr. M.K. Das, Former Principal Scientist, ICAR-CIFRI, Barrackpore, West Bengal

Dr. Sudhir Raizada, ADG (Inland Fisheries), ICAR, New Delhi

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

Ms. Camille Cyncynatus, Director Sales, Pacific Biosciences, South Asia

Dr. Sunita H. Khurana, Director, Institute of Secretariat Training and Management (ISTM), New Delhi

Dr. N. Krishnakumar, Regional Representative, South and Central Asia, Bioversity International, New Delhi

Dr. A.K. Vyas, ADG (HRM), ICAR, New Delhi

Dr. A.S. Ninawe, Advisor, Department of Biotechnology, Ministry of Science and Technology, Govt. of India, New Delhi

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

Dr. Nitin Kaushal, Associate Director – Sustainable Water Management & Wild Rivers, WWF India, New Delhi

Prof. W. Vishwanath, Department of Life Sciences, Manipur University, Imphal

Shri Pawan Kumar, Member Secretary, Uttar Pradesh State Biodiversity Board, Lucknow

Dr. S. K. Singh, Joint Director, Department of Fisheries, Uttar Pradesh

Dr. V. K. Mishra, Regional Head, ICAR-CSSRI, Lucknow

Prof (Retd.) D. Ghosh, G. B. Pant, University of Agriculture & Technology, Pantnagar, Uttarakhand

Dr. Manoj Dixit, Vice Chancellor, Dr. R.M.L. Avadh University, Faizabad

Shri Chandra Prakash Tripathi, Secretary, Irrigation and Water Resources Department, Govt. of Uttar Pradesh, Lucknow

Dr. A. Gopalakrishnan, Director, ICAR-Central Marine Fisheries Research Institute, Kochi, Kerala

Dr. A. K. Singh, Former Director, ICAR-Directorate of Cold Water Fisheries Research, Bhimtal, Uttarakhand

Dr. Mandakini Pradhan, Professor and Head, Department of Maternal and Reproductive Health, Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow, Uttar Pradesh

Dr. S.K. Barik, Director, CSIR-National Botanical Research Institute, Lucknow

Dr. H. Rahman, Regional Representative for South Asia, International Livestock Research Institute (ILRI), New Delhi

Dr. R.K. Singh, Director, ICAR-Indian Veterinary Research Institute, Bareilly, Uttar Pradesh

Dr. Rajesh Bhatia, Former FAO Regional Technical Advisor

Dr. P.A. Rai, Director Bureau of Earth Science Survey, Raipur, Chhattisgarh

Dr. Sunil Khare, Professor of Biochemistry, Dept of Chemistry, Indian Institute of Technology Delhi, New Delhi

Dr. Premlata Singh, Principal Scientist & Head, Div. of Agricultural Extension, ICAR-IARI, New Delhi

Dr. Amarendra Kishore, President, Dharti Foundation, Rohini, Delhi

Prof. K. Larry Hammell, Professor and Associate Dean, Graduate Studies and Research in University of Prince Edward Island, Canada

Dr. A.G. Ponniah, Former Director, ICAR- NBFGR, Lucknow & ICAR-Emeritus Scientist, ICAR-CMFRI, Chennai Centre, Tamil Nadu

Prof. Dr. Ir. Pieter Van, Director, International Centre for Aquaculture Research and Development, University of Aberdeen

Prof. Valerie Jane Smith, Senior Academic, Scottish Oceans Institute, St. Andrews University, Scotland

Dr. Mansour El Matbouli, Professor and Head, Clinical Unit for Fish medicine and Deputy Head, Clinic in University of Veterinary Medicine, Vienna

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

Dr. Parimal Roy, Director ICAR- National Institute of Veterinary Epidemiology and Disease Informatics, Bengaluru, Karnataka

Prof. Iddya Karunasagar, Senior Director (International Relations), Nitte University, Mangalore, Karnataka

Dr. C. V. Mohan, Senior Scientist, Aquaculture, World Fish Center, Penang, Malaysia

Dr. K.K. Vijayan, Director, ICAR-Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu

Dr. T. Ravishankar, Director, ICAR-Central Institute of Fisheries Technology, Kochi, Kerala

Dr. Bangali Babu, Former National Coordinator, National Agriculture Innovation Project, New Delhi

Dr. A.D. Pathak, Director, ICAR-Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh

Dr. U.K. Sarkar, Principal Scientist & Head, ICAR-CIFRI, Barrackpore, West Bengal

