

ANNUAL REPORT

2016-17



ICAR-Directorate of Coldwater Fisheries Research
Bhimtal, Uttarakhand, India



Front Cover:

Theme : Breeding and production cycle of rainbow trout
(*Oncorhynchus mykiss*)



Back Cover:

Theme : ICAR-DCFR Extension activities to promote
rainbow trout farming

ANNUAL REPORT

2016-2017



ICAR-Directorate of Coldwater Fisheries Research
Bhimtal - 263136, Nainital
Uttarakhand, India



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ICAR-DCFR Annual Report 2016-2017

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Preface



During the year 2016-2017, ICAR-DCFR has made steadfast progress in its research and development efforts to sustainably manage coldwater fisheries resources and enhance farmed fish production in the Indian uplands through scientific innovations, technological refinements/developments and knowledge sharing in varying agro-ecologies, using available natural resources and farmers-centric approaches. Pursuing our endeavours, the Directorate has been working for resource assessment and development of GIS based aquaculture site suitability maps covering few districts of Himachal Pradesh and Jammu & Kashmir; fish biodiversity maps for major river drainages in western Himalayan region; assessment of habitat status and fish diversity in selected river drainages and lakes. Contributions towards aquaculture development includes captive breeding and larval rearing of *Neolissochilus hexagonolepis*, *Naziritor chelynoides*, *Barilius bendelisis*, *Puntius ticto* in controlled glass aquaria conditions; development of zero water exchange hatchery for coldwater fishes, especially minor carp and rainbow trout; elucidation of the impact of temperature on captive gonadal maturation of golden mahseer; characterization of aromatase encoding genes in golden mahseer; expression profiling of kisspeptin1 in the BPG axis of golden mahseer; detection of appetite markers in golden mahseer, identification of optimum protein requirement of snow trout; and nutrient profiling of indigenous fishes were carried out. Further, a comprehensive database of pathogenic bacteria in rainbow trout farms was developed through systematic surveillance of coldwater fish diseases and pathogens; three bacterial isolates having algicidal activity against *Microcystis aeruginosa* were identified. Significant research output in genetics and biotechnology includes the development and validation of fish viral peptide based nano delivery system; development of an inexpensive and robust RACE methodology; characterization of 26 growth and maturation related gene markers in snow trout; hi-throughput profiling of intestinal bacterial community in snow trout; genetic characterization of chocolate mahseer populations; identification of potential gene markers for thermal tolerance in snow trout; transcriptome database of immune response in golden mahseer to counter bacterial infection; and expression of recombinant Mx protein and transfection studies using its promoter for potential reporter gene assays.

In order to promote mahseer based recreational fisheries in north-east India, scientists organized a National Interactive Meet with stakeholders at Assam. The Directorate also organized various other trainings, field demonstrations, farmer advisories and exhibitions to disseminate scientific knowledge on various aspects of coldwater fisheries and aquaculture to farmers, fisheries officers and other concerned stakeholders. Awareness-cum-ranching programmes were organized to revive the natural population of golden mahseer. Under tribal sub-plan activity, rainbow trout farming is being promoted as a remunerative livelihood option by provision of infrastructure and inputs for adopted tribal farmers. Under NEH activity, two chocolate mahseer hatcheries were established each in Meghalaya and Nagaland. Likewise, a portable carp hatchery and trout feed extruder were installed in Arunachal Pradesh. Introduction of rainbow trout farming in Nagaland has been initiated for the first time.

The Directorate also strengthened linkages with other ICAR research institutes, fisheries departments of hill states, agricultural universities, non-governmental organisations and central agencies such as National Fisheries Development Board and Department of Biotechnology for promoting research, extension and capacity building.

The ICAR-DCFR has received resolute support from ICAR to pursue its various activities. In this regards, I am deeply indebted to Honourable Secretary, DARE and Director General, ICAR, Dr. T. Mohapatra for his visionary guidance. I am also grateful to the Deputy Director General (Fisheries), Dr. J.K. Jena and the Assistant Director General (Inland Fisheries), Dr. S. Raizada for their constant motivation and direction in the planning and execution of the research, extension and other developmental activities of this Directorate. I acknowledge and appreciate the combined contribution of all the scientists and staff members of the Directorate for the successful progress made during the year. I also extend a special thanks to the members of the editorial committee for their meticulous effort in compiling and bringing out the Annual Report 2016-2017.



(A.K. Singh)
Director

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EXECUTIVE SUMMARY

The primary mandate of ICAR-Directorate of Coldwater Fisheries Research is to sustainably manage coldwater fisheries resources in Indian uplands and substantially augment hill aquaculture production through comprehensive research initiatives, technological interventions and knowledge transfer mechanisms. In this milieu, the achievements and various activities of the Directorate during the reporting period 2016-17 are briefed below:

Resource assessment and management

- Assessment of ichthyofaunal diversity and habitat status of the river Western Ramganga indicated that the species assemblage structure has a longitudinal pattern of distribution along the stream gradient, with increase in species diversity, richness and dominance as the altitude decreases.
- Under the eco-biological study of selected Himalayan mountain lakes, a new species of copepod of the genus *Hesperodiaptomus*, having high concentration of carotenoids was discovered from lake Maheshwar kund situated in Munshiyaari, Uttarakhand.
- GIS based aquaculture site suitability maps have been generated for Kullu and Kinnaur districts of Himachal Pradesh, and Leh and Kargil districts of Jammu & Kashmir, based on physicochemical parameters of water, infrastructure facilities and input availability.
- Similarly, GIS based fish biodiversity maps for major river drainages such as Indus, Sutlej, Zaskar, Beas, Chenab and Shyok in the western Himalayan region were prepared using primary and secondary data on ichthyofaunal diversity.

- Habitat ecology, population status and inter-specific variance of *Schizothorax* spp. in selected snow fed tributaries of Kameng drainage in Arunachal Pradesh are being studied. Preliminary analysis suggests habitat suitability for the abundance of snow trout.
- Diversity, altitudinal distribution and migration routes of endemic fishes in selected Himalayan drainages are being investigated, documented and digitized under the National Mission for Sustaining the Himalayan Ecosystem. Further, pilot carp and trout farming trials are being carried out in the identified hotspots of climate change.
- Coldwater fish germplasm repository centres have been established at Bhimtal and Champawat, with nearly 3400 specimens of indigenous coldwater fishes collected from different upper reach tributaries of river Ganga. For stock enhancement and conservation, breeding of *Garra gotyla* was successfully attempted.
- The buoyancy changing capacity of *Microcystis aeruginosa* which apparently allows them to migrate to different depths and its notable abundance in winter was observed in Naukuchiyatal lake ecosystem.

Aquaculture oriented research and development

- Indigenous fishes of food value have been targeted for complete domestication under the prioritized programme on species diversification for hill aquaculture. Captive rearing, induced breeding and larval rearing of *Labeo pangusia* has been achieved. Reproductive performance, breeding biology and ontogenic development

of *Bangana devdevi* and *Osteobrama belangeri* is being evaluated in field conditions. General and reproductive biological observations have been made in wild collected *Raiamas bola*. Further, captive breeding and larval rearing has been attempted.

- For the first time, observation of reproductive behaviour, captive breeding, larval rearing and seed production of *Neolissochilus hexagonolepis*, *Barilius bendelisis* and *Naziritor chelynoides* has been achieved in controlled glass aquaria conditions.
- A prototype zero water exchange glass aquarium hatchery with sand-gravel bed filtration system was successfully developed and used for egg incubation and larval rearing of minor carp (*Labeo dyocheilus*) and rainbow trout.
- The feasibility of composite carp farming at high altitudes in polyhouse covered polylined ponds/tanks is being assessed through field experimentation. Preliminary observation indicated better growth of grass carp and improved common carp in this culture system.
- Effect of temperature on the gonadal maturation of golden mahseer has been experimentally elucidated in captivity. Higher rearing temperature resulted in elevated concentrations of estradiol and progesterone in females, however with concurrent decrease in the plasma levels of cortisol and total immunoglobulins. Further, for molecular assessment of captive maturation in golden mahseer, the complete coding sequence of two isoforms of aromatase brain type (*cyp19b*) has been characterized.
- The gene expression profile of kisspeptin1 and its receptor in the brain-pituitary-gonad axis of wild collected adult male and female golden mahseer during different gonadal developmental stages has been explicated.
- Goblet cell dynamicity in digestive tract, zymogen granule dynamicity in pancreas and supra-nuclear vesicles in hindgut were microscopically ascertained to be histological markers of appetite

in early life stages of golden mahseer.

- The lipid metabolism of snow trout (*Schizothorax richardsonii*) was found to dynamically respond to feed availability and deprivation, in terms of whole body lipid content, plasma triglycerides, viscerosomatic index and volume of hepatocytes.
- Based on growth response to graded levels of dietary protein, the optimum dietary protein requirement of snow trout was found to be apparently high (45-50%). However, poor feed utilization (FCR of 7-15) could be a major reason for the slow growth of this species.
- A robust and inexpensive RACE methodology has been developed for full length characterization of cDNA, and 26 partial or complete nucleotide sequences of markers related to digestion, metabolism, growth and maturation of snow trout were obtained.
- Comparative analysis of the intestinal bacterial composition, abundance and dynamics in captive and wild snow trout revealed a decrease in bacterial diversity with the transition from wild to captivity. *Cetobacterium somerae* was the most abundant species.
- Comparative analysis of extruded and pelleted rainbow trout starter feed indicated that the method of feed preparation and pellet integrity has a direct relevance to hatchery management, in terms of survival and water quality.
- Based on the estimated nutritional quality of selected endemic fish species, *Setipinna phasa*, *Semiplotus semiplotus* and *Barilius bendelisis* showed more than 100% potential contribution of fatty acids and minerals to recommended daily allowance.
- Seed production of important coldwater fishes such as improved Hungarian common carp (7.29 lakh fry), golden mahseer (65,000 fry), rainbow trout (56,000 fry), snow trout (38,000 fry) and ornamental fishes was carried out. The revenue generated from the sale of carp, mahseer and ornamental fish seed amounted to 2.74 lakh rupees.

Disease surveillance and health management

- Under the National Surveillance Programme on Aquatic Animal Diseases, 82 rainbow trout and carp farms/hatcheries from 4 districts in Uttarakhand and 2 districts in Himachal Pradesh were surveyed for the presence of coldwater fish diseases and samples collected from infected fish were screened for viral, bacterial, fungal and parasitic pathogens.
- A comprehensive database of pathogenic bacteria, their occurrence, seasonal distribution, prevalence in rainbow trout and sensitivity/resistance property of isolates to commercial antibiotics has been developed for selected trout farms in the Indian Himalayan region.
- The complete coding region of Mx gene and Mx promoter of snow trout has been identified, cloned in expression vector and used to develop plasmid constructs for transfection and reporter gene assay. Other interferon stimulated genes such as PKR and IRF3 of snow trout have also been identified and cloned.
- Three non-pathogenic bacterial isolates *Pantoea eucrina*, *Pseudomonas oryzihabitans* and *Fictibacillus nanhaiensis* were found to have significant algicidal activity against the harmful bloom forming *Microcystis aeruginosa*, albeit through different process.
- Under the All India Network Project on fish health, primary data on the use of aqua drugs and therapeutics have been collected from 51 fish farms in Manipur and Nagaland. Table salt, lime and potassium permanganate were found to be the most commonly used agents for fish health management in hill aquaculture practices.

Molecular genetics and biotechnological contribution

- Members of the suppressor of cytokine signaling family, SOCS-1a and SOCS-3a were identified as potential gene markers for thermal stress tolerance in *S. richardsonii*.
- Haplotype diversity, nucleotide diversity, number of polymorphic sites and genetic divergence has been studied in geographically distinct chocolate mahseer populations using mitochondrial genes and SSR markers.
- Transcriptome analysis of the response of golden mahseer to *Aeromonas hydrophila* infection indicated that transcripts associated with the complement system, antimicrobial peptides, immune responsive acute phase proteins, and other stress-related proteins trigger the adaptive mechanism to counter bacterial infection.
- Three peptide nano systems were designed from fish viral proteins, synthesized and purified. Further, the cargo carrying capacity of one of the cell penetrating peptides has been successfully validated *in vitro* using plasmid DNA containing GFP gene.

Important events, extension activities, trainings and other developments

- A two days national interactive meet of scientists and stakeholders on 'Mahseer in recreational fisheries and eco-tourism in north-east India' was organized by ICAR-DCFR at Jasingfaa Aqua Tourism Resort, Nagaon, Assam during 1-2 October 2016.
- Practical demonstrations of rainbow trout and carp culture and breeding; awareness programmes on fish health management; farmer-scientist interaction meets and farm input distribution programmes were routinely organized at ICAR-DCFR field centre, Champawat and in the villages involved in hill aquaculture practices.
- Farm specific advisories and technical support were provided to rainbow trout and carp farmers of Uttarakhand, Sikkim and Himachal Pradesh, including those from the villages adopted under the 'Mera Gaon Mera Gaurav' programme.
- To rehabilitate the golden mahseer population in their natural habitats, hatchery reared

mahseer fingerlings were released at the confluence of the rivers Saryu and Mahakali at Pancheshwar, and in Bhimtal lake, through ranching programmes.

- Under the Tribal Sub-Plan programme, rainbow trout farming is being promoted as a livelihood option in disadvantaged areas of Leh in Jammu & Kashmir and Munshyari in Uttarakhand through awareness cum training programmes; establishment of ova hatching facilities; construction of raceways; and seed distribution for adopted tribal farmers. To support the developmental activities, field experimentation were carried out to optimize the conditions for prolonged transportation of rainbow trout seed. Pilot studies was also conducted to promote small-scale farming of rainbow trout in FRP tanks in remote tribal areas with minimum use of water.
- Under North East Hill activities, two chocolate mahseer hatchery units were established at Ganol Apal, West Garo Hills, Meghalaya and Suteplenden, Mokokchung district, Nagaland, to promote artificial propagation and conservation of this important endemic species. Further to meet the demand of seed and feed, a portable carp hatchery has been installed at Ziro valley and trout feed extruder/ drier has been installed in the Nyukmadung farm campus of ICAR-NRC on Yak, Dirang, Arunachal Pradesh. For the first time, initiatives have been taken to introduce rainbow trout culture in Nagaland. Collaborative research programmes are also undertaken to explore the

important coldwater fish fauna that inhabits selected Himalayan drainages in north-east.

- The research and development activities of the Directorate were exhibited and disseminated to farmers and other stakeholders at twelve different conferences, seminars and kisan melas organized across the country.
- Several groups of farmers and school/college students visited the experimental facilities of the Directorate at Bhimtal and Champawat, and interacted with the scientists.
- Two training programmes on 'Breeding and hatchery management of mahseer' and 'Hill fish farming for the upliftment of rural economy in north-east region' were conducted for state fisheries department officials at Bhimtal, Uttarakhand and Aizawl, Mizoram.
- Under the capacity building initiative, the scientific, technical and administrative staffs of the Directorate were encouraged to attend specialized training programmes. At the same time, several student research projects are also being supervised and carried out.
- The scientific cadre strength of the Directorate was further bolstered by the joining of Dr. Raghvendra Singh, Mr. Kishor Kunal, Mr. R.A.H. Bhat and Mr. P.A. Ghanie.
- During the reporting period, the research activities of the Directorate resulted in 30 peer-reviewed publications in reputed international and national journals.

INTRODUCTION

2.1. Brief history

The Indian Council of Agricultural Research established the National Research Centre on Coldwater Fisheries (NRCCWF) on 24th September 1987, during the seventh five year plan, to address the research and development needs of the coldwater fisheries sector. Since its inception, the centre has made substantial contributions in the assessment of coldwater fishery resources and in the development of breeding and rearing technologies for the culture of important exotic and indigenous coldwater fish species in the hilly expanse of the country, albeit the constraints in terms of manpower and infrastructure.



ICAR-DCFR, Bhimtal

Considering the expanding activities of NRCCWF and the prospects of coldwater aquaculture and fisheries in different Himalayan states, the research centre was upgraded to ICAR-Directorate of Coldwater Fisheries Research (DCFR) during the eleventh five year plan. Since then, the Directorate has made commendable efforts to develop location and situation specific aquaculture technologies for all the Himalayan states extending from Jammu & Kashmir to Arunachal Pradesh

and to harness the available fishery resources in a sustainable manner.

Over the past 29 years, the Directorate has emerged as the certified (ISO 9001:2015) nodal facility in the country to carry out research investigations focused on endemic coldwater fish species, priced exotic trouts (rainbow and brown trout) and carps (Chinese and common carp). The Directorate is evolving continuously to address new challenges in the coldwater fisheries sector and it is striving towards sustainable enhancement of fish production and fish farmers income in Indian uplands.

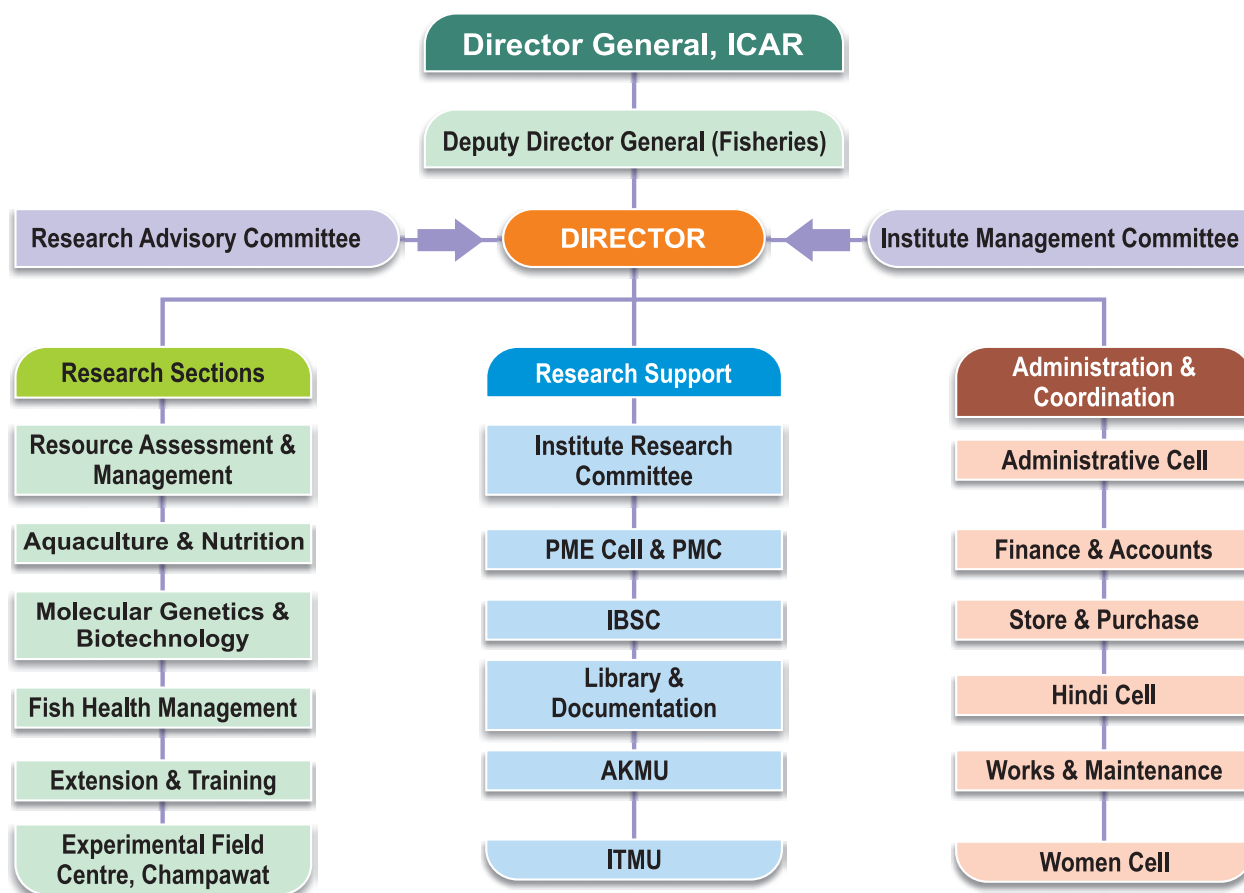
2.2. Location

The headquarters of ICAR-DCFR is located at Bhimtal (29°19'52.647"N 79°33'18.083"E), Nainital district, Uttarakhand, at an altitude of 1470 m above msl. The nearest railway station is Kathgodam, 22 km from Bhimtal and 278 km from Delhi. The nearest major airport is Indira Gandhi International Airport, New Delhi. At present, a small airport is also in operation at Pantnagar. The experimental field centre of the Directorate is at Chirapani in Champawat district (29°17'55.537"N 80°6'8.915"E) of Uttarakhand, which is about 150 km from Bhimtal.

2.3. Mandate

- To conduct basic, strategic and applied research in coldwater fisheries and aquaculture.
- To act as repository of hill fisheries resources.
- Human resource development through training, education and extension.

2.4. Organizational set-up



2.5. Management

As mandated by the Indian Council of Agricultural Research, a high powered Research Advisory Committee (RAC) guides the Directorate on thrust areas of research and on new scientific initiatives. The RAC also evaluates and monitors the progress of research activities carried out in the Directorate. Similarly, the Institute Management Committee (IMC) supervises the various administrative and financial aspects of the Directorate, under the chairmanship of the Director. A number of other internal committees such as Institute Research Committee (IRC), Project Monitoring and Evaluation Committee and Institute Joint Staff Council (IJSC) are in place for decentralized management.

2.6. Infrastructure

Building and farm

The Directorate is functioning from its main building complex situated at Industrial area, Bhimtal. The main complex has several facilities such as sectional laboratories, library, AKMU cell, refurbished aquarium, wet labs, flow-through raceways, hatchery, guest house, committee rooms and auditorium. A mahseer seed production unit is also operational at a separate site in Bhimtal. Moreover, the Directorate has an experimental fish farm facility at Chhirapani, Champawat, Uttarakhand. The field centre has trout hatchery, cemented nursery and grow-out raceways with water recirculation system, ponds, tanks for conducting experiments, check dam, reservoir, laboratories, meeting hall, staff quarters and guest house.