Commitment to societal Initiatives of Government of India and ICAR



WORLD SOIL DAY

The ICAR-National Bureau of Fish Genetic Resources, Lucknow celebrated World Soil Day at its main campus on 05.12.2017. Soil health cards were distributed on this occasion among 30 fish farmers of Barabanki district. The soil health card distribution ceremony was graced by Smt. Jai Devi, Member of Legislative Assembly (MLA), Malihabad, Lucknow. Dr. K.K. Lal, Director, ICAR-NBFG, Lucknow welcomed

the guests and explained about overall importance of soil health cards in improving production as well as farmers income & human health. Dr. V.K. Mishra, In-charge, ICAR-CSSRI Regional Station, Lucknow also present in the function and shared his views on proper soil management for sustainable farming and better returns. An interactive meeting with the farmers was also held on the occasion.





Supporting Namami Gange with ranching of 2.0 lakhs Carp Fingerlings in river Ganga

The initiative, one of its kind in India, is aimed for sustainable utilization of Aquatic Biodiversity, which is closely linked to the health of natural rivers systems. Fish is an important component in this system to maintain the equilibrium of environment. ICAR-NBFGR, through this initiative, supports the efforts of Govt. of India and the Govt. of Uttar Pradesh towards the Namami Gange Program.

Rivers of Indo-Gangetic Plains are native abode of the Indian major carps (Catla, Rohu and Mrigal) and other minor carps. Hence, conservation of these fishes in this native range of population is an important National Biodiversity Goal. Through this ICAR-NBFGR has undertaken a large-scale propagation assisted stocking of carps in river Ganga with the use of wild type broodstock. Adhering to the objective

of conservation of natural genetic diversity, the fish fingerlings were produced from the brood stock which was raised and maintained in ICAR-NBFGR farm with the original collection of wild types from the river Ganga, to avoid the risk of genetic mixing. Stocking in the protected areas, gives fingerlings the opportunity to grow to adults and thereby, support future generations of fish population.

Hon'ble Prof. S. P. Singh Baghel Ji, Minister of Livestock, Minor Irrigation and Fishery, Govt. of Uttar Pradesh visited ICAR-NBFGR, Lucknow on 20th December, 2017 at 10.00 AM and flagged off as symbolic inauguration of the institute's initiative of ranching of carp fingerlings in the holy river Ganga, in the presence of Shri Pawan Kumar, Secretary, Uttar Pradesh State Biodiversity Board, Lucknow and Dr. S. K. Singh, Joint Director, Department of Fisheries, Uttar Pradesh.



The staff of ICAR-NBFGR ranched around 2.0 lakhs advanced fingerlings of five carps (Catla, rohu, mrigal, calbasu and bata) varieties in river Ganga. These fingerlings were ranched at Chapra Ghat, Bithoor near Kanpur which is protected as religious heritages. Dr. U. S. Gautam, Director, ICAR-ATARI, Kanpur, also participated in this event of releasing the fingerlings. Such efforts are aimed to support augmenting the natural population of these important carp species and also conserve from decline which can happen due to various anthropogenic activities.



International Yoga Day

The International Yoga Day was celebrated at ICAR-National Bureau of Fish Genetic Resources, Lucknow on 21.06.2017. Dr. Kuldeep K. Lal, Director addressed the participants and narrated about importance of yoga in betterment of performance in all walk of life. The common yoga protocol released

by Ayush Ministry, Govt. of India was followed by the participants from 6.30 to 8.00 AM at administrative block of the institute. The function was started with prayer and ended with *sankalp*. The similar programme was also organised at PMFGR Division of ICAR-NBFGR, Kochi.



Swachh Bharat Activities

ICAR-National Bureau of Fish Genetic Resources, Lucknow has been promoting Swachh Bharat Abhiyan mission to ensure a clean and green campus and contribute in making India more beautiful. The institute has been actively observing and promoting Swachh Bharat Mission since its inception. In the reporting year, other than the routine monthly activities, the institute observed 2 Swachhta Pakhwadas to create awareness on the importance of environment and Swachh Bharat mission. The summary of those programs are as follows:

1. A Swachhta Pakwada was organised by ICAR-NBFGR from May 16 - May 31, 2017. During this period, 14 different cleaning and awareness

activities were undertaken by the staff and research scholars of the institute like mass swachhta pledge, “say no to plastic” pledge, cleaning of office buildings, campus, farm section, guest house etc. To generate awareness on the importance of garbage utilization, a lecture on “composting” and “clean and safe environment” was held.