ICAR-DCFR main building and farm complex at Bhimtal



Renovated aquarium complex at ICAR-DCFR, Bhimtal

Laboratory facilities

The Directorate has well equipped laboratories to support research on molecular genetics, biotechnology, diagnostic virology, bacteriology, environmental fish biology, nutrition and geo-informatics. In addition, new laboratories have been established to support research on molecular biochemistry, nutritional physiology and diagnostic mycology. The wet laboratory facilities have also

been strengthened by the addition of flow through experimental units that can facilitate the conduct of growth trials and physiological experiments in coldwater fishes. One pilot-scale feed mill is also installed in the main campus of the Directorate to meet the basic requirement of fish feed in the experimental farm.



Newly established laboratories (Left: Nutritional Physiology & Right: Fish Parasitology and Mycology)

2.7. Support services

Prioritization Monitoring and Evaluation cell

A separate unit called the Prioritization Monitoring and Evaluation cell monitors the implementation and progress of research projects undertaken by the Directorate. This cell organizes the annual meeting of Institute Research Committee (IRC) to evaluate the progress made in each research project and approve the work programme for the following year. The new proposals are also approved by the IRC after thorough evaluation of the objectives, practical utility, manpower and financial involvement. The PME cell is responsible for maintaining the records of project reports through RPP system and for dealing with all the associated technical matters. The cell also keeps a record of publications, training programmes, deputation and participation of scientists in seminars, symposia, workshop and conferences.

Agricultural Knowledge Management Unit

The Agricultural Knowledge Management Unit (AKMU) of this Directorate provides the facilities for internet access (BSNL), scanning and printing to all scientists and other staff members. It also serves as network administrator and monitors the LAN connectivity of around 50 computers at this Directorate. In AKMU cell, desktop computer and internet facilities are also available for research scholars and students working under various project/programmes. Internet facilities at the experimental field centre, Champawat is provided through BSNL.

The website of the Directorate (<http://www.dcfcr.res.in>) has been modified as per Guidelines for

Indian Government Website (GIGW) and certified for Standardization Test Quality Certification (STQC). The website is also being regularly updated as per the ICAR guidelines, under the AGROWEB project. The site presents information about the Directorate's manpower, mandate, research projects, major achievements, technology generated and consultancy services. Further, the conduct of training programmes, seminars, symposia, recruitments and tender notices are being notified in the website. The Directorate's website is also linked to the website of Indian Council of Agricultural Research (<http://www.icar.org>). Electronic mail and messaging solutions (mail server) are also maintained at this Directorate for secure communication via webmail.

Library and documentation unit

The library and documentation unit of the Directorate acts as a repository of literature and information. It provides services to scientists, staff members, research scholars, students and other individuals from neighboring organizations interested in scientific literature on coldwater fisheries and allied subjects. All scientific books have been catalogued with barcoding. The library also provides the facility to access free online publications and articles of many international and national journals through www.cera.jccc.in. The library maintains active reprography services by producing departmental publications and supplying required photocopies to the scientists and research scholars. Recently, an *inventory of e-journals* containing more than 35,000 soft copies of important fisheries research articles has been developed. The documentation section is entrusted with the responsibility of publishing



AKMU facility of ICAR-DCFR



Library

scientific bulletins, brochures, pamphlets, annual report and newsletters. The library maintains exchange relationship with several other research organizations. The annual reports, special publications and technical bulletins published from time to time are being mailed to about 250 organizations, institutions, fishery agencies, etc.

Institute Technology Management Unit

The Institute Technology Management Unit has been constituted under the chairmanship of Director, for dealing with patents and other intellectual property rights developed at the Directorate. It is also responsible for safe transfer of technologies and for providing information about ICAR guidelines on IPR issues. Training and guidance are provided for concerned scientists with respect to IPR issues. The ITMU cell observes World Intellectual Property day on 26th April every year by organizing a special workshop.

2.8. Staff strength (as on 31.03.2017)

Category	Sanctioned	Filled	Vacant
Director (RMP)	1	1	-
Scientific	30	28	2
Technical	14	12	2
Administrative	13	12	1
Supporting	15	11	4
Total	73	64	9

2.9. Financial statement

(Rupees in lakh)

Major Head of Account	Approved R.E. 2016-17	Actual Expenditure 2016-17
Non-Plan	647.00	619.37
Plan	515.50	513.56

Budget statement for the year 2016-17

(Rupees in lakh)

Head of Account	Budget (R.E.)		Expenditure	
	Plan	Non-Plan	Plan	Non-Plan
Establishment charges incl. Pension	0	600.00	0	572.92
Travelling allowance	15.00	1.00	14.99	1.00
Research and operational expense	125.00	14.00	124.99	14.00
Administrative expense	135.00	24.00	134.99	23.88
HRD	2.50	0	2.48	0
Building	40.00	0	40.00	0
Equipment	50.00	2.00	49.08	1.59
Information technology	12.00	0	11.83	0
Library	40.00	3.00	40.00	2.98
Furniture and fixture	20.00	0	19.49	0
Miscellaneous expenses	2.50	3.00	2.42	3.00
NEH component	55.00	0	54.82	0
TSP component	18.50	0	18.47	0
Total	515.50	647.00	513.56	619.37

RESEARCH ACHIEVEMENTS

3.1. Resource assessment and management

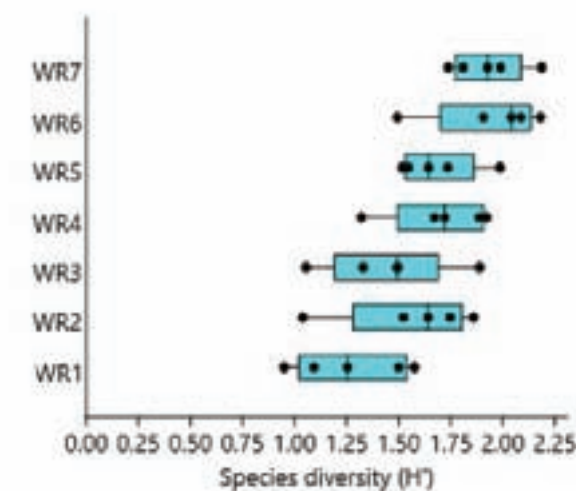
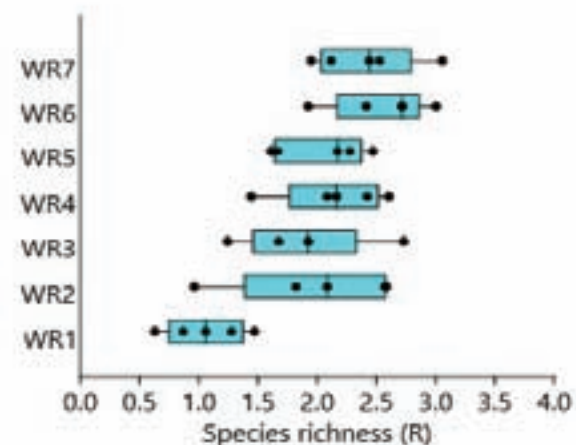
To enable sustainable management and utilization of the distinct class of fishes inhabiting the extremely diverse coldwater ecosystems (streams, rivers and lakes), the Directorate is continuing its efforts to scientifically explore fish diversity, perform ecosystem assessment and map the aquatic resources in selected Himalayan drainages.

3.1.1. Ichthyofaunal diversity, habitat assessment and molecular characterization of important species from selected Himalayan drainages

The natural fish populations of several Indian rivers including hill streams are declining both quantitatively and qualitatively due to various anthropogenic reasons. As habitat is considered to be a tangible resource that can be measured and modeled considering future changes, habitat assessment of rivers/streams in relation to the ichthyofaunal diversity provides a tool for determining tolerable and quality habitat conditions for inherent fish species. In the present investigation, the river western Ramganga (one of the principal rivers from the Shiwaliks of Western Himalayas and a major tributary of River Ganges) was selected for the study and attempts were made to assess the qualitative and quantitative diversity of available fish fauna on reach scale for the habitat/health assessment of the river based on environmental indices. It was also envisaged to study different factors responsible for the dispersal of species and important limiting factors for the distribution of species. Quantitative data on fish species were collected from seven locations (WR1-WR7) at an altitudinal range of 1026 to 755 m above MSL in the mountain stretch of the river. Apart from this, different abiotic parameters including

physical characters of the surveyed streams were also recorded.

Fishes belonging to 14 genus and 25 species were collected and identified. Trends in species richness and diversity were assessed based on Margalef (R) and Shannon-Weiner (H') index, respectively. The 'R' ranged from 1.79-2.79 while H' varied from 1.75 to 2.47. Both the variables increased with decreasing altitude. However, the evenness



Increasing trends in species richness and diversity with decreasing altitudes

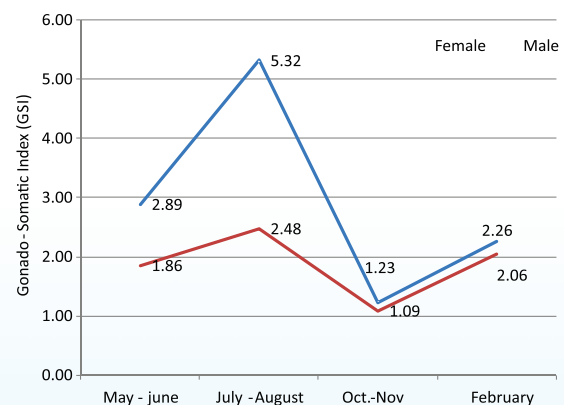


nMDS ordination plot of different sampling sites from Bray-Curtis similarity matrix of species abundance

showed an opposite trend which might be due to the proportional abundance of few dominance species in the upstream region. The k -dominance curve which is the ranked abundances, expressed as percentage of the total abundance of all species plotted against the relevant species rank clearly showed that the downstream (WR4-7) have lower evenness and higher dominance than upstream zone (WR1-3). This indicated that the evenness decreased with decreasing altitudes. Moreover, to study the fish distribution/occurrence at different sampling locations and find the species assemblage structure at different habitat, multivariate analysis using hierarchical clustering method and non-metric multidimensional scaling (nMDS) was performed based on similarity matrix using Bray-Curtis similarity index. The hierarchical clustering method based on group average linking delineated two major groups of locations based on the species abundance at different altitudinal heights at the 70% arbitrary similarity level. A 2D-nMDS ordination plot (stress level = 0.01) have shown distinct grouping of upstream and downstream sites at 60% similarity level. The clear separation of sites indicated that the species assemblage structure has a longitudinal pattern of distribution along the stream gradient.

3.1.2. Habitat assessment and eco-biological study of selected mountain lakes of central and north-eastern Himalayan region

Habitat assessment, ecology and fish faunal diversity studies were carried out in five selected lakes of Uttarakhand (Bhimtal, Sattal, Naukuchiatal, Nainital and Maheshwar kund), three lakes of Sikkim (Memenchu, Hangu and Lampokhari), three lakes of Arunachal Pradesh (PTso, Shungatser and Sela1) and one lake from Mizoram (Tamdil). The habitat information generated from the high altitudinal lakes of Arunachal Pradesh and Sikkim is the first report of its kind. With respect to fish biology, seasonal gonado-somatic index (GSI) in male and female golden mahseer (*Tor putitora*) from Bhimtal lake was assessed. The results indicated that the highest GSI values in both sexes were recorded during the breeding season (July-August) and conversely lowest GSI values were recorded in the winter season (prior to February). In addition, studies related to seasonal changes in thyroid hormone profile (T3 and T4 levels) and density of thyroid follicles in kidney (histological observation) of golden mahseer from Bhimtal lake are also under progress.



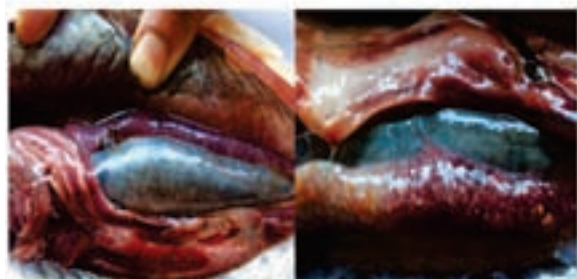
Seasonal variation in GSI of golden mahseer



Summer (May - June)



Monsoon (July - August)



Pre-Winter (October - November)



Winter (January - February)

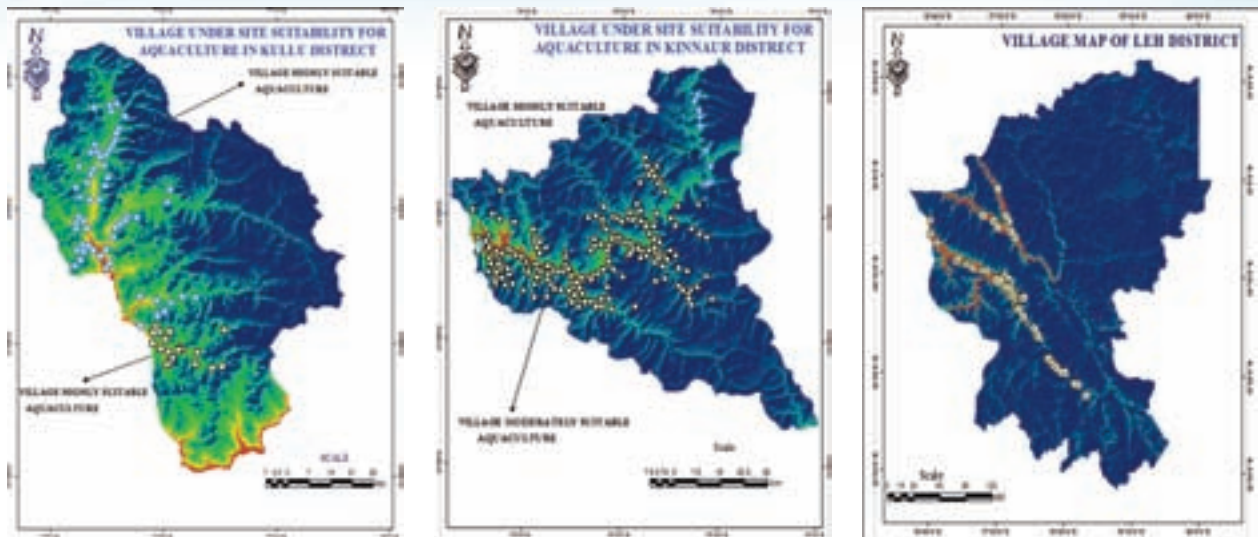
Gonadal cycle of male and female golden mahseer during different seasons of the year

Another major breakthrough was the discovery of a new species of copepod having high concentration of carotenoids. The species was collected from Maheshwar kund lake situated in the central Himalayan region, Munshiyari, Uttarakhand (29°20'52"N and 79°31'55"E) at an altitude of 5219 m above MSL. Taxonomic examination of the collected specimens resulted in the identification of a previously undescribed species of the genus *Hesperodiaptomus*. The distinctive features of the discovered species were: In right fifth leg of male, first exopod has long stout spinous process on inner distal margin. Outer margin of first exopod was straight and smooth with slight triangulation expansion into succeeding segment. The inner lateral margin has butterfly-like sclerotization hyaline membrane inserted on the inner lateral side of first exopod. Right endopod was extremely reduced and rudimentary. In 20th segment of female right antenna, a long tooth like elongated structure extended to outer margin. The species has close morphological similarities with the available description of *Mastigodiaptomus albuquerquensis*. Species level confirmation is under process and the information has been communicated to ZSI's arthropod repository.

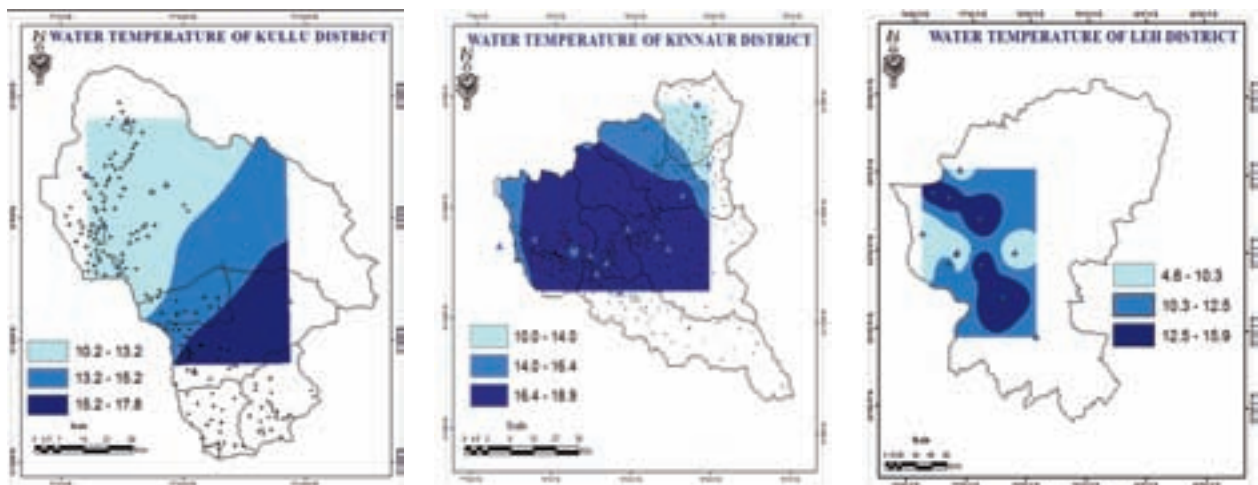
3.1.3. Study on development of spatial database of coldwater fishery resources in western Himalayan region

Spatial information from India WRIS (ISRO), Digital Globe - Quick Bird (Arc GIS), ASTER-USGS satellites and village boundary map from Survey of India were used to generate GIS based thematic maps for aquaculture site suitability in Kullu and Kinnaur districts of Himachal Pradesh and Leh and Kargil districts of Jammu & Kashmir in the western Himalayan region of India. Moreover, the physicochemical parameters of water collected from different locations in the target districts and interpolation techniques were used to prepare thematic maps of each physicochemical water parameter, with respect to aquaculture site suitability. Infrastructure facilities such as road and seed distribution units were also digitized.

Similarly, fish biodiversity maps for different river drainages in the western Himalayan region were prepared using primary and secondary data on ichthyofaunal diversity. Information on inhabitant fish fauna was merged to physical maps of the drainages.



Thematic village level aquaculture site suitability maps



Thematic water temperature zonation maps



Fish biodiversity maps of river Indus, Sutlej and Zaskar

3.1.4. Assessment of population status, species diversity and habitat ecology of snow trout *Schizothorax* species in selected streams of Indian Himalayan Region

The study was conducted in three snow-fed tributaries viz., river Dirang chu (27.3537N, 92.2506E), Sangti (27.3517N, 92.2681E) and Tenga (27.2186N, 92.43E) of Kameng drainage in West Kameng district of Arunachal Pradesh in the Eastern Himalayas. The topography of the basins was hilly with steep slopes, situated at an altitude ranging from 1411-1512 m above msl. Water in all the sampling sites remained clear and transparent during the study period. Most of the basic water quality parameters were within the optimum level (temperature, 11.4-14.3; pH, 7.3-7.9; dissolved oxygen, 8.1-8.3; total dissolved solids, 8-25) suggesting good health of the habitat and conduciveness for the abundance of snow trout. Snow trout specimens were collected from each of the sites for taxonomical identification on the basis of morphometric and meristic character. The major gears employed for catching snow trouts were cast nets and noose and line. The average catch per unit effort (CPUE) of noose and line fishing gear was recorded as 1.8-2.2 kg/per hour/gear. CPUE of cast nets will be determined in due course of time. The collected specimens were identified as *Schizothorax*

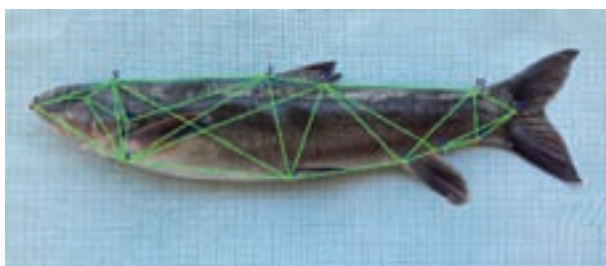
richardsonii, *Schizothorax labiatus* and *Schizothorax progastus*. The average size of snow trout varied with the habitat from which it was collected, maximum at Tenga (278 g and 31.1 cm), minimum (88 g and 19.3 cm) at Sangti and intermediate at Dirang (117.6 g and 22.1 cm). Truss network was constructed by interconnecting 14 landmarks to yield 31 distance variables that were extracted from digital images of specimens using a linear combination of three software platforms, namely tpsUtil, tpsDig2w32 (Rohlf) and paleontological statistics (PAST). Determination of the inter-specific morphological variances among the snow trout populations is in progress.

3.2. Aquaculture oriented research and development

With respect to fish production and conservation related hill aquaculture, more emphasis has been laid on addressing the challenges in breeding and captive management of important endemic coldwater fish species. Apart from that, species diversification, complete domestication and standardization of culture practice forms the thrust areas of the aquaculture oriented research projects undertaken by the Directorate.

3.2.1. Photo-thermal manipulation for gonadal maturity of golden mahseer in captivity

To elucidate the effect of temperature on the gonadal maturity of golden mahseer (*Tor putitora*) in captivity, an experimental trial was conducted in the Directorate's mahseer hatchery complex at Bhimtal.