2. A special “Swachhta Hi Seva” cleanliness program was organised by ICAR-NBFGR from September 15 to October 2, 2017. Sixteen cleaning related programmes and activities were carried out including a mass sapling plantation program of mango, lemon along with flowering plants such as Chinese rose and manokammna. Cleaning activities were undertaken at all the laboratories of the institute, parking and boundary premises.





Digital India

Cashless transactions

The ICAR-NBFGR, Lucknow continued implementing the digital mode in its financial transactions. During the year under report, out of total 5341 transactions (*i.e.* 97.64%) amounting to Rs. 71.14 crores, were cashless transactions.

Government E-Market (GeM)

The Institute is implementing Government of India's policy of e-procurement. During the year under report, total 117 different kind of items amounting to

Rs. 43.95 lakhs were processed through GEM (Govt. e-marketing). All the tenders were implemented through e-tendering process.

GO Green

The institute has a functional roof top Grid Connected Rooftop Solar Power System with installed capacity of 250 KWp. The system with 6 three phase inverters of 50 KVA (4 nos.), 30 kVA (1 nos.) and 20 kVA (1 nos.) is contributing towards production of green energy. The solar power system was commissioned under the RESCO Model of implementation.

Ganga Aquarium: Public Awareness on 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 46 aquaria that display more than 100 fish species of both fresh and marine water. The live aesthetic displays serves as an avenue to enhance awareness towards fish diversity and its conservation among public. Recently the aquarium has thrust to display indigenous fish

species. Some of the rare attractions are chitala, butter catfish, sun catfish and redlined torpedo from Western Ghats and pengba from Chindwin basin in Manipur. Among marines, the aquarium has saltwater Crab (*Scylla sp.*) and other marine forms, like scorpion fish, clownfish, damsels, sea anemones and starfish. Public also enjoy watching the freshwater fishes like arowana, flower horn, alligator gar, ghost fish etc.





In the reporting year, 15,766 visitors including both children and adults visited the facility.

LIST OF PERSONNEL

Research Management

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

Technical Staff

1.	Dr. Rajesh Dayal		Chief Technical Officer
2.	Dr. S. M. Srivastava	-	Chief Technical Officer
3.	Dr. A. K. Yadav		Chief Technical Officer
4.	Shri Amar Pal	-	Chief Technical Officer
5.	Shri S. P. Singh	-	Assistant Chief Technical Officer
6.	Shri Babu Ram	-	Assistant Chief Technical Officer
7.	Dr. Ajay Kumar Singh	-	Assistant Chief Technical Officer
8.	Mrs. Reeta Chaturvedi	-	Assistant Chief Technical Officer
9.	Shri Ramashankar Sah	-	Assistant Chief Technical Officer
10.	Shri Subhash Chandra	-	Senior Technical Officer
11.	Dr. Akhilesh Kr. Mishra	-	Senior Technical Officer
12.	Dr. (Mrs.) Ranjana Srivastava	-	Senior Technical Officer
13.	Shri Ravi Kumar	-	Senior Technical Officer
14.	Shri Amit Singh Bisht	-	Senior Technical Officer
15.	Shri Prem Chandra	-	Senior Technical Officer
16.	Shri Satyavir Chaudhary	-	Senior Technical Officer
17.	Shri S. K. Singh	-	Senior Technical Officer
18.	Shri R.K. Shukla	-	Technical Officer
19.	Shri B. N. Pathak	-	Technical Officer
20.	Shri Samarjit Singh	-	Technical Officer
21.	Shri Om Prakash	-	Technical Officer
22.	Shri Rajesh Kumar	-	Senior Technical Assistant
23.	Shri Om Prakash-II	-	Senior Technical Assistant
24.	Dr. Vikash Sahu	-	Senior Technical Assistant
25.	Shri Vijay Kumar Singh	-	Senior Technical Assistant
26.	Shri Raj Bahadur	-	Senior Technical Assistant
27.	Shri Gulab Chandra	-	Senior Technical Assistant
28.	Shri B. K Rao	-	Technical Assistant
29.	Shri K. K Singh	-	Technical Assistant
30.	Shri Ram Bharose	-	Technical Assistant

Administrative Staff

1.	Shri Darvesh Kumar	-	Administrative Officer
2.	Shri Ravi Bhadra		Assistant Finance & Accounts Officer
3.	Shri Navin Kumar		Assistant Administrative Officer
4.	Shri Tej Singh Seepal	-	Assistant Administrative Officer
5.	Smt. Mamta Chakraborty	-	Private Secretary
6.	Shri Ram Sakal	-	Personal Assistant
7.	Shri Sandeep	-	Jr. Stenographer
8.	Smt. Kaneez Fatima	-	Assistant
9.	Shri Swapan Debnath	-	Assistant
10.	Shri S. N. Srivastava	-	Assistant