Truss box image of *Schizothorax richardsonii* depicting the 14 landmarks



Sampling site at river Tenga, Arunachal Pradesh

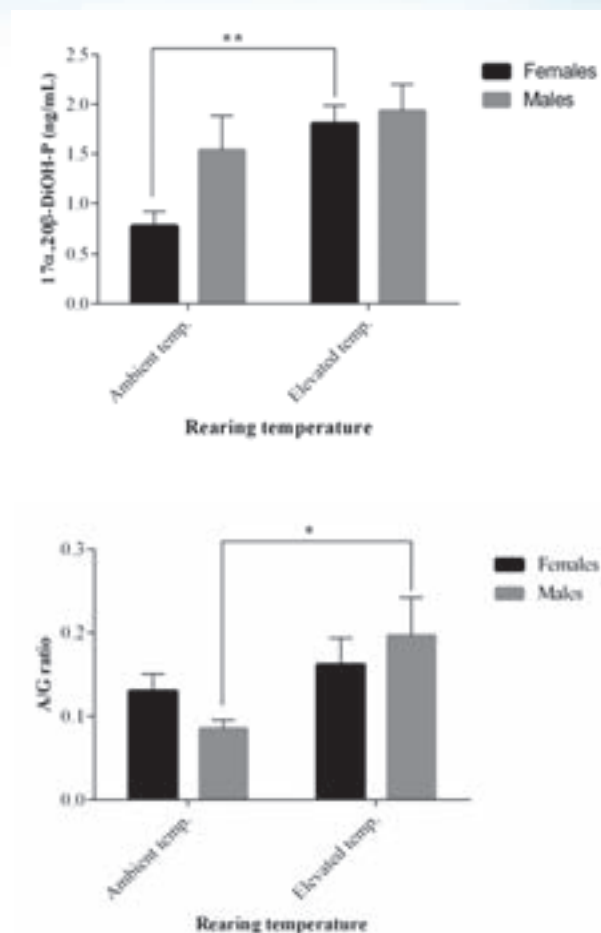


Experimental setup and sampling

Captive adult female and male golden mahseer were randomly distributed in FRP tanks of 2000 L capacity and experimentally reared under two thermal regimes i.e., ambient temperature ($21.2 \pm 1.4^\circ\text{C}$) and elevated temperature ($23.7 \pm 1.3^\circ\text{C}$). In each tank, an internal circulation of water was maintained using submersible pumps, coupled with continuous aeration. During the four month experiment, fishes were fed twice a day *ad libitum* with a broodstock diet containing 35% crude protein. Important water quality parameters were monitored periodically. At the end of the trial, tissue and plasma samples were collected and appropriately stored for various molecular, biochemical and histological analysis.

Estimation of plasma hormone levels, stress biomarkers and immune parameters

Important maturation related hormones, stress biomarkers and immune parameters were estimated using commercially available ELISA kits. In case of 17β -estradiol, significantly ($p < 0.05$) higher plasma concentration were observed in females reared at elevated temperature compared to females at ambient temperature. Likewise, increase in rearing temperature had enhanced the 17α , 20β -diOH-progesterone levels in females. Males also had higher levels of 17α , 20β -P in elevated temperature group but were non-significant. There was no significant impact of elevated temperature on vitellogenin levels of either females or males, however a 29% increase in mean values of vitellogenin was observed in females reared at elevated temperature. Further, rearing at elevated temperature had significantly enhanced cortisol levels, but there was no significant effect of sex type on cortisol levels of golden mahseer. Concerning the other stress markers, there was no significant change observed in plasma glucose, anti-oxidative enzymes such as superoxide dismutase, glutathione-s-transferase and total anti-oxidant levels with respect to both sex and rearing temperature of golden mahseer. Similarly, we did not find any significant effect of either sex type or elevated temperature on total plasma protein, albumin and globulin levels of golden mahseer. However, A/G ratio of male golden mahseer had significantly increased at elevated rearing temperature. Conversely, the total plasma



immunoglobulin level in both male and female golden mahseer was found to be significantly decreased at elevated rearing temperature compared to ambient temperature group.

Cloning and characterization of CYP19A and CYP19B (aromatase) genes

Two full length isoforms of CYP19B (aromatase brain type) in *Tor putitora* were cloned and sequenced using in house 5' and 3' RACE technique. The two isoforms of CYP19B mRNA were different in their 3' sequence, where one was complete form with 3032 nucleotides which we termed as full length form and another as truncated form with 2229 nucleotides. The full length form of CYP19B contained 108 bp of 5' UTR, 1524 bp of open reading frame (ORF), 1400 bp of 3' UTR and coded for 508 amino acid containing protein. The truncated form of CYP19B contained 108 bp of 5' UTR, 1290 bp of ORF, 831 bp of 3' UTR and coded for a protein containing 430 amino acids. Similarly, we have cloned and sequenced 1447 bp of CYP19A

(gonad type) which consists partial cds and 3' UTR using 3' RACE technique. Evolutionary studies, protein modeling studies and expression analysis is under progress to understand the functional significance of these two isoforms of aromatase brain type transcripts.

Field exploration for breeding possibilities of golden mahseer at Tehri

To assess the breeding possibilities of golden mahseer for *in situ* conservation and rehabilitation, a field exploration was carried out at the THDC project site at Tehri, Uttarakhand. Samples were collected from adult golden mahseer to assess their gonadal maturity status by profiling reproductive hormone levels in plasma, gonadal histology and gene expression analysis.



In situ sampling of golden mahseer at Tehri

3.2.2. Molecular characterization and gene expression profiles of kiss genes in golden mahseer during different gonadal development stages

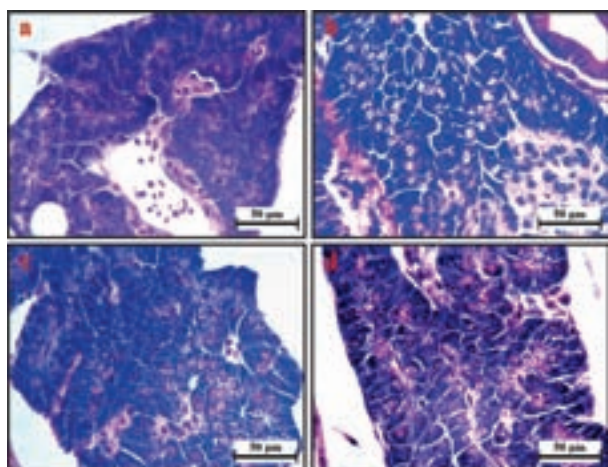
Ovarian developmental stages of wild female golden mahseer were studied during the annual spawning season. Oogenesis and transcript levels of kisspeptin 1 (*kiss1*) and its receptor (*kiss1r*) mRNA in brain-pituitary-gonad (BPG) tissue was studied. The qPCR analysis shows that *gm-kiss1* and *gm-kiss1r* mRNA are expressed in BPG axis of both the sexes of adult golden mahseer. Further, gonadal development stage dependent changes in expression of mRNA encoding kisspeptin 1 (*gm-kiss1*) and its receptor (*gm-kiss1r*) was studied

in the brain, pituitary and gonads of adult male and female golden mahseer. In brain and gonad the *gm-kiss1* and *gm-kiss1r* mRNA expression was comparatively higher during the initial stage of spermatogenesis and oogenesis. In pituitary, the transcript level of *gm-kiss1* and *gm-kiss1r* was consistently low throughout the gonad development and varied marginally. Between male and female, the *gm-kiss1* mRNA expression level in brain and ovary of female golden mahseer was several folds higher than the brain and testis of male fish. In addition to the gene expression analysis, membrane interaction study of kiss1 peptide was carried out in different membrane mimicking environments using fluorescence spectroscopy. Fluorescence was observed in aqueous and trifluoroethanol (TFE) for tyrosine residues. The peptide showed different fluorescence maxima in aqueous and TFE.

3.2.3. Devising a feeding regimen based on return of appetite in golden mahseer (*Tor putitora*) larvae/juvenile

A pilot postprandial study was conducted with 45 and 90 days post-hatch (dph) golden mahseer larvae to screen and identify the potential histomorphological markers of appetite. Samples of three larvae/fry were taken after feeding (goat liver), at 30 minutes, 6, 12, 18 and 24 hours. In total, 45 samples were collected, fixed in Bouin's fixative and processed as whole fish because of their small sizes. After processing and embedding, each samples were sectioned serially (around 10 to 30 slides were prepared per sample) and stained. Characterization of histological markers of appetite was carried out by microscopic observations of all the histological slides. In observational scanning, the possible histological markers such as goblet cell dynamicity (in buccal cavity, esophagus, fore, mid and hindgut), food content, texture and color in fore, mid and hindgut, zymogen granule dynamicity in pancreas, and supra-nuclear vesicles in hindgut were checked and confirmed as appetite markers. Specifically, goblet cell numbers in esophagus were found to decrease after feeding; at 6 hours after feeding, the density was drastically lower and the re-building up of goblet cell density were seen at 12 and 18 hours. The difference in density was not apparent in 18 and

24 hours. The foregut distention was found to begin at 30 minutes after feeding, maximum distention was seen at 6 hours, and after that the progression of gradual constriction was observed. Maximum constriction was seen at 24 hours of feeding. Similar changes were seen in the midgut as well. In the pancreas, a gradual reduction in zymogen granules were seen until 6 hours, or in other words maximum reduction in zymogen granule was seen at 6 hours of feeding and later at 12, 18, and 24 hours they were found to increase. In hindgut, a gradual progression in density and size of supranuclear vesicles were seen until 12 hours of post feeding. There were some vesicles even at 24 hours and 30 minutes post feeding.



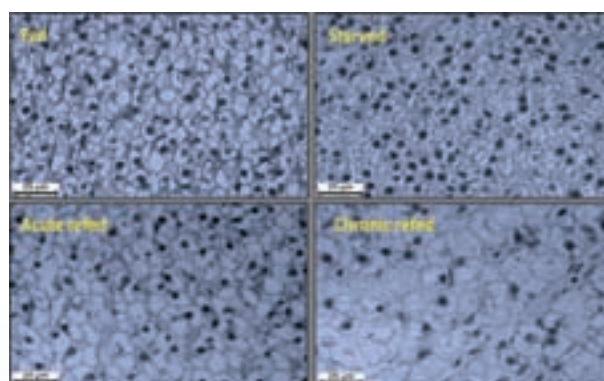
Dynamicity of zymogen granules in pancreas at 30 minutes (a), 6 hours (b), 12 hours (c) and 24 hours (d)

3.2.4. Decoding the constraints in growth, maturation and captive management of snow trout (*Schizothorax richardsonii*, Gray 1832)

The prospect of including endemic coldwater fishes such as snow trout in hill aquaculture is hampered by critical factors such as slow growth, early maturity and lack of captive management protocols. To address this concern, three experimental feeding trials have been conducted in snow trout (*Schizothorax richardsonii*) to elucidate their growth and physiological response to nutritional status (feed availability/deprivation), graded levels of dietary protein (25-50%) and different feeding strategy (feed ration/alternate day).

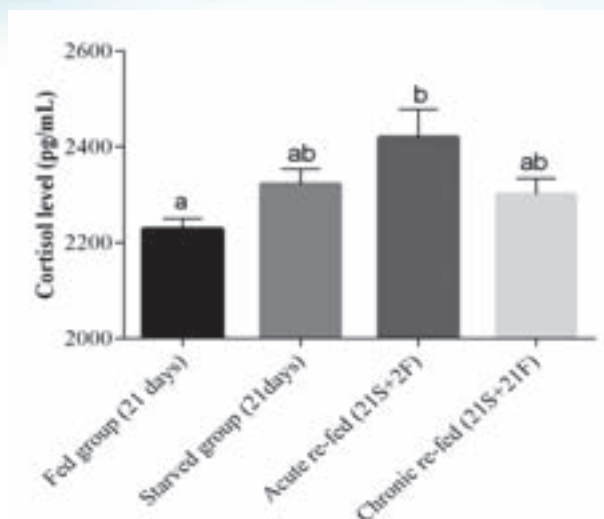
Feeding experiments and analyses

The first experiment was a 6 week feeding trial to ascertain the effect of nutritional status on growth and related indices in fish of 5 g size. The control group was fed continuously for three weeks, whereas one of the treatment groups was starved for three weeks and the other was starved and refed for three weeks, respectively. While starvation was associated with weight loss, refeeding induced a compensatory growth like response. Analysis of whole body composition indicated that lipid level was significantly lower in starved group as compared to fed group with a reciprocal difference in moisture content. Plasma triglyceride levels and viscera-somatic index concurred with the changes in whole body lipid content. The analyzed fatty acid profile did not reveal any clear trend. Histological observations suggested that the liver undergoes dynamic structural changes with changing nutritional status, as hepatocyte volume was found to decrease with starvation and increase on refeeding. Likewise, the presence of vacuoles in the enterocytes was also influenced by nutritional status.

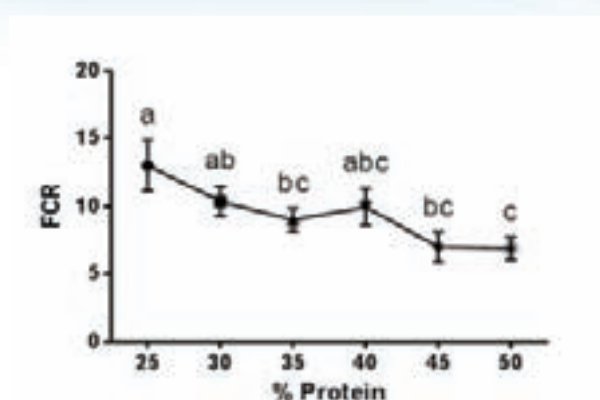
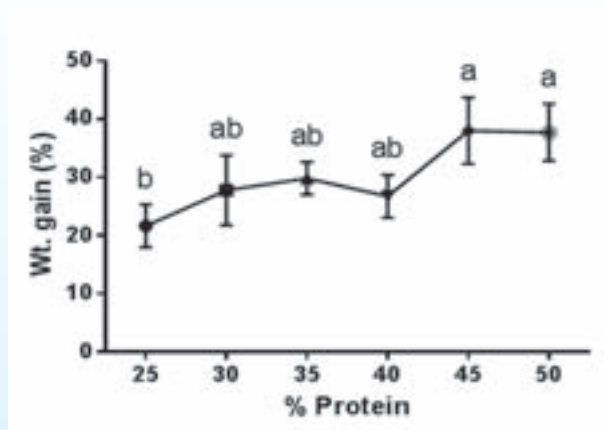


Changes in hepatocyte volume under different nutritional conditions

With respect to stress markers, plasma cortisol was found to be higher in acute refeed group, but subsided to the level of control group after chronic re-feeding. Anti-oxidative enzymes such as glutathione peroxidase and superoxide dismutase activity, and total plasma immunoglobulins did not show any significant change with nutritional regime.



In the graded protein experiment, a long term (100 days) feeding trial was conducted using six practical diets containing 250-500 gram protein per kilogram feed. The protein-energy ratio was consequently different between the diets, with respect to the level of protein source (fish meal and soybean meal) and carbohydrate source (wheat flour). Measurement of growth indices at the end of the trial suggested that the diets containing 45 and 50% protein elicited the highest growth. For a cyprinid fish with predominantly herbivorous feeding habit, snow trout apparently requires high protein for growth. Moreover, the most striking observation with respect to feed utilization is the very low feed conversion ratio that ranged 7-15. For further clarification, nutrient utilization efficiency is being examined based on retention and loss estimates derived from comparative carcass analysis.

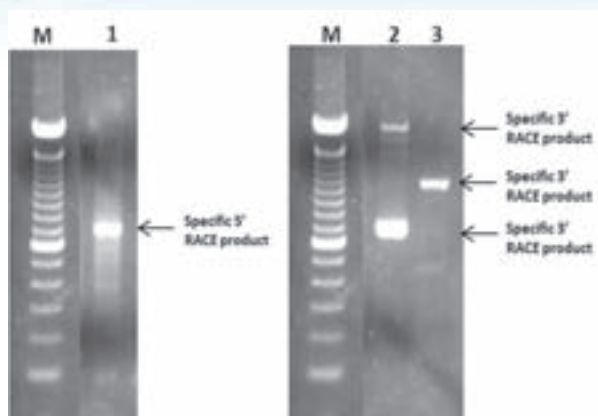


In the third nutritional trial, feed ration and alternate day feeding strategy was found to significantly influence weight gain and specific growth rate in snow trout. The study also reaffirmed the compensatory growth ability of this fish.

Development of robust RACE methodology and characterization of growth, metabolism and maturation related gene markers

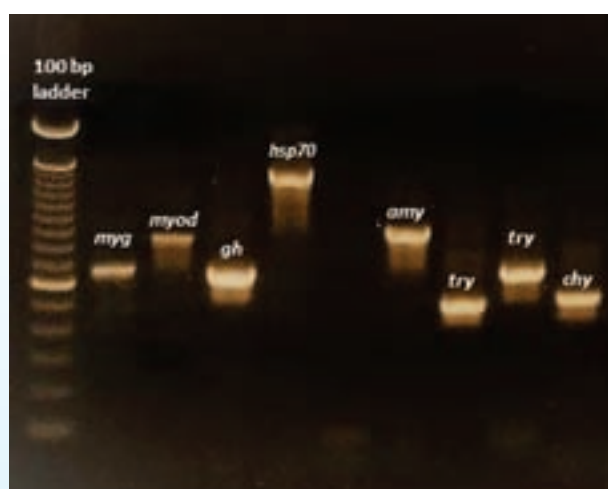
Random amplification of cDNA ends (RACE) is a PCR technique used for amplification of either 5' or 3' ends of a cDNA. It is also used to identify isoforms, variants and different forms of one gene. Considering the constraints and limitations in using commercial kits, we standardized an in-house 5' RACE technique based on the template switching ability of MMLV reverse transcriptase H minus and 3' RACE based on step out PCR technique. Further, we designed fish specific probes and performed many other technical modifications that enhanced the specificity of RACE product amplification. Ultimately, this led to very clear and single product amplification, and there was no requirement of nested PCR. Using this in-house RACE method we have amplified complete 5' RACE product for 7 genes and complete 3' RACE product for 14 genes of snow trout. Importantly, this in house RACE method was much cheaper than commercially available RACE kits.

In order to decipher the molecular mechanisms underlying slow growth and early maturity in the Indian snow trout *Schizothorax richardsonii*, partial



5' RACE and 3' RACE products of aromatase genes from snow trout (M: 1 kb DNA marker, Lane 1: 5' product of cyp19b, Lane 2: 3' isoforms of cyp19b, Lane 3: 3' product of cyp19a)

or complete coding sequences (cDNA) of important growth, metabolism and maturation related genes were PCR amplified using specifically designed primers, cloned using suitable vector/competent cells, bi-directionally sequenced, edited, cross-checked for homology and submitted to NCBI GenBank. The cDNA sequences obtained were those of genes encoding the digestive enzymes trypsin (635 bp), chymotrypsin (472 bp), amylase (763 bp), lipase (952 bp); paracrine hormone ghrelin (451 bp); metabolic enzymes such as glucokinase (1400 bp), pyruvate kinase (650 bp), glucose 6-phosphatase (1000 bp), fatty acid synthase (1700 bp) and hydroxy-acyl-CoA dehydrogenase (600 bp); transcriptional factor peroxisome proliferator-activated receptor-alpha (1000 bp); heat shock

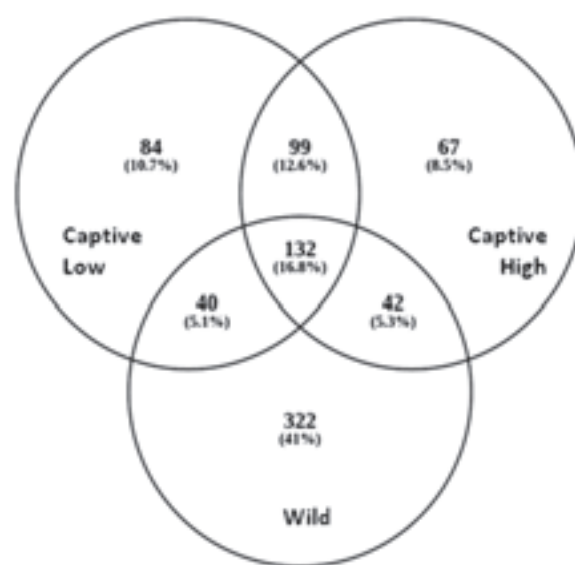


Amplified fragments of snow trout gene markers

protein 70 (900 bp); mechanistic target of rapamycin (1400 bp); myogenic regulatory factors such as myogenin (1306 bp), myoD (1443 bp), myostatin1 (1062 bp), myf5 (417 bp) and myf6 (680 bp); growth hormone (593 bp), growth hormone receptor (1261 bp) and insulin like growth factor 3 (850 bp); full and truncated isoforms of aromatase brain type (3006 and 1916 bp) and aromatase gonad type (1437 bp). Post sequencing analysis indicated that majority of the snow trout gene markers showed high similarity to common carp.

Metagenomic analysis of snow trout gut-microflora

Using culture independent high-throughput 16S rRNA amplicon NGS analysis, the intestinal bacterial composition, abundance and dynamics was comparatively studied in captive and wild snow trout. Diversity of the gut-microbiota apparently decreased in captivity and the changes in bacterial community composition were further influenced by dietary protein content. The most abundant bacteria were *Cetobacterium somerae*, belonging to the class Fusobacteria. Further, the proportion of Fusobacteria and Proteobacteria was found to be strongly influenced by wild to captivity transition and dietary protein intake.



Venn diagram representing the shared and unique gut microbial OTUs in wild and captive snow trout

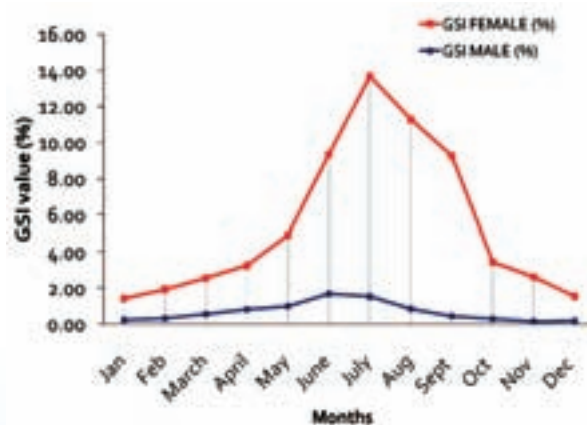
Breeding and captive management of snow trout

Mature specimens of *Schizothorax richardsonii* were collected from Gaudi, Ladhiya and Chhirapani rivulets and maintained in raceways at Champawat field centre. The stocking density was kept at 25-30 fish per m² and water flow rate was maintained at 20-25 litre per minute. Provision of shelters in the raceway was found to be congenial. The snow trout breeding trial was undertaken in last week of September 2016. From the collected and maintained stock, 54 females and 150 mature males were selected for the breeding experiment. The size of female brooders used for the purpose was of 51-116 g mean weight and 17.2-26 cm mean length. Gametes were stripped from the brood fish, mixed and the fertilized eggs were placed in flow-through incubation units. Formaldehyde treatment was administered as a prophylactic measure to prevent fungal infection during egg incubation. Hatching was observed within 120-144 hours post fertilization at a temperature range of 17.8-18.7°C. Appearance of eye spots and development of eyes started after 20-24 hours of hatching and black color melanin pigments occurred at 72 hours post-hatch. Yolk sac absorption completed within 84-168 hours post-hatch and then fry started exogenous feeding on supplementary diet. Totally, 38,000 fry were produced with a fertilization rate of 74-78% and hatching rate was 36-42%.

3.2.5. Domestication, biology and breeding of Indian trout *Raiamas bola* (Hamilton, 1822)

Raiamas bola is an endemic cyprinid fish belonging to the subfamily Rasborinae (Danioninae). Being a potential food and game fish, study on its biology and breeding behavior was undertaken to develop captive breeding protocol, essentially for aquaculture diversification and conservation of the species. Few wild specimens of *Raiamas bola* were collected from different locations in the river western Ramganga. In the wild, the species is known to exhibit nocturnal behavior, insectivorous feeding habit and thermal preference of 10-26°C. Morphological data collected from the wild specimens indicated high degree of positive correlation between length and weight ($R^2=0.94$),

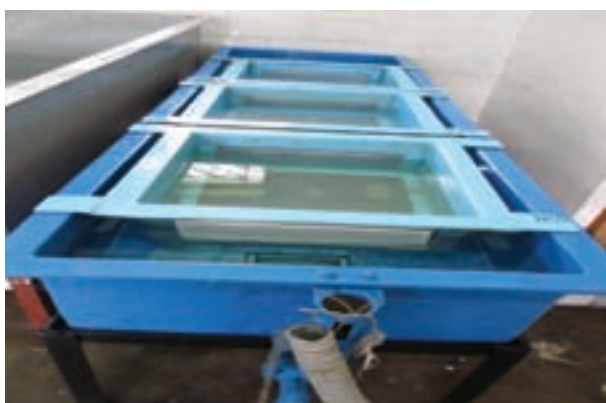
and the length-weight equation obtained was $W=0.021026L^{2.398}$. The obtained slope value i.e., 2.39 suggests that the wild stock may be under stress and apparently follows non-isometric growth pattern ($b \neq 3$). Likewise, the calculated mean condition factor (Kn) of the collected specimens was 0.6 ± 0.1 , much less than the optimum (i.e., $Kn=1$). Nevertheless, more seasonal data are required for ascertaining these facts. The collected fish were further maintained in the farm facility at Bhimtal for observation of general and reproductive biology. In pond condition, the collected wild fish gained on an average 53 ± 11 g in one year. In wild, brooders of the age 3+ years and mean body weight 60-140 g showed full maturity with eggs release and oozing milt during second week of May. During different maturity stages, gonadosomatic index ranged from 3.2 ± 0.1 to 13.1 ± 1.2 . Sexual dimorphism in morphological characters was evident only during the spawning season. Females showed soft and bulged belly with swollen light reddish vent. Ovarian and testicular development indicates July-August as the breeding season.



Captive breeding of *Raiamas bola* was attempted during July-August 2016. Some of the fish collected from the wild obtained full maturation during the month of late June to July. The average size of females and males were 82.2 ± 2.7 g weight 22.1 ± 6.5 cm length and 71.4 ± 9.2 g weight 16.5 ± 8.5 cm length, respectively. During the month of May, a single preparatory dose of Ovaprim at the rate of 0.1 ml/kg of male and 0.3 ml/kg of female was intraperitoneally administered for successful gonadal maturation and spawning. The induced

fishes were then maintained separately. Eggs were stripped from two females and mixed with the milt from a mature male. Incubation of the fertilized eggs was done in a flow through system with an average water flow of 2 L/minute. Hatching occurred after six days at water temperature of 18-22°C, and the hatchlings were kept in the hatching tray for four days until yolk sac was fully absorbed. The fecundity of the female was estimated in the range of 10,000-12,000 per kg body weight. Egg fertilization rate was 62%, whereas spawn survival percentage was 73%.

breeding gonadal and liver histology, fertilization and hatching percentages, hatching times and embryonic development were recorded or analyzed. These fishes breed once in a year. While female sheds all their mature eggs in one time, males release milt in protracted manner. Hence, we inferred that either same male can be used at least two times for fertilization or ratio of female to male can be raised in a breeding pool. The study of larval development and ontogeny of vital organ systems such as digestive, thyroid endocrine, olfactory and gustatory is in progress.



Egg incubation in flow through system and newly hatched larvae

Larvae of *Bangana devdevi* and *Osteobrama belangeri*

3.2.6. Captive rearing, breeding biology and seed production of *Bangana devdevi*, *Labeo pangusia* and *Osteobrama belangeri*, three endemic fishes of north eastern Himalaya

During captive breeding at Tomba & Sons fish farm, Manipur, the reproductive performance of gnaton (*Bangana devdevi*) and pengba (*Osteobrama belangerii*) was evaluated. Basic data such as broodstock size, sex ratio, gonadosomatic index, size frequency distribution of eggs, pre- and post-

Labeo pangusia is another potential candidate species for diversification of mid hill aquaculture in north eastern Himalayan region. Therefore, an attempt was made for captive rearing and breeding of *Labeo pangusia* at Nameri Eco Camp, ABACA, Nameri National Park in Assam. Brood fishes in the 3+ year age group were reared in cemented tank of 0.02 ha size. The breeding trial commenced with the selection of male and female brooders of *Labeo pangusia*, which had attained full gonadal maturity.

Breeding of *Labeo pangusia*Nesting pit of *Barilius bendelisis*

The size of the brooders ranged from 1-2 kg in weight and 35-50 cm in length. For both male and female brooders (2:1 ratio), the inducing agent Ovartide was administered at the rate of 0.5-1 ml/kg body-weight. After injection, the fishes were kept in breeding hapas overnight for courtship and mating. The fishes spawned after 6-8 hours of hormonal injection, with 70% fertilization success. The fertilized eggs of *Labeo pangusia* were transparent white in colour and round in shape. The hatching percentage was 50% and a substantial number of fry was produced after the experimental breeding trial.

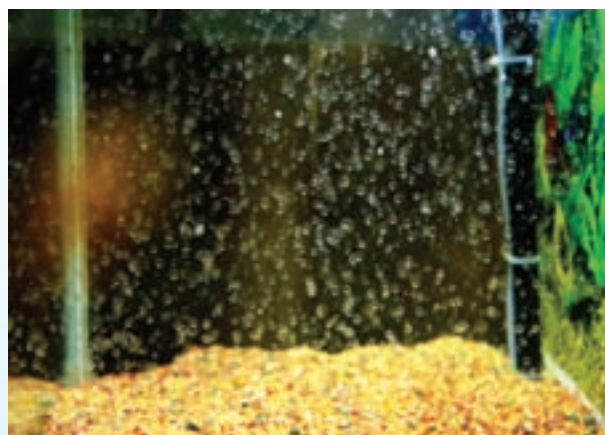
3.2.7. Domestication, biology and breeding of selected indigenous ornamental fish species of coldwater region

Mature specimens of *Barilius bendelisis*, *Puntius ticto*, *Naziritor chelynooides* were collected from the wild, acclimatized and reared in controlled aquaria conditions. Breeding behaviour of these fishes was then closely monitored. For the first time, it was observed that hill trout *Barilius bendelisis* and chocolate mahseer *Neolissochilus hexagonolepis* lay eggs in batches and make pits in gravel for eggs incubation. In case of *Puntius ticto*, eggs were semi-adhesive and hatchlings were very tiny. Breeding and larval rearing of *B. bendelisis*, *P. ticto*, *N. chelynooides* and *N. hexagonolepis* was also successfully accomplished in zero water exchange conditions. Survival (95%) and growth was found to be 3 times better in glass aquaria than in FRP tanks. Different stages of embryonic

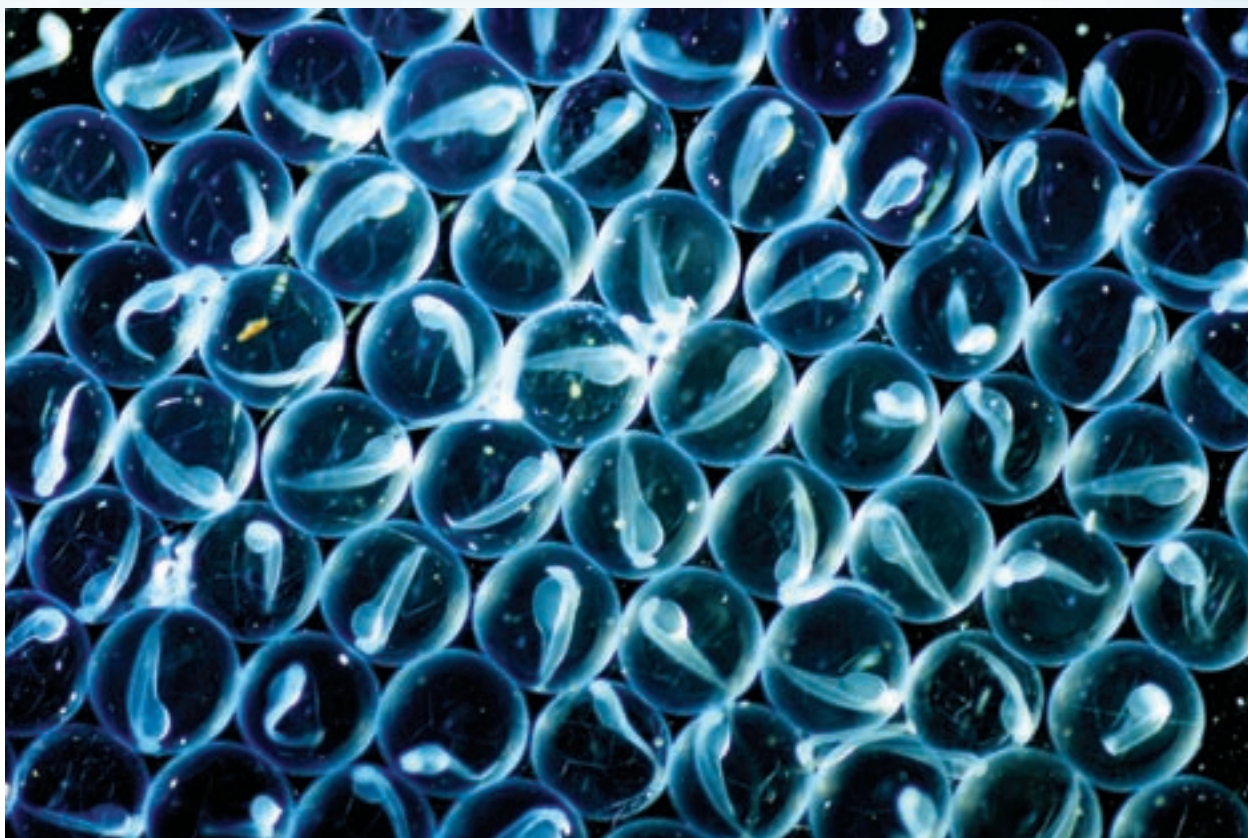
and larval development of these fishes were also recorded. Eventually, 6000 fingerlings of *Barilius bendelisis*, *Naziritor chelynooides* and *Neolissochilus hexagonolepis* were produced.

Zero water exchange fish hatchery

A prototype zero water exchange glass aquarium hatchery (90x45x60 cm) with a water holding capacity of 120-150 L and sand-gravel bed filtration system has been developed. A thick layer (8-10 cm) of sand gravel (3-5 mm size) was used as a substrate for the biological filtration system, which was operated by power-head pump having a capacity of 1500 L per hour and matured with nitrifying bacteria. The hatchery was loaded with 40,000 fertilized eggs of *Labeo dyocheilus* and continuously churned by the internal water circulation. The hatching percentage was observed to be 80-92% after 72 hours. The spawn were fed egg yolk suspension



Zero water exchange hatchery unit



Developing embryos of *L. dyocheilus*

after complete yolk-sac absorption. At the end of 21 days, the survival percentage of the fry was 84-90%, with uniform growth and no water exchange. Water quality parameters were within permissible levels (>7 mg/L dissolved oxygen; <0.05 mg/L unionized ammonia; 18-22°C temperature) and the produced fry were healthy. As per calculation, 300 carp spawn can be produced using 1 liter of water (i.e., 330 L of water for 1 lakh spawn) in this hatchery. Whereas, in conventional carp hatcheries, egg incubation and production of 10 spawn requires 1 L water (i.e., 10,000 L of water for 1 lakh spawn). Refining and up-scaling of this technology is promising for minimum water use in hill aquaculture.

The same hatchery set-up was successfully used for egg incubation and larval rearing of rainbow trout, which conventionally requires a water flow through arrangement. Incubation of 1000 fertilized eggs of rainbow trout and subsequent larval rearing required only 100-120 L of water in this system, as compared to the requirement of approximately

1,40,000 L in flow through systems. Growth, survival and welfare of the fish were apparently not compromised. The preliminary observations suggests the possibility of drastically reducing water use in rainbow trout hatcheries using the above zero water exchange hatchery prototype.

3.3. Disease surveillance and health management

Potential bacterial pathogens in rainbow trout farms of northern India and maintenance of bacterial agents

A comprehensive database of pathogenic bacterial flora, their occurrence, seasonal distribution, prevalence in trout, and sensitivity/resistance property of isolates to commercial antibiotics has been developed for selected trout farms in the Indian Himalayan region under this project. Analysis of bacterial samples from trout farms of Uttarakhand in central Himalayan region showed the presence of *Aeromonas*

hydrophila, *Aeromonas veronii* (ichthiosmia), *Aeromonas popoffii*, *Aeromonas allosaccharophila*, *Pseudomonas fluorescence*, *Lactococcus garvieae*, *Citrobacter freundii*, *Escherichia coli*, *Micrococcus*, *Acidovorax facilis*, *Bacillus*, *Enterobacter*, *Brevibacillus agri*, *Shewanella*, *Morganella*, *Gamma proteobacterium* and *Hafnia alvei*. Based on their ubiquitous presence, the different species under genus *Aeromonas* was considered to be the most commonly occurring opportunistic primary trout pathogens in different seasons (summer, monsoon and winter). Analysis of microbial samples from trout farms of Sikkim in north-eastern Himalayan region showed bacterial flora dominated by *Serratia*, *Pseudomonas putida*, *Micrococcus*, *Vagococcus*, *Hafnia alvei*, *Morganella*, *Rahnella aquatilis*, *Klebsiella*, *Pantoea*, *Pseudomonas veronii*, *Carnobacterium maltaromaticum*, *Carnobacterium divergenes*, *Pseudomonas fluorescens*, *Yersinia*, *Erwinia* and *Corynebacterium* sp. Bacteria of the genus *Pseudomonas* and *Carnobacterium* were considered as predominant groups in trout farms of Sikkim. Based on hemolytic activity, virulence/serum activity study and 16S rRNA, *gyrB* and *rpoD* gene characterization, the important bacterial pathogens isolated from trout farms of Jammu & Kashmir were found to be *Aeromonas hydrophila*, *Aeromonas allosaccharophila*, *Aeromonas sobria*, *Hafnia alvei*, *Citrobacter freundii*, *Serratia* sp, *pseudomonas fluorescence* and *Enterobacteriaceae*. Isolates identified in lieu of bacterial population



Ulceration in caudal peduncle region of rainbow trout

from different trout farms of Himachal Pradesh were *Lactococcus garvieae*, *Citrobacter freundii*, *Proteus hauseri*, *Pantoea agglomerans*, *Erwinia raphontici*, *Aeromonas hydrophila*, *Aeromonas veronii*, *Hafnia alvei*, *Pseudomonas fluorescens*, *Pseudomonas geniculata*, *Plantibacter*, *Escherichia coli*, *Lelliottia amnigena*, *Microbacterium*, *Staphylococcus*, *Plegiomonas*, *Mollerella wisconsensis*, *Enterococcus casseliflavus*, *Enterococcus gallinarum*, *Carnobacterium divergens*, *Carnobacterium maltaromaticum*, *Bacillus firmus*, *Stenotrophomonas*, *Kluwea* and *Paenibacillus*. Predominant bacteria in few trout farms of Himachal Pradesh belonged to the family *Enterobacteriaceae*. The exhaustive data generated through this project would facilitate well thought-out standpoints for controlling challenges related to pathogenic bacterial infections in rainbow trout farms across India.

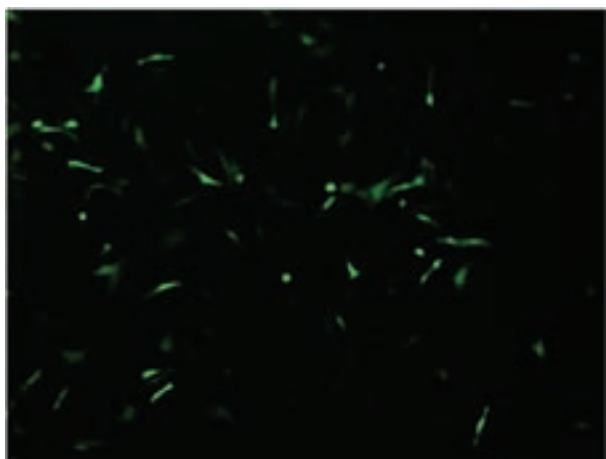
3.4. Molecular genetics and biotechnology

3.4.1. Bioprospecting of genes and allele mining for thermal stress tolerance of *Schizothorax richardsonii*

Members of the suppressor of cytokine signaling (SOCS) family are crucial for the control of a variety of signal transduction pathways that are involved in immunity, growth, and development of organisms. The orthologs of SOCS-1a and SOCS-3a genes in *Schizothorax richardsonii* were identified using specific primers designed from transcriptome database and available teleost SOCS family genes. Additionally, we also examined the expression level of SOCS-1a and SOCS-3a genes in eight different tissues (gills, muscle, liver, spleen, kidney, heart, intestine, and brain) and thermally challenged *S. richardsonii* samples using qPCR. mRNA expression of both the SOCS genes was detectable in all the eight tissues. The SOCS-3a gene was highly expressed in gill followed by spleen and heart. The expression of SOCS-1a gene was low in most tissues, but it had a relatively higher expression in gill and spleen. It was also detected that the mRNA levels of both the SOCS genes were significantly up-regulated in thermally challenged fish.

3.4.2. Development of fish viral peptide based nano system for intracellular delivery of biomolecules

Three peptide nano systems (RR28, LR28 and KR24) were designed from fish viral proteins using bioinformatics tools. The designed peptides were synthesized by solid phase peptide synthesis (SPPS) using Fmoc chemistry on rink amide MBHA resins. Further, these peptides were purified by semi-preparative RP-HPLC and their purity was further checked by analytical RP-HPLC. The mass of the peptides was confirmed by mass spectrometry (MALDI-TOF-MS). The synthesized peptide nano systems were found to interact with the plasmid DNA and able to form complexes which was visualized in gel electrophoresis (gel retardation assay). Large scale plasmid DNA (phmGFP, Promega) was prepared by carrying out all the steps at 4°C to obtain maximum quantity of supercoiled plasmid DNA. Out of the three synthesized peptides



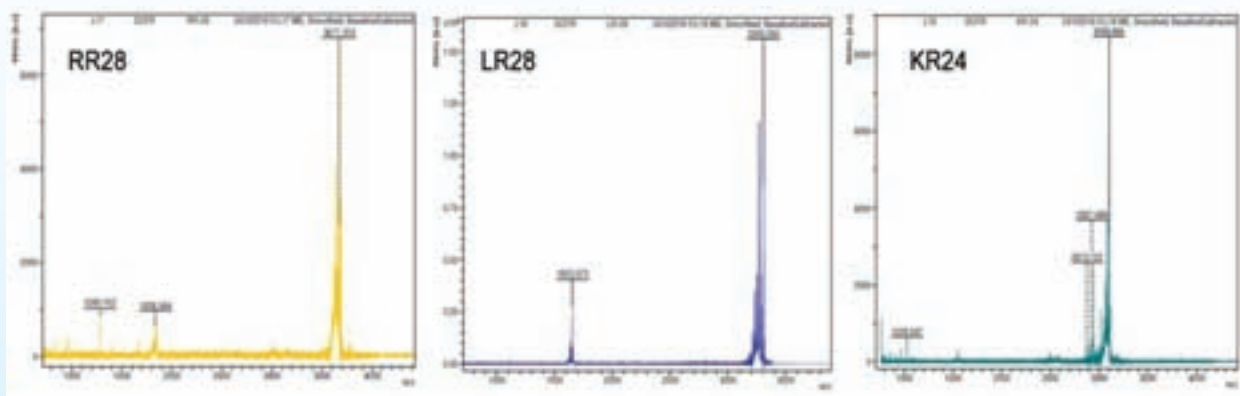
Delivery of GFP gene using RR28 peptide in fish cells (CHSE-214)

(RR28, LR28 and KR24), RR28 has been tested for its cargo carrying capacity. The peptide was found to carry plasmid DNA containing green fluorescent protein gene inside fish cell line, CHSE. Further modifications of RR28 will be done in order to make it more efficient and cost effective.