11.	Shri P. K. Awasthi	-	Assistant
12.	Smt. Sunita Kumari	-	Assistant
13.	Shri Sajivan Lal	-	Assistant
14.	Shri Shreelal Prasad	-	Senior Clerk
15.	Shri Vinay Kumar Srivastava	-	Senior Clerk
16.	Shri Santosh Kumar Singh	-	Senior Clerk
17.	Shri Ram Baran		Jr. Clerk
18.	Shri P.C. Verma	-	Jr. Clerk
19.	Shri Rajan Kr. Malhotra	-	Jr. Clerk
20.	Shri Vikrant Gupta	-	Jr. Clerk
Supporting Staff			
1.	Shri Laxman Prasad	-	Skilled Support Staff
2.	Shri Dukhi Shyam Deo	-	Skilled Support Staff
3.	Shri Anil Kumar	-	Skilled Support Staff
4.	Shri Indrajit Singh	-	Skilled Support Staff
5.	Shri Prahalad Kumar	-	Skilled Support Staff
6.	Shri Chhote Lal	-	Skilled Support Staff
7.	Shri Ashok Kumar	-	Skilled Support Staff
8.	Shri Dinesh Kumar	-	Skilled Support Staff
9.	Shri Balram Babu Bajpai	-	Skilled Support Staff
10.	Shri Ashok Kumar Awasthi	-	Skilled Support Staff
11.	Shri Sidhnath		Skilled Support Staff
12.	Shri Ram Lakhan	-	Skilled Support Staff
13.	Shri Sunit Kumar	-	Skilled Support Staff
14.	Shri Jai Narain Tiwari	-	Skilled Support Staff
15.	Shri Anwar	-	Skilled Support Staff
16.	Shri Sanjay Kumar	-	Skilled Support Staff
17.	Smt. Seema Devi	-	Skilled Support Staff
18.	Smt. Raj Kumari		Skilled Support Staff

Human Resource Development Initiatives

The HRD cell of the ICAR-NBFGR, Lucknow actively pursues the initiative of ICAR on human resource management and facilitate its staff for attending various training programmes for capacity building and also lent support in organizing training programmes in the institute.

A. Physical targets and achievements

S. No.	Category	Total No. of Employees	No. of trainings planned for year 2017-18 as per ATP	No. of employees undergone training during April-Sept 2017	No. of employees undergone training during Oct 2017-March 2018	Total number of employees undergone traing during April 2017-March 2018	% realization of trainings planned during 2017-18
1	2	3	4	5	6	7 (5 + 6)	8
1	Scientist	35	14	9	9	18	128.5
2	Technical	37	10	11	8	19	190
3	Administrative & Finance	20	14	2	1	3	21.42
4	SSS	18	18	0	18	18	100

B. Financial targets and achievements (All employees)

S. No.	RE for HRD 2017-18			Actual Expenditure up to 31st March, 2018 for HRD			% Utilisation
	Plan	Non-plan	Total	Plan	Non-plan	Total	
	(Lakh Rs.)	(Lakh Rs.)	(Lakh Rs.)	(Lakh Rs.)	(Lakh Rs.)	(Lakh Rs.)	2016-17
1	2	3	4 (2+3)	5	6	Col. 5+6=7	(Col 7*100/Col.4)=8
1	5.59	0	5.59	5.57	0	5.57	99.57

C. Number of trainings organized for various categories of ICAR-NBFGR employees including winter/summer schools and short trainings

S. No.	Category	No. of trainings organized during April 2017 to September 2017	No. of trainings organized during October 2017 to March 2018	Total number of trainings organized during April 2017- March 2018	No. of participants (Only ICAR employees)		
					Organizing Institute	Other ICAR Institutes	Total
1	2	3	4	Col. 3+4=5	6	7	6+7=8
1	Scientist		1	1	35	9	44
2	Technical		1	1	30	0	30
3	Administrative & Finance		1	1	20	0	20
4	SSS		1	1	18	0	18



Back cover

Large-scale ranching program by ICAR-NBFGR, Lucknow for *in situ* conservation supports “*Namami Gange*” (detailed report page nos. 107-108).
Slogan © NBFGR

नमामि गंगे

मत्स्य संरक्षण का अभियान, देशज मछली पर अभिमान



भारत
ICAR



भा.क.अनु.प.-राष्ट्रीय मत्स्य आनुवंशिक संसाधन ब्यूरो

ICAR-National Bureau of Fish Genetic Resources

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