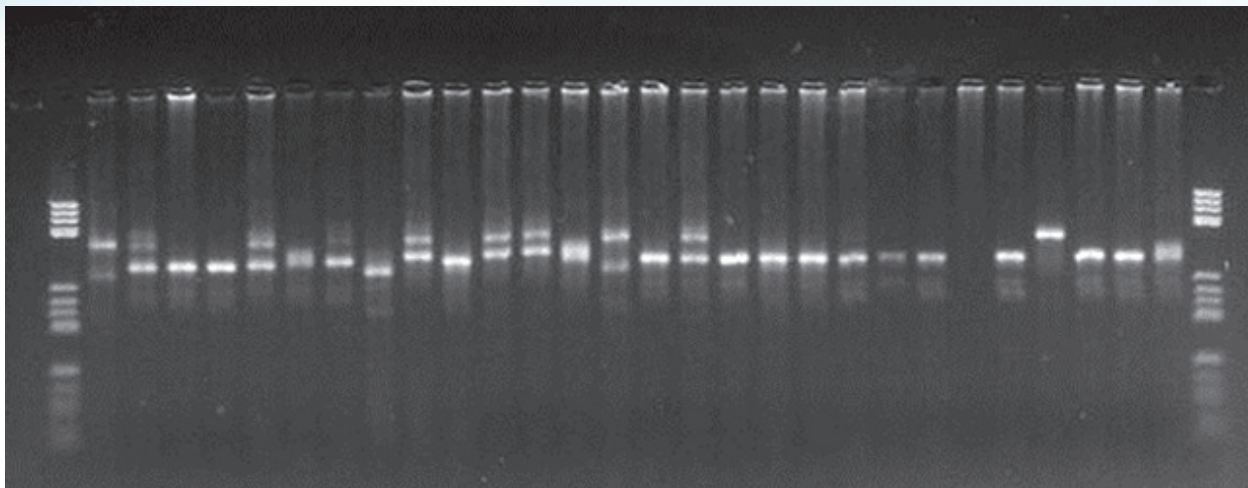
3.5. Outreach activities

3.5.1. Fish genetic stock

Efforts to genetically characterize the eleven populations of chocolate mahseer collected from three north eastern states of India were continued using mitochondrial genes and SSR markers. Sequence analysis of mitochondrial genes COI, Cyt-b and ATPase 6/8 revealed that the haplotype diversity, nucleotide diversity and the number of polymorphic sites were maximum in the Umiam (Meghalaya) population. Further, genetic divergence analysis indicated that Dikrong (Arunachal Pradesh) population was genetically more diverged from other populations. In addition to mitochondrial genes, simple sequence repeat (SSR) markers were also mined to strengthen our understanding of the genetic structure of different populations of chocolate mahseer. A total of 82,324 dinucleotide, 1,135 trinucleotide and 1,01,423 tetranucleotide SSR motifs were mined from the *de novo* assembled genomic DNA data (~3 GB). Bioinformatics analysis with stringent criteria resulted in the selection of 312 SSR markers (containing more than 20 continuous repeats). Finally, 52 loci were selected for primer synthesis, till now 30 loci were successfully validated in all the



Mass spectrum of the peptide nano systems



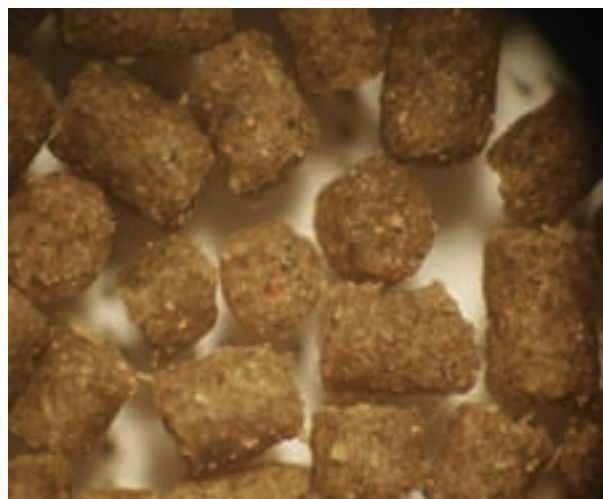
Validation of SSR markers in chocolate mahseer population

population and maximum loci were found to be polymorphic in this species. Validation and analysis of remaining loci are in progress. The validated markers will be valuable to identify variation among the population, recognize better performing stock and conserve this nearly threatened fish.

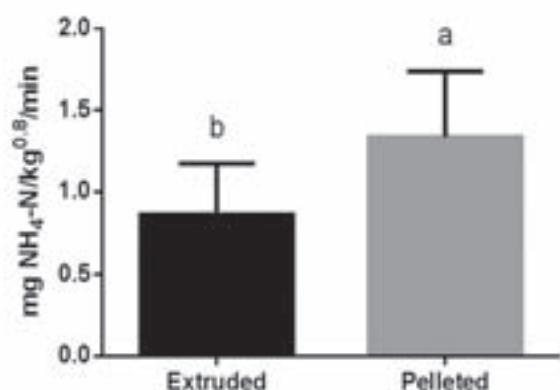
3.5.2. Fish feed

A five week feeding trial was conducted in rainbow trout fry to comparatively evaluate the efficiency of an on-farm pelleted feed against a commercial extruded feed, based on survival, growth, feed conversion, condition factor, oxygen consumption, ammonia production and physical characteristics of the feed pellet. The final body weight, weight gain percent and specific growth rate were high in both groups, but not significantly different. As a matter of fact, weight gain was above 550% in both the dietary groups, corresponding to feed conversion ratios of 0.93-0.96. Survival was, however, significantly lower in the pelleted diet fed group (84%) as compared to the extruded diet fed group (93%), which could be correlated with the higher postprandial ammonia accumulation in the pelleted diet fed group. Conversely, oxygen demand after feeding was not influenced by the physical make of the feed. Concerning the pellet characteristics of the two feeds, extruded feed had higher water stability, bulk density, superior pellet integrity and faster sinking rate, when compared to the pelleted feed. These findings suggest that starter

feed preparation method has a direct relevance to hatchery management, more in terms of survival of rainbow trout.



Pellet integrity of extruded and pelleted feed



Further, the differential growth response observed in the previous experiment conducted to evaluate two cost-effective practical rainbow trout starter feeds formulated based on either single (fish meal) or multiple protein (50% fish meal replacement) sources was substantiated based on changes in the carcass biochemical composition. The apparent differences in whole body protein, ash and amino acid content are being ascertained corresponding to the differences in weight gain. Besides, analysis of the transcriptional response of the fish to the two diets is in progress. In addition, an up-scaled feeding trial was attempted to evaluate the effect of fortifying the trout starter feed with graded concentrations of micronutrients and attractants on growth, well-being and stress tolerance. Preliminary observations suggested that the fortified starter feeds yielded higher growth and the size of the starter feed crumble was apparently critical for its efficiency.

3.5.3. Nutrient profiling and evaluation of fish as a dietary component

The nutrient quality of endemic coldwater fish species viz. *Schizothorax niger*, *Schizothorax curvifrons*, *Schizothorax esocinus*, *Schizothorax plagiostomus*, *Schizothorax progastus*, *Aspidoporia morar*, *S. phasa*, *Macrognaathus aral*, *Clupisoma garua* and *Barilius bendelisis* were analyzed during the reporting period. The analyzed fish samples contained 2.1-6.5% (*S. progastus* to *S. curvifrons*) total fat. Based on total fat content, *S. niger*, *S. curvifrons*, and *S. esocinus* are considered as medium-fat fish, containing 4-8 g fat/100g, which may be due to their same geographical location. On the other hand,

S. plagiostomus and *S. progastus* are considered as low-fat fish which contains 2-4 g fat/100 g. In the other fish species, total fat ranged from 2.1% in *M. Aral* to 11.6% in *S. phasa*. Based on total fat content, *A. morar*, *B. bendelisis*, and *S. semiplotus* are considered as medium-fat fish, containing 4-8 g fat/100g; *M. aral* and *C. garua* considered as low-fat fish containing 2-4 g fat/100 g; and *S. phasa* belongs to high fat category containing above 8 g/100g of fat. With respect to mineral content, the lowest value of phosphorus was 580 mg/100g in *S. progastus* and the highest was 830 mg/100g in *S. plagiostomus*. Likewise, the lowest and highest potassium contents were 450 mg/100g and 700 mg/100g in *S. progastus* and *S. plagiostomus*, respectively. The lowest level of calcium (350 mg/100g) was found in *S. progastus* and highest in *S. niger* and *S. curvifrons* (430 mg/100g). Sodium was lowest (70 mg/100g) in *S. progastus* and highest (180 mg/100g) in *S. plagiostomus*. The lowest magnesium content was present in *S. esocinus* (70 mg/100g) and highest level (150 mg/100g) was in *S. plagiostomus*. The lowest and highest iron concentrations were found to be 11.4 mg/100g in *S. niger* and 12.5 mg/100g in *S. progastus*. Zinc content of fish samples were between 2.6 and 6.5 mg/100g for *S. plagiostomus* and *S. curvifrons*, respectively. Average manganese content of the fish samples varied from 0.4 to 1.6 mg/100g for *S. curvifrons* and *S. niger*, respectively. In terms of fatty acid profile, myristic acid (C14:0) in *M. aral* and *S. phasa*, and palmitic acid (C16:0) in *C. garua*, *A. morar*, *B. bendelisis* and *S. semiplotus* were found to be dominant among saturated fatty acids. Palmitoleic acid (C16:1) in *M. aral*, *A. morar*, *B. bendelisis* and *S. semiplotus*, and oleic acid (C18:1) in *S. phasa* and *C. garua* were dominant among mono-unsaturated fatty acids. Among poly-unsaturated fatty acids, *S. semiplotus* > *S. phasa* > *B. bendelisis* showed more n-3 than n-6 and *M. aral* > *C. garua* > *A. morar* showed the reverse n-3/n-6 ratio. Specifically among n-3 fatty acids, *S. semiplotus* had high alpha linolenic acid (C18:3n-3), *B. bendelisis* had high EPA (C20:5n-3), and *S. phasa* had high DHA (C22:6n-3). Among the n-6 fatty acids, arachidonic acid (C20:4n-6) followed by linoleic

acid (C18:2n-6) were predominant. The potential contribution or dietary value (DV%) of all these fish against RDA for PLW was estimated. Based on the calculated values, *S. phasa*, *S. semiplotus* and *B. bendelisis* showed more than 100% potential contribution to RDA for PLW.

3.6. Inter-Institutional collaborative project

Development and evaluation of polyhouse covered fish polytank for fish rearing in high hills of Uttarakhand

Under the All India Coordinated Research Project on Plasticulture Engineering and Technologies, the Directorate is collaborating with ICAR-VPKAS to assess the feasibility of fish farming at high altitudes in polyhouse covered polylined ponds/tanks. The field experimentation is being conducted at Mukteswar, Uttarakhand. Six polylined ponds were prepared for fish rearing and four of these were covered with dome shaped galvanized iron pipe polyhouse. The dimension of each polylined pond was 9.8×3.0 m in the top and 7.4×0.6 m at the bottom; depth was 1.2 m with 1:1 side slope; and water holding capacity was approximately 20 m³. The dimension of the polyhouse was 11 m length, 4.2 m width and 1 m



Carp culture in polyhouse covered polylined ponds

span with central height of 3 m. The total area of each polyhouse was 46.2 m². Advanced fingerlings of exotic carp and minor carp were stocked in all the six polylined ponds on 6th August 2016. Monthly temperature and relative humidity were recorded regularly. Water temperature in the polylined ponds covered with polyhouse was about 3.7 to 9.7°C higher than the open polytanks during August 2016 to March 2017. Preliminary observation indicated better growth of grass carp and improved strain of common carp in this culture system. Growth of the minor carp was also encouraging with the advantage of cleaning excess periphyton assemblage in the pond.

3.7. Externally funded projects

3.7.1. Transcriptome profiling of immune responsive genes in golden mahseer (DBT funded project)

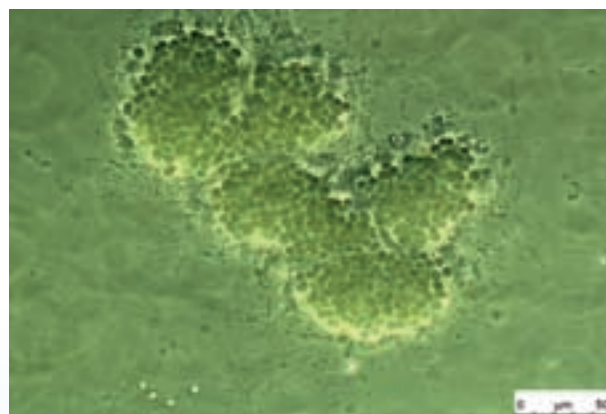
Transcriptome profiling is a useful tool to decipher the novel mechanisms behind immune responses of the fishes. Utilizing a high throughput sequencing technology, we studied the gene expression profile of golden mahseer (*Tor putitora*) after *Aeromonas hydrophila* challenge and validated the expression profile using qPCR assay. The liver transcriptome profile in the present study showed a concurrent expression pattern in both, *in silico* and qPCR analysis in response to bacterial challenge. A total of 2,408 unigenes were significantly altered during the bacterial challenge. From the present RNA-seq analysis and qPCR assay, it was evident that the complement system, antimicrobial peptides, immune responsive acute phase proteins, and other stress-related proteins trigger the adaptive mechanism to counter the initial bacterial infection. The differentially expressed genes were mainly involved in the pathways such as cell surface receptor signaling, TH1 and TH2 cell differentiation, pathogen recognition, and immune system process/defense response especially complement cascade. Finally, twelve unigenes including ankyrin, serum amyloid, hsp4b, STAT3, complement factor c3 and c7 were validated using qPCR and found to be differentially expressed in accordance with *in silico* expression analysis.

In general, most of the unigenes related to innate immunity show highest level of expression during early hours of infection (12–24 h), and then gradually reduces towards longer time points. Whereas, unigenes related to adaptive immunity were highly expressed at longer time points. The qPCR results were observed to be in anonymity with differential gene expression analysis of transcriptome data. Altogether, the immune response of golden mahseer studied through RNA-Seq analysis was broadly indicative of a rapid and multifaceted host as well as a pathogen-directed strategy aimed at immune-sculpting effector responses to improve chances of survival. The present study provided the first transcriptome database of any mahseer species under bacterial infection. Also, improved understanding of mahseer's immune response should aid in the identification of shared and pathogen or tissue specific unigenes with utility as disease biomarkers as a preventive measure in mahseer aquaculture system.

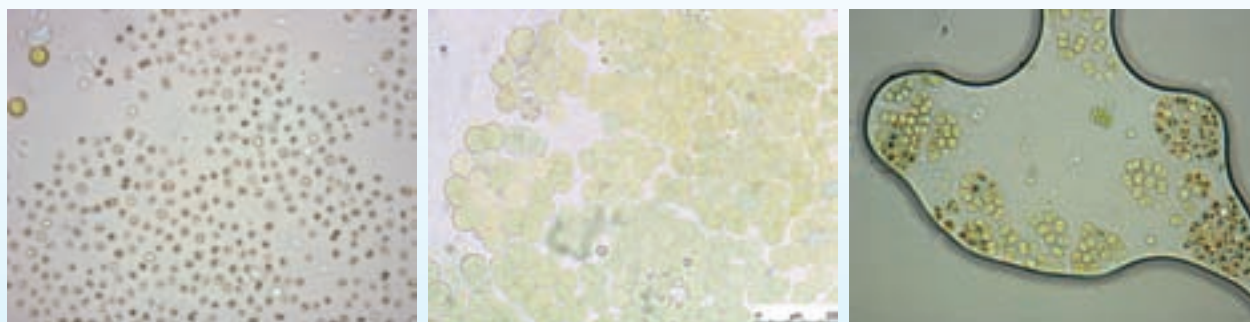
3.7.2. Development of bacterial bioremediation measures for the mitigation of microalgal blooms in freshwater aquaculture ponds (DBT funded project)

The major bloom forming blue green algae in ponds and lakes of Uttarakhand was identified as *Microcystis aeruginosa*, by PCR amplification of its 16S rRNA gene. For its biological control, 21 freshwater bacterial isolates from the sediment and surface water of natural lakes and aquaculture ponds of Bhimtal, Uttarakhand were screened for algicidal activity against *Microcystis aeruginosa*. Among them, only three bacterial strains had significant algicidal activity against *M. aeruginosa*. These

three strains were identified up to the species level by morphological characteristics and biochemical tests. The identities of the bacterial isolates were further confirmed by partial amplification of 16S rRNA gene and its homology comparison. The three bacterial isolates with algicidal activity were *Pantoea eucrina* (U8; KY426067), *Pseudomonas oryzihabitans* (U10; KY426066) and *Fictibacillus nanhaiensis* (U12; KY426064). All the three bacterial strains killed *M. aeruginosa* by direct contact, but had different algicidal process. Algicidal activity of strain U8 towards *M. aeruginosa* was initiated after 6 days of inoculation (1.66×10^6 cfu/ml) and the cyanobacterial cell component were extensively aggregated. Algicidal activity of U10 towards *M. aeruginosa* was observed after 5 days of inoculation (6.6×10^7 cfu/ml), and cells were significantly swollen, which subsequently resulted in lysis of cells. Algicidal activity of U12 was at peak after 6 days of inoculation (1.78×10^8 cfu/ml), and algal cells were decomposed. Filtrate from the bacterial cell was also added to *M. aeruginosa* culture, but no algicidal affect was observed. This suggests that extracellular secretions are not inhibitory to the cyanobacterium,



Algal lytic bacteria colonized near *Microcystis* sp.



Algicidal activity of *Pantoea eucrina*, *Pseudomonas oryzihabitans* and *Fictibacillus nanhaiensis*

and only direct contact between the bacterium and cyanobacterium are lethal. The pathogenicity of the algicidal bacteria was assessed by in-vitro enzymatic assay, and all the three strains were found to be non-pathogenic.

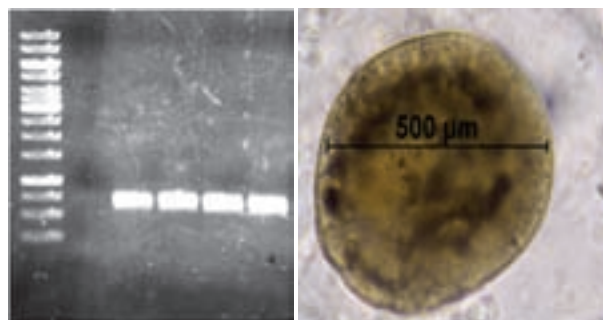
3.7.3. Surveillance of coldwater fish diseases in Himachal Pradesh and Uttarakhand (NFDB funded multi-institutional project)

Under the National Surveillance Programme for Aquatic Animal Diseases (NSPAAD), 82 trout and carp farms/hatcheries from 4 districts (Champawat, Almora, Chamoli and Udham Singh Nagar) of Uttarakhand and 2 districts (Kullu and Mandi) of Himachal Pradesh were visited for disease surveillance and base line data collection. Total 229 tissue samples were collected from 27 fish farms belonging to all six districts in both the states. Seventy six pooled samples were screened for viral, bacterial, fungal and parasitic pathogens. Screening for VHSV, IPNV and IHN by RT-PCR was confirmed to be negative in the samples collected from trout farms of both the states. Positive control developed earlier for the diagnosis of VHSV using RT-PCR was used for routine screening of the samples. The general profiling of bacterial flora characterized were *Aeromonas hydrophila*, *Aeromonas veronii* (ichthiosmia), *Aeromonas allosachharophila*, *Pseudomonas fluorescence*, *Citrobacter freundii*, *Escherichia coli*, *Micrococcus*, *Acidovorax facilis*, *Enterobacter*, *Morganella*, *Hafnia alvei*, *Enterococcus gallinarum* and *Carnobacterium*. Under passive surveillance, outbreak of itch disease in rainbow trout juveniles was observed at Champawat during August-September 2016. The infection caused the mortality of juveniles in the size range of 12-22 g. The infection was diagnosed and successfully controlled. Nucleotide sequences of fungal samples collected from nine rainbow trout farms of Himachal Pradesh was found similar to *Saprolegnia diclina*. The morphological characterization of *Saprolegnia* was done based on predominance of diclinous antheridia branches. Genotypic characterization was done using internal transcribed spacer (ITS) universal primer. Outbreak of Saprolegniasis in golden mahseer stock maintained at the mahseer hatchery complex, Bhimtal was also attended during

July 2016. During sample collection under active surveillance, base line data including important water quality parameters, GPS coordinates and altitude of all the fish farms/hatcheries from Himachal Pradesh and Uttarakhand were collected and uploaded to NSPAAD web portal.



Disease surveillance at Bairangana trout farm, Chamoli



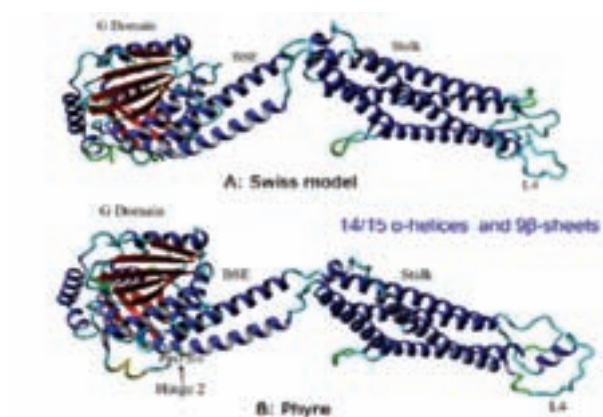
Molecular screening of *Saprolegnia* sp.

Tomite of *I. multifilis*

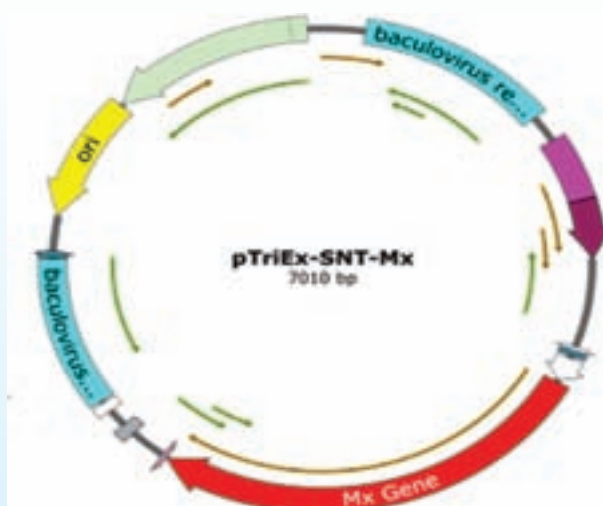
3.7.4. Development of a method for detecting the presence of any virus signal in clinical samples of fish (ICAR National Fellow Scheme)

Nucleotide sequence of the complete coding region of Mx gene along with UTR was obtained and submitted to NCBI GenBank (KU529282.1). The open reading frame of Mx was cloned in an expression vector pTRiEx1.1 for the expression of recombinant protein. Mx promoter region was identified using genome walking and characterized using bioinformatic tools namely Yapp, PATCH and JASPAR. Upon analysing the nucleotide sequence, it was evident that the said sequence qualified as promoter because it had the basic characters namely, transcription start site, a downstream promote element and a TATA box. A plasmid construct

(pGL-CMV-GFP-Neo) was developed in order to standardize transient transfection of CHSE-214 and EPC cells. Moreover, another construct pGL-RBT-Mxpro-GFP-Neo was developed that would act as a positive control in reporter gene assay. Likewise, snow trout Mx promoter was cloned in pGL-3-Mxpro-SNT-GFP. Transient transfection of CHSE-214 and EPC cells was standardized with two commercially available transfection agents and transfection was standardized using pGL-CMV-GFP-Neo. Other important interferon stimulated genes namely dsRNA dependent protein kinase (PKR) and interferon regulatory factor-3 (IRF-3) were also identified and cloned. The nucleotide sequences of the respective cDNA were submitted to GenBank (KX447496.1 and KX775963.1). Moreover, the open reading frame of PKR has been cloned in an expression vector to study the recombinant proteins.



3D structure of Mx protein



Snow trout Mx cloned in pTriEx1.1

3.7.5. National Mission for Sustaining the Himalayan Ecosystems - Ecosystem monitoring and sustainable development of coldwater fisheries in Himalayan regions of India (DST funded multi-institutional project)

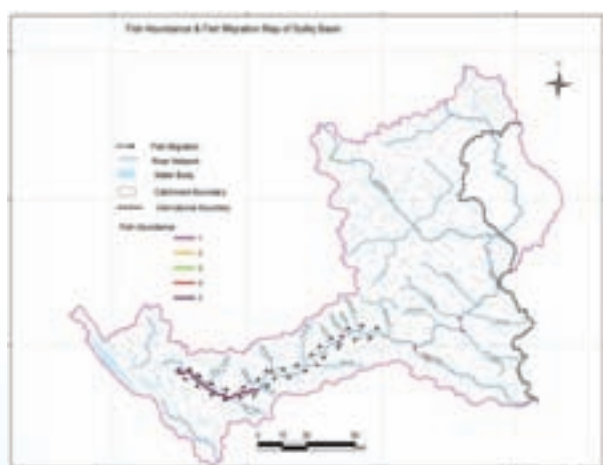
Under the NMSHE taskforce 6 on Himalayan agriculture, the ICAR-Directorate of Coldwater Fisheries Research has been entrusted with the responsibility to conduct research on sustainable fish production and food security in Himalayan areas, covering broader issues of resource mapping, monitoring and development of integrated fish farming in Himalayan region. In order to create a database and monitoring system, information on coldwater fish biodiversity was collected from different rivers, lakes and reservoirs of Himachal Pradesh and Uttarakhand, and mapping of fisheries resources was carried out. Water resources in these areas have also been digitized in GIS platform for the creation of resource map.



Digitized river network of Uttarakhand

The estimated total length of the river network in Himachal Pradesh was 10464 km, including 1431 km of main river course and 9033 km of subsidiary tributaries. In Uttarakhand, the estimated total length of the river network was 10928 km, including 2057 km of main river course and 8871 km of tributaries. Distribution of fish species in these river courses was found to be dependent on flow rate, nature of substratum, water temperature and availability of food. 35 fish species belonging to 6 orders, 9 families and 20 genera were recorded from Yamuna River. 51 species belonging to 13 families and 27 genera were recorded from Sutlej River. 21

species belonging to 5 families and 9 genera were recorded in the upper stretches of Ganga. 17 species belonging to 5 families and 15 genera were recorded in river Kosi. The major fish species in the rivers and streams of mid and lower Himalayas were *Schizothorax richardsonii*, *Schizothorax esocinus*, *Garra gotyla*, *Barilius bendelisis*, *Tor putitora*, *Bangana dero*, *Crossocheilus diplochilus* and *Labeo dyocheilus*. With respect to the cold desert Himalayan region, fisheries resource mapping was carried out in the major rivers of Ladakh division viz. Indus, Zaskar and Shyok. 21 species belonging to 3 orders, 4 families and 10 genera were recorded in these upland rivers of Ladakh, Jammu & Kashmir. Generally, the physicochemical characteristics of water and biotic parameters were significantly different between the main river course and side tributaries. The side tributaries were found to provide shelter, feeding and breeding ground for endemic species, supporting greater biodiversity, abundance and richness of native fish fauna. The altitudinal distribution and migration routes of the major species such as golden mahseer and snow trout were also examined.



Fish abundance and migration map of river Suttlej

For modelling and simulation in the context of climate change, data on weather, soil and water characteristics were collected and integrated in aquaculture suitability maps. For vulnerability assessment, indicators were categorized as sensitivity, exposure and adoptive capacity. Further, data concerning area under fish culture, total fish production, total number of fish seed

production units, workforce engaged in fisheries, fish eating population, gender gap, number of fisheries cooperatives, fisheries related policies and programmes were collected for Himachal Pradesh and Uttarakhand. Dudholi, Todera and Jur Kafun villages in Doonagiri area of Almora District, Uttarakhand and Chushout, Hunder and Thang village in Leh-Ladakh region have been selected as climate change related aquaculture hotspots for pilot study. Polylined ponds and raceways have been prepared to evaluate integrated carp farming in Almora and rainbow trout farming in Ladakh, respectively. Critical inputs like seed and feed were provided to the adopted farmers and fish culture cycle is being regularly monitored.



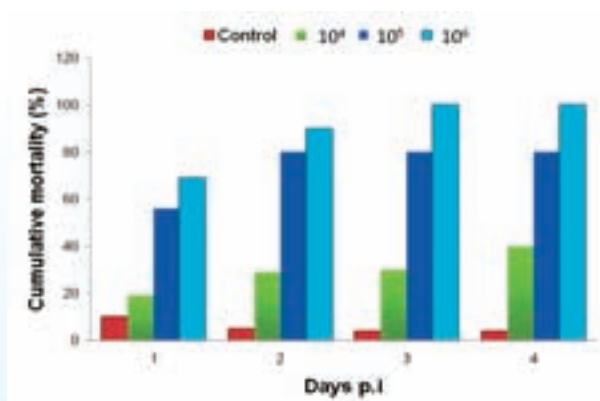
Integrated carp culture in polylined ponds at JurKafun

3.7.6. All India network project on fish health - Aquaculture medicine and therapeutics

Primary data on the use of aqua-drugs in hill aquaculture were collected from Imphal, Ukhrul and Thoubal districts of Manipur; and Dhimapur and Kohima districts of Nagaland. 45 farms in Manipur and 6 farms in Dhimapur were covered under the survey. The aqua-drugs used in Manipur were common salt, lime, KMnO_4 , CIFAX, Bio-F (probiotic), APC-Carpmin forte (mineral nutrient fortified with probiotics), Ultra Xide (antifungal and antibacterial), APC-Aquamix and Minamil (mineral vitamin mixtures), malachite green, GenOxy and OptiOxygen (DO improvers), Aquaflavin (antibacterial), BioKlean (soil probiotic) and APC- Planktomin. In Nagaland, salt was mostly used for treating bacterial infections in fish, while

lime was used for pond preparation. It was found that no other drugs, antibiotics and chemicals were used in aquaculture practices there. The state-wise database on the use of aqua drugs and chemicals in coldwater aquaculture were updated with the collected information.

Moreover, for addressing the food safety concern of aquaculture drugs, a laboratory trial was conducted to study the efficacy and target animal safety of oxytetracycline (OTC) on fingerlings of golden mahseer. Experimental fish (150 nos.) were collected from river Kosi in Ramnagar and acclimatized to laboratory conditions. The golden mahseer fingerlings were then challenged with *Aeromonas hydrophila*, laboratory strain RTS 02, by intra-peritoneally injecting three different concentrations i.e., 3.6×10^4 , 9.2×10^5 and 4.9×10^6 CFU/ml. Cumulative mortality increased when challenged with higher bacterial concentrations. Haemorrhages in the ventral body surface and vent were observed in the fishes infected with 10^6 CFU/ml *Aeromonas hydrophila* RTS 02. Histo-pathological examination of gill, liver and kidney revealed fusion and infiltration of mononuclear cells in primary gill lamellae; degeneration of glomeruli and increase in melanomacrophage (MMC) in kidney; focal hepatic necrosis, infiltration of inflammatory cells and MMC in liver. Efficacy study of oxytetracycline (OTC) is still under progress.



3.7.7. National network of germplasm centre for prioritized finfishes of Ganga basin (upland) for conservation and aquaculture

Subsequent to the establishment of coldwater fish germplasm repository centres at Bhimtal and



Exploratory collection of coldwater fish germplasm



Collected specimen of *Garra gotyla*

Champawat, exploratory surveys were carried out in some of the rivers and streams of upland Ganga river basin viz Kosi river, Ganga river, Gomati river, Saryu, Mahakali, Lohawati, Gaudi, Ladhiya, Chhirapani and Western Ramganga. Totally 3377 specimens of different endemic coldwater fishes such as *Schizothorax richardsonii* (2400 nos.), *Nazirator chelynooides* (185), *Tor putitora* (95), *Garra gotyla* (265), *Barilius bendelisis* (312), *Barilius vagra* (10) and *Schistura obliquofacia* (110) were collected from the tributaries of river Ganga and maintained in the germplasm repository. In terms of conservation and stock enhancement of important indigenous fishes, breeding of *Garra gotyla* was successfully attempted for the first time in DCFR, Bhimtal. Male and female brood fish were selected from the germplasm repository and were administered 0.2-0.4 ml/kg ovotide to induce spawning. Spawning period was observed to be 10-12 hours and hatching occurred 28-36 hours after injection. Likewise, breeding of *Schizothorax richardsonii* was successfully carried out at Bhimtal and Champawat field centre of DCFR during the months of October and November, and 10,000 fry

were produced. The cyclic changes in reproductive parameters such as gonado-somatic index (GSI) and fecundity of *S. richardsonii* and *N. chelynoidea* were also monitored from January to December 2016. In *Schizothorax richardsonii*, peak GSI values were recorded in the months of October-November. Average GSI in male ranged from 1 ± 0.2 (in May) to 9.8 ± 0.9 (in November), whereas the average GSI in female ranged from 3.1 ± 0.5 (in May) to 26.5 ± 1.8 (in November). Ova diameter ranged from 0.49 mm in May to 2.89 mm in November. The observed relative fecundity ranged from 10,800-11,600 ova per 100 g body weight. In *Nazirator chelynoidea*, peak GSI values in male (6.1) and female (15.8) were recorded in the month of August.

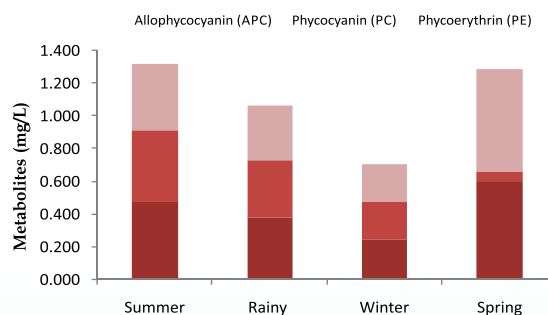
3.7.8. Variant of cyanobacterial metabolites and their significance on aquatic environment in a western Himalayan lake (DST-National Post-Doctoral Fellowship Scheme)

This study was carried out to establish the association of cyanobacteria with other ecological components and elucidate the possible role of their metabolites in the Naukuchiyatal lake ecosystem in central Himalayas. For this purpose, abundance of cyanobacteria, other planktons and spatiotemporal variations in depth-wise water quality were examined in monthly intervals. Out of the 77 plankton species identified, 6 species were cyanobacteria. Three species of the collected cyanobacteria were then isolated by repeated plating and axenically cultured using BG-11 Media under controlled environmental conditions. Cyanobacterial metabolites (phycocyanin, phycoerythrin, allophycocyanin,

phaeophytin, chlorophyll a, microcystin-LR, microcystin-YR and geosmin) were extracted from known quantity of cyanobacteria, quantified, cleaned up by solid-phase extraction and analysed using high-performance liquid chromatography. Based on the preliminary observations, it can be said that *Microcystis aeruginosa* may have buoyancy changing capacity which allows them to migrate to different depths (highest at 25 m in winter). Further, abundance of *Microcystis aeruginosa* was notably high during winter and it was influenced by dissolved oxygen concentration and N/P ratio of water. The toxic potential of the extracted cyanotoxins to fish, protozoa and other aquatic fauna is yet to be tested.



Culture unit for microalgae



LIST OF ONGOING PROJECTS

4.1. Institutional Projects

Project code	Project title	Project leader & associates	Year of start	Year of completion
A. Resource assessment and management				
CF-6	Ecosystem assessment and mapping of aquatic resources in Indian Himalayan region	D. Sarma (Coordinator)		
	Sub-project 1: Ichthyofaunal diversity, habitat assessment and molecular characterization of important species from the selected Himalayan drainages	S. Ali N.N. Pandey P. Kumar S.K. Mallik	2015	2018
	Sub-project 2: Habitat assessment and eco-biological study of selected mountain lakes of central and north-eastern Himalayan region	D. Sarma R.S. Patiyl D. Baruah P. Sharma R.S. Haldar	2015	2018
	Sub-project 3: Study on development of spatial database of coldwater fishery resources in western Himalayan region	P. Kumar A.K. Giri P.A. Ganie A.K. Saxena	2015	2018
	Sub-project 4: Assessment of population status, species diversity and habitat ecology of snow trout <i>Schizothorax</i> species in selected streams of Indian Himalayan region	D. Baruah D. Sarma P. Sharma K. Kunal P.A. Ganie	2016	2019
B. Aquaculture oriented research and development				
AQ-16	Captive management of golden mahseer in perspective to aquaculture and conservation	A.K. Singh (Coordinator)		
	Sub-project 1: Photo-thermal manipulation for gonadal maturity of golden mahseer in captivity	M.S. Akhtar D. Sarma Ciji, A. Rajesh, M.	2014	2017
	Sub-project 2: Molecular characterization and gene expression profiles of kiss genes in golden mahseer during different gonadal development stages	N. Shahi D. Thakuria	2014	2017
	Sub-project 3: Devising a feeding regimen based on return of appetite in golden mahseer (<i>Tor putitora</i>) larvae/juvenile	P. Sharma D. Sarma M.S. Akhtar	2016	2019
AQ-17	Decoding the constraints in growth, maturation and captive management of snow trout (<i>Schizothorax richardsonii</i> , Gray, 1832)	A.K. Singh (Coordinator)		
	Sub-project 1: Central and peripheral regulation of feed ingestion and nutrient uptake in snow trout, <i>Schizothorax richardsonii</i>	B.S. Kamalam N.N. Pandey P. Sharma	2015	2019

Project code	Project title	Project leader & associates	Year of start	Year of completion
	Sub-project 2: Nutrient mediated metabolic regulation of growth and well being in snow trout, <i>Schizothorax richardsonii</i>	M.S. Akhtar Ciji, A. A.K. Giri	2015	2019
	Sub-project 3: Myogenic regulation and protein turnover of muscle growth in snow trout <i>Schizothorax richardsonii</i>	Rajesh, M. D. Thakuria B.S. Kamalam	2015	2019
	Sub-project 4: Endocrine aspects of growth and maturity of snow trout, <i>Schizothorax richardsonii</i>	Ciji, A. Rajesh, M. P. Sharma P. Dash	2015	2019
	Sub-project 5: Development of captive management and seed production protocol of snow trout, <i>Schizothorax richardsonii</i>	S. Chandra A.K. Giri	2015	2019
AQ-19	Domestication, biology and breeding of selected fishes for species diversification in mid-hill aquaculture	N.N. Pandey (coordinator)		
	Sub-project 1: Domestication, biology and captive breeding of Indian trout <i>Raiamas bola</i> (Hamilton, 1822)	N.N. Pandey S. Ali R.S. Haldar	2015	2018
	Sub-project 2: Captive rearing, breeding biology and seed production performance of <i>Bangana devdevi</i> , <i>Labeo pangusia</i> and <i>Osteobrama belangeri</i> , three endemic fishes of North Eastern Himalaya	D. Sarma D. Baruah P. Sarma	2016	2019
	Sub-project 3: Domestication, biology and breeding of selected indigenous ornamental fish species of coldwater region	S.G.S. Zaidi N.N. Pandey	2016	2019
C. Molecular genetics and biotechnology				
AQ-15	Bioprospecting of genes and allele mining for thermal stress tolerance of <i>Schizothorax richardsonii</i>	A. Barat P.K. Sahoo S. Ali Siva, C.	2014	2017
AQ-18	Development of fish viral peptide based nano system for intracellular delivery of biomolecules	D. Thakuria N. Shahi K.V. Chanu R.A.H. Bhat	2015	2018

4.2. Inter-Institutional Outreach Activities (Fisheries Division-ICAR)

Project code	Project title	Project leader & associates	Year of start	Year of completion
NMP-1	Fish genetic stock	A. Barat P.K. Sahoo S. Ali R.S. Patiyal Siva, C.	2014	2018
NMP-2	Fish feed	N.N. Pandey S. Chandra M.S. Akhtar B.S. Kamalam	2014	2018

Project code	Project title	Project leader & associates	Year of start	Year of completion
NMP-3	Nutrient profiling and evaluation of fish as a dietary component	D. Sarma M.S. Akhtar Ciji, A. P. Sharma	2014	2018

4.3. Inter-Institutional Collaborative Projects (ICAR)

Project code	Project title	Project leader & associates	Year of start	Year of completion
CIFT-DCFR	Investigations on fish behaviour and responsible fishing system	R.S. Patiyal P. Kumar	2015	2018
VPKAS-DCFR	Development and evaluation of polyhouse covered fish polytank for fish rearing in high hills of Uttarakhand under All India Coordinated Research Project on Plasticulture Engineering and Technologies	N.N. Pandey R. Singh	2015	2018

4.4. Externally Funded Projects

Project code	Project title	Project leader & associates	Year of start	Year of completion
DBT-5	Development of bacterial bioremediation measures for the mitigation of microalgal blooms in freshwater aquaculture ponds	N. Shahi S.K. Mallik	2014	2017
NSPAAD	National surveillance programme on aquatic animal diseases - Surveillance of coldwater fish diseases in Himachal Pradesh and Uttarakhand	S. Chandra S.K. Mallik R.S. Tandel R.A.H. Bhat	2014	2017
ICAR-National Fellow	Development of a method for detecting the presence of any virus signal in clinical samples of fish	A. Pande	2014	2019
NMSHE	National Mission for Sustaining the Himalayan Ecosystems (Taskforce 6 for Himalayan Agriculture) (A) Ecosystem monitoring and sustainable development of coldwater fisheries in lower and mid Himalayan regions of India	N.N. Pandey S. Ali R.S. Patiyal Rajesh, M. P. Kumar	2015	2019
	(B) Ecosystem monitoring and sustainable development of coldwater fisheries in cold desert Himalayan regions of India	P. Kumar N.N. Pandey B.S. Kamalam A.K. Giri	2015	2019
AINP-Fish Health	All India network project on fish health: Aquaculture medicine and therapeutics (Component-1)	S.K. Mallik N. Shahi R.S. Tandel	2015	2017
CRP-AB	National network of germplasm centre for prioritized finfishes of Ganga basin (upland) for conservation and aquaculture	R.S. Patiyal S. Chandra	2014	2017
DST-NPDF	Variant of cyanobacterial metabolites and their significance on aquatic environment in a western Himalayan lake	S.I. Singh D. Sarma	2016	2018

IMPORTANT EVENTS AND MEETINGS

5.1. Research Advisory Committee meeting

The RAC meeting was convened at Bhimtal during 24-25 March 2017. The RAC meeting was chaired by Dr. M. Sinha and attended by the esteemed members Dr. S. Raizada, Dr. S.C. Mukherjee, Dr. A.K. Sahu and Dr. H.C.S. Bisht. At the outset, the new research advisory committee was welcomed and apprised of all the research and development activities of the Directorate by Dr. A.K. Singh, Director. Following which, brief presentations on the progress of each institutional and external research projects were given by the principal investigators. The RAC critically discussed the progress and achievements of the ongoing



Dr. A.K. Singh presenting the Directorate's activities to RAC



Release of the Hindi magazine 'Himjyoti' by RAC

and completed projects. The committee also gave important suggestions for the progress of the projects and appreciated the collective efforts made by the Directorate to address research gaps and challenges in coldwater fisheries and aquaculture sector. During the meeting, the hindi magazine of the Directorate 'Himjyoti' was released by the RAC chairman and members.

5.2. Institute Research Committee meeting

The IRC meeting of the Directorate was held on 18-19 May 2016 under the chairmanship of Dr. A.K. Singh, Director. Progress of the ongoing research projects and proposals for new projects were presented by concerned scientists. This was followed by thorough discussion, appraisal and comments on future orientation of the technical programme.



Project discussion during IRC meeting

5.3. Institute Management Committee meeting

The IMC meeting of the Directorate was convened on 25th March 2017 under the chairmanship of Dr. A.K. Singh, Director. Other respected members present during the meeting were Dr. S. Raizada, Dr. R.S. Chauhan, Shri G.B. Oli, Dr. S.K. Verma, Dr. J.K. Bisht, Shri K. Kalia, Shri P.



IMC meeting

Bisht and Shri R.S. Negi (member secretary). Issues related to institute management and procurement proposals were discussed and approved.

5.4. Foundation day celebration

The 29th foundation day of the Directorate was commemorated on 24th September 2016. The occasion was graced by guests of honour Dr. B.S. Bisht, Director, BIAS and former vice-chancellor, GBPUAT, Dr. R.S. Chauhan, Dr. S. K. Verma and Dr. Dinesh Sati. The function was attended by all the scientist, staff and research scholars of the Directorate and local dignitaries. Dr. A.K. Singh, Director, briefed the gathering about the various activities and accomplishments of the Directorate. Following that, Dr. Dinesh Sati, a senior geologist, delivered the foundation day lecture on Himalayan geology and provided interesting insights on the formation and geological dynamicity of Himalayas.



Dr. Dinesh Sati delivering the foundation day lecture

5.5. Agriculture education day

To create awareness among the children and youth about the role and contribution of agriculture in the economy and development of the country, and the importance of agriculture education in the creation of trained manpower for catering to the needs of the farmers, the Directorate organized 'Agriculture education day' activities on 3rd December 2016 at Bhimtal and Champawat. An essay competition was organized on the topic 'Importance of agriculture in the country's development' for the students of Lakes International School, Bhimtal. Totally 96 students of class X, XI and XII enthusiastically participated in the competition. Likewise, an oral quiz competition on the same theme was organized for the students at Government primary and higher secondary school, Morari, Champawat. 61 students actively participated in the quiz competition and all the winners were given prizes. On this occasion, an invited talk on the topic 'Agriculture education: its role and importance' was also organized at ICAR-DCFR, Bhimtal. The talk was delivered by eminent academician, Dr. B.S. Bisht, Director, Birla Institute of Applied Sciences and Former Vice-Chancellor, GBPUAT, Pantnagar. Dr. Bisht elaborated the different avenues and opportunities of agriculture education available in the country and abroad, and urged the students for choosing agriculture related career in their life to serve the country's farming communities. Students and teachers of Lake



Essay competition at Lakes International School, Bhimtal



Awareness talk at Govt. school, Champawat



Cleaning of laboratories

International School and the staff of the Directorate participated in the programme. The event was coordinated by Dr. Prem Kumar, Dr. S. Ali, Mr. A.K. Giri and Dr. R. Singh.

5.6. Swachhta Pakhwara

Under the Swachh Bharat Mission of the Government of India, Swachhta Pakhwara was enthusiastically observed at the Directorate's headquarters at Bhimtal and field centre at Champawat in two phases during 2-31 October 2016. All the scientists, staff, research scholars and contractual personnel undertook the oath of Swachhta mission and devoted one hour each day and actively participated to achieve the cleanliness goals and objectives of the Swachhta Pakhwara. Various activities such as cleaning of office premises and adjoining areas of the campus were organized. Initiatives were also taken to create interest and awareness among locals for cleanliness and proper disposal of waste. Signboards indicating waste



Display of cleanliness signboard at Bhimtal lake

disposal and garbage bins were installed at various places in and around the campus. All the staff and scholars of the Directorate were also urged to spread the message of Swachh Bharat Mission in their localities and organize Swachhta Abhiyan in their colonies/mohallas. Besides, practical talks on positive thinking and living; conservation of environment and sustainable living was delivered by Dr. H.C. Kapil and Dr. N.P. Melkania.



Cleaning inside the Directorate's premises

5.7. National productivity week

National productivity week was observed at the Directorate during 12-18 February 2017, with the theme 'From waste to profits through reduce, recycle and reuse'. A recycling pit was dug out to burn and reuse the degradable waste collected within the premises. During this period, awareness on the importance of fish as wellness indicators of aquatic ecosystems and other fish conservation and culture activities were imparted to 74 visiting students and staff of Whitehall School, Haldwani and 45 B.V.Sc students from Mizoram.

5.8. Vigilance awareness week

Vigilance week was observed at the Directorate during 31st October to 5th November 2016, with the theme 'Public participation in promoting integrity and eradicating corruption'. To create awareness of vigilance among the staff and scholars of the Directorate, lecture on 'moral and ethics for public servant' was delivered by Dr. S. Ali, Scientist. A vigilance pledge was collectively undertaken by all the staff and scholars. Essay writing and slogan writing competitions on the methods for eradicating corruption and the impact of corruption on integrity were conducted and the winners were given prizes.



Staff undertaking vigilance pledge

5.9. Independence and Republic day celebration

On 15th August 2016 and 26th January 2017, the Independence and Republic day of our nation was celebrated with a flag hoisting ceremony attended



Flag hoisting ceremony

by all the scientist and staff of the Directorate. Dr. A.K. Singh, Director, unfurled the national flag and encouraged the gathering to work in unison to achieve scientific breakthroughs that will benefit the different stakeholders involved in cold water fisheries and aquaculture.

5.10. International Yoga day celebration

As per the Government of India directive, the Directorate observed the International Yoga day on 21 June 2016 by organizing yoga session and lecture at Bhimtal and Champawat. During the early morning yoga session, various yoga asanas were demonstrated to the participants by the resource persons Dr. Shahla Zaidi, Dr. H.C. Kapil and Shri R. Gahtori. In the afternoon lecture, the importance of yoga for leading a healthy life was emphasized.

5.11. Hindi 'Saptah samaroh' celebration

To promote and recognise Hindi knowledge among the staff of the Directorate, the Hindi section in-charge Shri A.K. Joshi conducted several intramural linguistic competitions during September 2016. Prizes were distributed to the winners during the Foundation day celebration. In the same way, Hindi pakhwada related competitions were also conducted in the Experimental Field Centre at Champawat during 1-15 September 2016. Besides, a Hindi karyashala was organized for the students of Government Inter College, Champawat on 14th September 2016 on the topic 'Himalayee kshetron mein jalbayu parivartan ki chunotiyan'. The programmes at Champawat were coordinated by Dr. S. Chandra and Mr. A.K. Giri.



Hindi Karyashala organised at Champawat

EXTENSION ACTIVITIES AND OTHER SERVICES

Various extension activities such as farmer advisories, scientist-farmer interaction meets, farm input distribution, awareness programmes, frontline demonstrations, and exhibitions were carried out to disseminate the technological developments made by the Directorate to farmers.

6.1. Farmer oriented extension activities

- To commemorate 'Fish farmers day', a public awareness meet 'Kisan Goshti' was organized on 10th July 2016 at ICAR-DCFR field centre, Champawat. A mixed group of 40 men and women fish farmers of Champawat district attended the meet. They were briefed about the prospects of coldwater fish culture in hills, disease management in rainbow trout and composite carp farming and were shown the various activities of the field centre. Improved Hungarian strain common carp seed was distributed to interested fish farmers. The programme was coordinated by Dr. S. Chandra and Mr. A.K. Giri.



Field demonstration to farmers at Champawat

- Under the pilot study activity of National Mission for Sustaining the Himalayan Ecosystems, the Directorate organised awareness cum training programme on composite carp culture in poly-lined ponds for fish farmers at Jur Kafun village,

Almora on 18th November 2016. Hands-on training was given to the farmers on fish feed preparation and feeding using *Azolla*. On the occasion, carp seed were also distributed to some farmers. Data on water quality and fish growth were recorded in all the demonstrated fish ponds. The programme was coordinated by Dr. N.N. Pandey and Dr. Prem Kumar.



Distribution of carp seed for stocking

- Under the National Surveillance Programme on Aquatic Animal Diseases (NSPAAD), a one day mass awareness programme was organised on 'Disease management in coldwater aquaculture' at Bhimtal on 2nd July 2016. It was attended by 28 fish farmers from different



Dr. T. Mohapatra interacting with the farmers

villages in Champawat district. The participants were made aware about the commonly occurring diseases in hill aquaculture practices, importance of routine disease surveillance and better health management practices. During the programme, Dr. T. Mohapatra, Director General of ICAR, interacted with the farmers and emphasized on the potential of aquaculture to uplift their socio-economic status.

- Under NSPAAD, another one day mass awareness programme on fish health management was organised at Gadigaon village of Chamoli district, Uttarakhand on 21st February 2017. Totally 30 farmers from fishermen communities residing near the Alaknanda river and its tributaries participated in the programme, which was graced by Shri Gajendra Singh, Deputy GM (Environment), Tehri Hydro Electric Power Development Corporation. Basics of fish farming in ponds/raceways and disease control were discussed during the programme, which was coordinated by Dr. S. Chandra and Mr. S.K. Mallik.



Participants of the awareness programme at Gadigaon

- Scientific and technical guidance was provided to Mr. Alok Naskar, a farmer-entrepreneur from Bhimtal, on the integrated backyard culture of Hungarian strain common carp and grass carp with poultry. Every aspect was covered right from pond construction, fish stocking, feeding and water quality management. Further, bimonthly sampling is being carried out to monitor growth and water quality throughout the crop cycle. At the end of 11 months of culture, the average size of common carp was



Netting for growth assessment

35 g (from an initial weight of approx. 1 g) at an overall survival rate of 90%. The maximum size of fish was however, 810 g. The above activity is monitored by Dr. R.S. Haldar, Dr. Biju Sam Kamalam and Mr. Rajesh, M.

- On the occasion of world soil day, a scientist-farmer meet and demonstration was organised at Katharh village, Champawat on 5th December 2016. Given the importance of soil for any kind of farming practice including pond aquaculture, the ten farmers were demonstrated field methods to test various soil parameters such as pH, organic carbon, nitrate and phosphate. The programme was coordinated by Mr. A.K. Giri and Dr. Raghvendra Singh.



Demonstration of soil analysis

- In the agro-biodiversity seminar organized by ICAR-NBPGR regional centre, Bhowali at Dar village in Dharchula, Uttarakhand, on 20th October 2016, Dr. Raghvendra Singh and Mr. Kishor Kunal shared valuable information with farmers on the prospects of hill aquaculture and fisheries development in Darma valley.



Dr. R. Singh sharing the prospects of hill aquaculture

6.2. Rehabilitation of endangered and threatened endemic coldwater fishes

Under the national network of fish germplasm conservation, the Directorate organized a ranching and rehabilitation programme of golden mahseer (*Tor putitora*) and snow trout (*Schizothorax richardsonii*) at the confluence of the rivers Saryu and Mahakali at Pancheshwar, Champawat district of Uttarakhand on 24th October 2016. The programme coincided with the International Angling Event jointly organized by Uttarakhand Tourism and Kumaon Mandal Vikas Nigam Ltd. Totally 1500 fingerlings of the endemic golden mahseer and Indian snow trout were released at the selected river site, in the presence of Shri Hemesh Kharkwal, Honourable

Parliament Secretary and Member of Legislative Assembly from Champawat, Admiral D.K. Joshi (retd.) and other dignitaries, eminent journalists and anglers from various regions of the country and abroad. The programme was coordinated by Dr. R.S. Patiyl and Dr. D. Baruah.



Golden mahseer and snow trout ranching at Pancheshwar

6.3. Participation in exhibitions

The research and development activities of the Directorate were exhibited and disseminated to farmers, students, researchers and other stakeholders at several conferences, seminars, symposia, workshops and kisan melas organized across the country. The details of the participations are mentioned in the table below.

Kisan Mela, ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora	9 th April 2016
PAF 3 rd Congress on Social Entrepreneurship in Aquaculture, ICAR-CIFE, Mumbai	27-29 April 2016
National conference on Developing Strategies and Institutions for Mahseer Conservation in India, School of Biotechnology, Devi Ahilya University, Indore	9-11 September 2016
100 th Kisan Mela and Agro-Industrial Exhibition, GBPUA&T, Pantnagar	17-20 October 2016
Regional Agriculture Fair (RAF) as Krishi Kumbh 2016, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut	28-30 November 2016
National seminar on Aquaculture Diversification: the way forward for Blue Revolution, ICAR-CIFA, Bhubaneswar	1-3 December 2016
XIII Agricultural Science Congress 2017, University of Agricultural Sciences, Bengaluru	21-24 February 2017
2 nd National Student Convention on Innovative Approaches for Academic Excellence in Higher Fisheries Education, ICAR-CIFE, Mumbai	3-5 March 2017
101 st Kisan Mela and Agro-Industrial Exhibition, GBPUA&T, Pantnagar	4-7 March 2017
National seminar on Priorities in Fisheries and Aquaculture, College of Fisheries, Rangeilunda, Berhampore, Odisha	11-12 March 2017
Krishi Unnati Mela 2017, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi	15-17 March 2017
Kisan Mela, ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora	22 nd March 2017



ICAR-DCFR exhibit in UAS, Bengaluru



Dr. T. Mohapatra, DG, ICAR in DCFR stall at ICAR-CIFE, Mumbai

6.4. Farm activities

Breeding and seed production of common carp

Breeding and large scale seed production of the improved Hungarian scaly and mirror carp strains was carried out at Champawat field centre during April to June 2016. Total 450 female brooders in the mean size range of 224-664 g were used for breeding



Selection of common carp brooders

purpose. Totally 7.29 lakh fry were produced. Based on demand 26,230 seed of various size groups (fry, fingerling and stunted yearlings) has been sold or distributed to fish farmers of Champawat, Almora and Nainital districts and state fisheries department of Uttarakhand earned revenue of Rs. 28150. The entire activity was coordinated by Dr. S. Chandra and Mr. A.K. Giri.



Common carp spawn



Common carp seed distribution

Maturity status of grass carp and silver carp brooders was also examined during July 2016 for subsequent breeding attempt. However, the females



Assessment of gonadal maturity in grass carp

of both the species were not found to be matured for spawning, whereas 5-7% of males were oozing milt.

Breeding and seed production of mahseer

For the purpose of breeding and seed production, 100 pairs of golden mahseer (*Tor putitora*) brooders and 30 pairs of chocolate mahseer (*Neolissochilus hexagonalepis*) brooders are being maintained at the Directorate's mahseer hatchery complex at Bhimtal. During the reporting period (2016-17), totally 65,000 seed of *Tor putitora* were produced and Rs. 2.3 lakh revenue was generated from the sale of golden mahseer seed. Besides, 5000 seed of chocolate mahseer was produced in the Directorate's aquarium facility. For rehabilitation of the natural population, 10,000 seed of golden mahseer were ranched in Bhimtal lake. Another 10,000 fingerlings of golden mahseer are being maintained in the rearing pond of mahseer hatchery for experimental purpose. The breeding activities were coordinated by Dr. D. Sarma and Dr. M.S. Akhtar.



Netting of mahseer brooders at Bhimtal hatchery complex

Seed production of rainbow trout

As the rainbow trout brooders maintained in the Champawat field centre of the Directorate was lost in an unavoidable natural black water event in April 2016, 1 lakh rainbow trout eyed ova were obtained from Kokernag trout farm, Jammu & Kashmir. Another batch of 10,000 rainbow trout eyed ova was obtained from Patlikuhel trout farm, Himachal Pradesh. Following incubation and larval rearing in the trout ova house at Champawat, approximately 56,000 rainbow trout fry were produced. Besides,

rainbow trout fingerlings of the size range 3.3-8.8 g were distributed to the tribal farmers of Munshyari, under TSP programme. The scientific team of Dr. S. Chandra, Dr. R.S. Patiyal, Mr. A.K. Giri, Dr. R. Singh, Mr. R.A.H. Bhat, Mr. P.A. Ghanie and Mr. K. Kunal were involved in the rainbow trout seed production activity.



Incubation of eyed ova in the trout hatchery at Champawat



Supply of rainbow trout seed to State Dept. of Fisheries, Uttarakhand

Collection, breeding and seed production of snow trout

To revamp the experimental stock in Champawat field centre, 650 adult and 3000 fry of snow trout (*Schizothorax richardsonii*) were collected from Chalthi, Gaudi and Chhirapani streams. During September 2016, breeding of snow trout was carried out and totally 38000 fry were produced with an observed functional fecundity of 1218-1674; fertilization rate, 74-78%; incubation period, 120-144 hours; and hatching rate, 36-42% at water temperature 17.8-18.7°C. The entire activity was coordinated by Dr. S. Chandra and Mr. A.K. Giri.



Wild collection of snow trout



Snow trout brooders at Champawat

Breeding and seed production of ornamental fish

Breeding and seed production of ornamental fish viz. goldfish and koi carp was successfully carried out in the farm complex at Bhimtal and revenue of Rs. 16,460 was generated from the sale of ornamental fish. The entire activity was coordinated by Dr. R.S. Patiyal.



Seed production and sale of ornamental fish

6.5. Farmer and student visits

- A group of 18 fish farmers and 2 fisheries department officers from Meghalaya visited the ICAR-DCFR facilities at Bhimtal during 21-24 July 2016 and interacted with the scientists.



Meghalaya farmers visiting the farm complex at Bhimtal

- A group of 22 undergraduate students from College of Fishery Science, S.V. Veterinary University, Muthukur, Andhra Pradesh visited ICAR-DCFR, Bhimtal on 12th August 2016 and interacted with the scientists.



Student visit to Mahseer hatchery at Bhimtal

- A group of 104 students from St. Joseph's College, Nainital visited ICAR-DCFR, Bhimtal on 15th September 15, 2016 and interacted with the scientists.
- A group of 50 farmers associated with Sri Karan Narendra Agriculture University, Jobner, Jaipur district, Rajasthan visited ICAR-DCFR, Bhimtal during 23rd October 2016 and interacted with the scientists.



Rajasthan farmers at ICAR-DCFR, Bhimtal

- A group of 74 students of Class X from Whitehall School, Lamachaur, Haldwani, visited ICAR-DCFR, Bhimtal on 10th February 2017 and interacted with the scientists.
- A group of 43 undergraduate students from College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan visited ICAR-DCFR, Bhimtal on 7th March 2017 and interacted with the scientists.
- A group of 32 postgraduate students from Department of Zoology, University of Burdwan, West Bengal visited ICAR-DCFR, Bhimtal on 20th March 2017 and interacted with the scientists.
- A group of 21 undergraduate students from B.M. College of Agriculture, Rajmata Vijayaraje Sindhia Krishi Vishwa Vidyalaya, Khandwa (Madhya Pradesh) visited ICAR-DCFR, Bhimtal on 21st March 2017 and interacted with the scientists.
- A group of 23 postgraduate (M.Sc., Zoology) students from Babasaheb Bhimrao Ambedkar University, Lucknow (Uttar Pradesh) visited ICAR-DCFR, Bhimtal on 30th March 2017 and interacted with the scientists.

- A group of 13 postgraduate (M.Sc., Zoology) students with fisheries specialization along with two faculty from Aligarh Muslim University visited ICAR-DCFR, Bhimtal on 31st March 2017 and interacted with the scientists.
- A group of 40 students of Govt. P.G. College, Champawat visited the ICAR-DCFR experimental field centre on 12th November 2016 for professional exposure. They were given practical demonstrations and lectures on rainbow trout and carp farming.



Practical demonstration for students at Champawat

- A group of 150 students along with their teachers from Fulargaon Public School, Champawat visited the ICAR-DCFR field centre at Champawat, they were demonstrated trout and carp farming activities.
- A group of 40 students along with their professors from Govt. Inter College, Tamli, visited the ICAR-DCFR experimental field centre, Champawat for their professional exposure.

TRIBAL SUB PLAN ACTIVITIES

In order to promote hill aquaculture and allied activities as a means of livelihood enhancement for the tribal farmers in rural areas of Uttarakhand and Jammu & Kashmir, the Directorate carried out various research and developmental activities under TSP programme. The details are listed hereunder.

7.1. Promotion of rainbow trout farming in Leh, Jammu & Kashmir

Keeping in view the harsh climatic and livelihood conditions in the cold arid zone of Ladakh, ICAR-DCFR has been painstakingly making efforts to establish rainbow trout culture in Leh by raising a cluster of raceways under the Tribal Sub Plan programme. Further to popularize trout culture as a source of employment and protein rich food, an awareness cum training programme on rainbow trout farming in highlands was organized at Chushout Shamma village, Leh on 2nd October 2016. The training was attended by 21 women of a self-help group and 4 youths. Some of the participants expressed interest in adopting the technology. Moreover, considering the difficulties in the timely availability of rainbow trout seed and to make farmers self-sufficient, the Directorate has initiated and established a rainbow trout ova hatching facility at Chushout Shamma village, Leh, with the



Survey for restoration and revival of trout culture in Leh

support of scientists from HMAARI, Stakana and ICAR-CAZRI, Leh. Two new tribal beneficiaries have also been identified in Nubra valley, Leh, to expand rainbow trout culture in the high altitude region. Besides, a detailed survey was undertaken to ascertain the extent of damage and siltation due to flash floods in previously constructed raceways, eventually for restoration of culture units and revival of rainbow trout culture in Leh.

7.2. Promotion of rainbow trout farming in disadvantaged areas of Uttarakhand

To initiate and promote rainbow trout farming as a remunerative livelihood option in the remote border areas of Dharchula and Munshyari, totally nine trout raceways have been constructed. Besides, the construction of four new raceways and a rainbow trout ova hatching facility is presently in progress at Munshyari. Further, 1.25 lakh eyed ova were procured from Department of Fisheries, Himachal Pradesh and Jammu & Kashmir; and incubated, hatched and reared at Bhimtal (25,000) and Champawat (1 lakh) for distributing to the farmers adopted under TSP. In the month of March 2017, optimum size rainbow trout fingerlings were stocked in the four newly constructed raceways in Munshyari, Pithoragarh district. Other input such as feed was also provided to the adopted tribal farmers.



Awareness cum training programme on rainbow trout farming in Leh



Incubation of eyed ova and rearing of trout at Bhimtal



Counting of trout fingerlings



Stocking and culture of rainbow trout in Munshyari



Packing of trout fingerlings in plastic bags

7.3. Field experimentation on prolonged transport of rainbow trout fingerlings

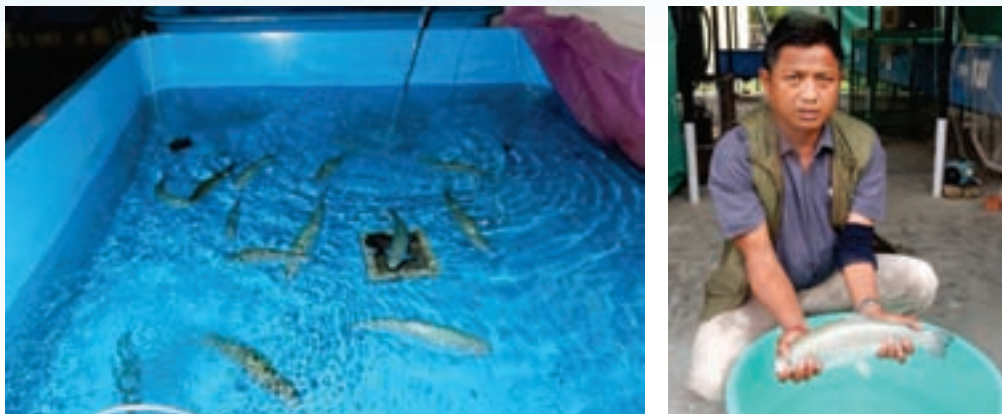
Under the TSP programme, a field investigation was carried out to optimize the long haul conditions suitable for transporting stock-size rainbow trout. The experimental fish (mean weight 4 ± 2 g and mean total length 5.5 ± 1.5 cm) were packed in plastic bags containing 6 L of stream water and 12 L of pressurized oxygen atmosphere, and transported by road in refrigerated truck at a constant temperature of 13°C . The total distance covered and duration taken was 750 km (from Patlikuh, Himachal Pradesh to Bhimtal, Uttarakhand) and 40 h, respectively. Critical factors such as starvation period, loading density, addition of salt and mild sedation with clove oil were evaluated based on fish survival and changes in water characteristics. On the basis of zero fish loss after transport and least adverse water quality, it is recommended that a starvation period of 72 h, loading density of 26.7 g/L and light sedation of fish with 40 ppm clove oil prior to packing is suitable for transporting rainbow trout juveniles in plastic bags up to 40 h.



Determining the changes in transport water quality

7.4. Experimental culture of rainbow trout in FRP tanks

With the objective to promote small-scale farming of rainbow trout in remote tribal areas, an experimental attempt was made to culture rainbow trout in portable FRP tanks (2000 L capacity with 1200 L water volume and 12 L/minute water flow). 550 rainbow trout fingerlings of mean weight 5 g were stocked and reared at $18\text{--}20^\circ\text{C}$ for a period of six months (May to October 2016). At the end of the trial, the total fish biomass in the tank was nearly 23 kg, with an average weight of 61 g and 70% survival.



Rainbow trout culture in FRP tank

Similarly, trout of mean weight 330 g reached 1020 g in 7 months (September 2016 to March 2017), when reared in FRP tanks at low densities. In a year, 550 g weight gain from eyed ova stage was noted. The preliminary observations suggest a promising prospect for backyard trout farming in FRP tanks.

7.5. Evaluation and optimization of a gravel bed biofiltration system

In order to minimize water usage in the rearing of rainbow trout and golden mahseer, a submerged gravel bed bio-filter was designed and developed. The characteristics of the in-built biofilter unit were as follows: depth of filter bed, 16 cm; surface to volume ratio, $800\text{m}^2/\text{m}^3$; water flow rate through the filter bed, 3600L/h; turnover rate, 5 times/h; water volume in rectangular FRP tank ($1.5 \times 1 \times 0.6\text{ m}$) 700 L. For calculating the NH_3 removal efficiency of the biofilter, different known levels of ammonia source (NH_4Cl_2) were added and the dynamics of TAN, NO_2 and NO_3 were studied. Initially, after the addition of 3 ppm TAN in the unit, the biofilter removed the entire NH_3 load in 6 days and corresponding NO_2

load in 7 days. But once the biofilter was matured, it had the capacity to remove 8 ppm of NH_3 and NO_2 within a day. In the next step, 7 kg of fish biomass were maintained in 1000 L circular tank with 1% feeding rate (CP 45%) without exchanging water until 3 days. As NO_3 levels were found to reach 40-60 ppm on the 4th day, 50% of water was cyclically exchanged on every 4th day to reduce the build-up of NO_3 . This simple low cost biofilter prototype has potential application for rearing fishes in hills by using limited water resource.



Evaluating the efficiency of gravel bed biofiltration unit

NORTH EAST HILL ACTIVITIES

Under the NEH programme, various research and development activities have been carried out in different north-eastern states namely Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Assam and Nagaland. The details of which are listed hereunder.

8.1. National interactive meet on mahseer in recreational fisheries and angling festival

The Directorate organized a two days national interactive meet of scientists, stakeholders and entrepreneurs on 'Mahseer in recreational fisheries and eco-tourism in north-east India' during 1-2 October 2016 at Jasingfaa Aqua Tourism Resort, Nagaon, Assam. The meet was inaugurated by Shri Parimal Shuklavidya, Honourable Minister of Fisheries, Govt. of Assam. The other dignitaries present were Dr. K.K. Vass, former Director, ICAR-CIFRI and ICAR-DCFR; Dr. P.C. Mahanta, former Director, ICAR-DCFR; Dr. A.K. Singh, Director, ICAR-DCFR; Dr. Gopal Krishna, Director, ICAR-CIFE; Dr. Kuldeep K. Lal, Director, ICAR-NBFGR; Directors of different State Fisheries Departments Mr. R.K. Dogra (Jammu & Kashmir), Mr. S.K. Das (Assam) and Mr. S.P. Singh (Mizoram); Mr. S.N. Ogale; Dr. K.K. Tamuli, Dean, AAU; Dr. Atul Borgohain, ABACA; Deputy Directors of Fisheries Mr. Neithoo, K. (Nagaland) and Mr. Tage Angom (Arunachal Pradesh); and Dr. R.N. Bhuyan, St. Anthony's College. About 120 delegates from different parts of the country including scientists, academicians, state fishery officials, NGO's and entrepreneurs participated in the meet. The various possibilities to sustainably exploit the socio-economic value of mahseer as a sport fish and to develop mahseer based recreational fisheries and ecotourism in northeast India was deliberated upon. The fish based eco-tourism model established at Jasingfaa Aqua Tourism Resort with the technical



Shri Parimal Shuklavidya inaugurating the national meet



Release of technical bulletin by Shri Shuklavidya and other dignitaries

support of ICAR-DCFR was appreciated. On the occasion, a technical bulletin entitled 'Mahseer in recreational fishery and ecotourism in India' was also released by Shri Shuklavidya. The programme was coordinated Dr. D. Sarma, Dr. D. Baruah, Dr. R.S. Patiyal, Mr. R.S. Tandel and Dr. R.S. Haldar.

In tandem with the national meet, the 6th North-East Angling Festival was also organized. About 100 anglers from north-eastern states and other parts of the country eagerly participated. Dr. A.K. Singh, Director, ICAR-DCFR inaugurated the angling festival. Shri Parimal Shuklavidya and Dr. P.C. Mahanta handed over the prizes to the winners of the angling competition. Moreover, a one day



Dr. A.K. Singh inaugurating the angling festival



Chocolate mahseer hatchery at Suteplenden, Nagaland



Hands-on training given by Mr. Derek D'Souza on angling



Chocolate mahseer hatchery at Tura, Meghalaya

workshop on 'Environmental conservation through angling' was organized, where about 50 participants including 30 post graduate students of the Tourism Department, Assam were trained on various aspects of eco-tourism through mahseer fish watching and angling by Mr. Derek D'Souza, a recognized International Angler from Bengaluru.

8.2. Development of captive breeding facilities for chocolate mahseer

To popularize artificial propagation and conservation of the endemic chocolate mahseer in north-eastern regions, two hatchery units were established at Ganol Apal (Tura), West Garo Hills, Meghalaya and Suteplenden (Longkong), Mokokchung district, Nagaland with necessary technical and financial support from the Directorate, in collaboration with the respective state fisheries departments. In continuation of such effort, the Department of Fisheries, Government of Mizoram is also being provided technical and financial support to establish one mahseer hatchery at Lunglei District for breeding and culture of chocolate mahseer.

8.3. Promotion of rainbow trout farming in north-eastern states

For promotion and expansion of rainbow trout farming, the Directorate is continuing to provide scientific and technical support to different north-eastern states under NEH programme. Under the guidance of Dr A.K. Singh, Director, for the first time an extensive survey programme was carried out by Mr. S.K. Mallik and Dr. R.S. Halder, along with the officials of Department of Fisheries, Govt. of Nagaland, to select a suitable site for rainbow trout culture in Nagaland. After the survey, the site Dzuleke (25°36.982'N, 93°57.123'E at 5502 feet above msl) in Kohima district was found suitable for the establishment of trout raceways. In the initial phase, technical and financial support have been provided for construction of two rainbow trout raceways at Dzuleke, Kohima and presently construction work is in progress.

Moreover, to meet the demand for rainbow trout feed, a feed extruder and drier was procured and installed in the Nyukmadung farm campus of



Site selection for construction of trout raceway at Dzuleke



Construction of trout raceways at Dzuleke, Nagaland

ICAR-NRC on Yak, Dirang, Arunachal Pradesh. The prepared trout feed will be supplied to state Government trout farms as well as private trout growers of the surrounding area.



Installation of trout feed extruder at Nyukmadung Yak farm

8.4. Establishment of portable carp hatchery at Ziro, Arunachal Pradesh

To facilitate seed availability and increase fish production from paddy-cum-fish culture at Ziro,

Lower Subansiri district, financial support has been provided to procure and install a portable carp hatchery unit at Guamco Multipurpose Cooperative Society Ltd., Ziro, Lower Subansiri district, in collaboration with the Department of Fisheries, Govt. of Arunachal Pradesh.

8.5. Exploration of fish diversity in north-east Himalayan region

With the objective to explore the important coldwater fish fauna that inhabits selected Himalayan drainages in north-east, the Directorate is collaborating with different institutes to carry out the following research programmes.

- Study on 'Ichthyofaunal diversity, habitat assessment and eco-biological studies of important fish species from selected Himalayan drainages of Manipur' is carried out in collaboration with the Institute of Bioresources and Sustainable Development, Department of Biotechnology, Govt. of India, Takyelpat, Imphal, Manipur.
- Study on 'Ichthyofaunal diversity, habitat assessment and eco-biological studies of important fish species from selected Himalayan drainages of Mizoram' is carried out in collaboration with Krishi Vigyan Kendra, Mamit, Lengpui, Mizoram.
- Study on 'Ichthyofaunal diversity, habitat assessment and eco-biological studies of important fish species from selected Himalayan drainages of Meghalaya' is carried out in collaboration with the Department of Fisheries, St. Anthony's College, Shillong, Meghalaya.
- Study on 'Resource assessment of mahseer (*Tor* spp.) in Dikhu river of Mokokchung district and adjacent area, Nagaland' is carried out in collaboration with Department of Zoology, Nagaland University, Lumami, Nagaland.
- Study on 'Domestication of snow trout for species diversification in mid-hill aquaculture in Arunachal Pradesh' is carried out in collaboration with Krishi Vigyan Kendra, West Kameng district, Dirang, Arunachal Pradesh.

TRAINING AND CAPACITY BUILDING

The ICAR-Directorate of Coldwater Fisheries Research was actively involved in knowledge sharing through need based training programmes for state fisheries department officials, farmers and all other interested stakeholders. Besides, emphasis was given to develop the aptitude and skills of the scientific, technical and administrative staff through various short courses and trainings. Student guidance was also an integral part of the research activities undertaken. The details of the trainings organized, participated and students guided are provided below.

9.1. Hands-on training on breeding and hatchery management of mahseer

ICAR-DCFR organized a six days hands-on training on 'Breeding and hatchery management of mahseer' at Bhimtal during 1-6 July 2016. Altogether, twenty fisheries officers representing 9 Himalayan states participated in the training. The training was inaugurated by Dr. T. Mohapatra, Secretary (DARE) and Director General (ICAR), in the presence of Dr. J.K. Jena, Deputy Director General (Fisheries Science), Dr. A.K. Singh, Director (DCFR) and other distinguished dignitaries of ICAR. The participants were involved in elaborate presentations, discussions



Dr. D. Sarma delivering a lecture

and practical demonstrations on various aspects of breeding, hatchery management and larval rearing techniques of golden and chocolate mahseer. Considering the endangered status of mahseer, the fundamental theme of the programme concerning the establishment of brood bank and hatchery facilities of mahseer in different hill states of India was also thoroughly deliberated. Field visit to the DCFR mahseer hatchery complex at Bhimtal was also organized. The program was coordinated by Dr. D. Sarma, Dr. D. Baruah, Dr. M.S. Akhtar and Dr. R.S. Haldar. The training was approved and sponsored by the National Fisheries Development Board.



Dr. T. Mohapatra inaugurating the training

9.2. Model training course for NEH Fisheries Officers at Mizoram

ICAR-DCFR organized an 8 days model training course on 'Hill fish farming for the upliftment of rural economy in north-east region' at Aizawl, Mizoram during 2-9 December 2016. Twenty fisheries officers from five north-east Himalayan states participated in the training. The inaugural session of the training was graced by Dr. B.D. Chakma, Minister of Fisheries and Sericulture, Govt. of Mizoram, Shri Thlamuana, Secretary, Department of Fisheries, Govt. of Mizoram, Dr.

A.K. Singh, Director, ICAR-DCFR and other senior officers of the Department of Fisheries, Mizoram. The training was focused on the various biological facets, scientific developments and challenges of hill aquaculture in north-east region. Diversification of aquaculture using more indigenous fishes and promotion of eco-tourism by establishing fish sanctuaries were discussed upon. Moreover, the research and development activities of ICAR-DCFR were highlighted and future field collaborations were encouraged to augment fisheries production of north-east Himalayan states. As a part of the training program, a field trip was also organized to practically observe the fish diversity in Koladan river of Mizoram. The program was coordinated by Dr. D. Sarma, Dr. P. Sharma and Dr. R.S. Halder. The training was approved and funded by the Department of Agriculture, Cooperation and Farmers Welfare, Government of India.



Dr. A.K. Singh addressing the MTC participants



Dr. B.D. Chakma with the MTC participants

9.3. Participation in Training

Scientific staff

- A.K. Giri attended a training program on 'Blue revolution' organized for farmers at Krishi Vigyan Kendra, Lohaghat during 22 March 2017.
- A.K. Giri, as Sector Magistrate, participated in the three days training on 'Leadership and motivation for personality development' conducted by the Election Commission of India at the District Magistrate office, Champawat during 17-19 January 2017.
- Kishor Kunal, as part of his professional attachment training, underwent a 26 days training on 'Identification of some families of fishes of northeast India' under the guidance of Dr. W. Vishwanath at the Fishery Research laboratory, Department of Life Sciences, Manipur University, during 8th August to 2nd September 2016.
- Kishor Kunal participated in the short course training programme on 'Recent advances in molecular taxonomy' organized at ICAR-Central Institute of Fisheries Education, Mumbai, during 5-14 December 2016.
- Parvaiz Ahmad Ganie participated in the training programme on 'Geospatial analysis of natural resource management' organized at ICAR-National Academy of Agricultural Research Management, Hyderabad, during 18-27 October 2016.
- Prem Kumar participated in the training programme on 'Developing winning research proposal in agricultural research' organized at ICAR-National Academy of Agricultural Research Management, Hyderabad during 20-24 September 2016.
- R.S. Tandel attended the winter-school training programme on 'Rapid diagnostics for fish health management' organized at ICAR-Central Institute of Fisheries Education, Mumbai during 18th November to 8th December, 2016.

- Raghvendra Singh, as part of his professional attachment training, underwent 3 week training on 'Different techniques of cryopreservation, ploidy induction and flow cytometry' at ICAR-National Bureau of Fish Genetic Resources during 20th August to 10th September 2016.
- Raja Aadil Hussain Bhatt, as part of his professional attachment training, underwent one month training on 'Viral diagnostics' under the guidance of Dr. K.V. Rajendran at ICAR-CIFE, Mumbai during 16th August to 17th September 2016.
- S.K. Mallik underwent a three months international training programme on 'Health management in aquaculture' at the Laboratory of Aquaculture & Artemia Reference Center, Ghent University, Belgium during 15th September to 15th December 2016.
- Siva, C., participated in the 21 days training course on 'Post genomic to phenomic approaches and methodologies for upgrading livestock production' organized at ICAR-Central Institute for Research on Cattle, Meerut during 6-26 September, 2016.
- R.S. Halder, as the nodal officer of ICAR-DCFR e-Procurement, participated in the 2 days training on 'Implementation of NIC's e-procurement solution through CPP Portal' organized at ICAR-Indian Veterinary Research Institute, Izatnagar, during 2-3 June, 2016.

9.4. HRD physical targets and achievements

Category	Total No. of Employees	No. of trainings planned for 2016-17 as per ATP	No. of employees undergone training during 2016-17
Scientist	28	13	10
Technical	12	4	3
Administration & Finance	12	4	4
Skilled supporting staff	11	11	0

9.5. HRD fund allocation and utilization (in lakhs)

Total HRD allocation as per RE 2016-17	Actual Expenditure 2015-16 for HRD
2.5	2.48

Technical staff

- A.K. Saxena participated in the training programme on 'Cyber security for ICAR technical personnel' organized at ICAR-Indian Agricultural Statistics Research Institute during 28th September to 5th October 2016.
- R.S. Halder and Santosh Kumar attended the training on 'Competency enhancement program for technical officers of ICAR' organised at ICAR-National Academy of Agricultural Research Management, Hyderabad, during 15-26 October 2016.
- R.S. Halder participated in the 10 days ICAR sponsored training programme on 'Application of remote sensing and GIS in natural resource management (ARSGN)' organized at ICAR-Indian Institute of Soil and Water Conservation (IISWC), Dehradun, during 20-29 September, 2016.
- Dr. Shaikhom Inaotombi Singh is carrying out his post-doctoral research funded by DST-SERB National Post-Doctoral Fellowship scheme on the topic 'Variant of cyanobacterial metabolites and their significance on aquatic environment in a western Himalayan lake', under the mentoring of Dr. D. Sarma.
- Rohit Kumar completed his PhD from Kumaun University under the supervision of Dr. P.K. Sahoo on the topic 'Isolation and characterization of immune responsive genes using transcriptome profiling of bacterial challenged golden mahseer'.
- Neeraj Kumar Sharma completed his PhD from H.N.B. University, Srinagar under the co-supervision of Dr. N.N. Pandey on the topic 'Study on season dependent physio-metabolic indices and thermal tolerance of *Barilius*

bendelisis (Hamilton)’.

- Neha Saxena completed her PhD from ICAR-CIFE, Mumbai under the co-supervision of Dr. R.S. Patiyl on the topic ‘Gonadal development and captive breeding of hill stream fish *Barilius bendelisis* (Hamilton, 1807)’.
- Ramesh Singh Chalal completed his PhD from Kumaun University under the co-supervision of Dr. Prem Kumar on the topic ‘Study on productivity assessment of Baigul reservoir using Geoinformatics with reference to fish production’.
- Kiran Belwal from Kumaun University has submitted her PhD thesis carried out under the supervision of Dr. Amit Pande on the topic ‘Characterisation of toll-like receptor 3 from Indian snow trout, *Schizothorax richardsonii*’.
- Vineeta Joshi from Kumaun University has submitted her PhD thesis carried out under the supervision of Dr. Debajit Sarma on the topic ‘Nutrient profiling of snow trout (*Schizothorax* spp.) distributed in India subcontinent region’.
- Preeti Chaturvedi from Kumaun University has submitted her PhD thesis carried out under the supervision of Dr. Amit Pande on the topic ‘Characterization of antimicrobial peptides in *Tor putitora*’.
- Prerna Sharma is pursuing her PhD from Kumaun University under the co-supervision of Dr. Neetu Shahi on the topic ‘Investigation on prevalence biology and pathogenesis of *Chryseobacterium* sp. isolated from cold water fish and their environment’.
- Annu Sharma is pursuing her PhD from Kumaun University under the supervision of Dr. Debajit Sarma on the topic ‘Changes in fatty acid profile with seasonal changes in environmental factors, natural food and thyroid endocrine system of golden mahseer (*Tor putitora*) in lacustrine ecosystem’.
- Lata Sharma is pursuing her PhD from Kumaun University under the supervision of Dr. S. Ali on the topic ‘Studies on genetic variability of

different wild populations of chocolate mahseer (*Neolissochilus hexagonolepis*) using molecular markers’.

- Surabhi Rawat is pursuing her PhD from Kumaun University under the supervision of Dr. Neetu Shahi on the topic ‘Development of bacterial bioremediation measures for the mitigation of algal and cyanobacterial blooms from freshwater aquaculture ponds’.
- Pankaj Nagar from G.B. Pant University of Agriculture and Technology completed his M.F.Sc. dissertation under the co-supervision of Dr. Prem Kumar on the topic ‘Effect of water recirculation on growth of *Catla catla*’.
- Namrata Gohain from West Bengal University of Animal and Fishery Sciences completed her M.F.Sc. dissertation under the co-supervision of Dr. R.S. Haldar on the topic ‘Economic analysis of trawl catch and socio-economics of the associated fishers over 2015-16 at Digha coast of West Bengal’.
- Kalpana Joshi from Kumaun University completed her M.Sc. dissertation under the co-supervision of Dr. Dimpal Thakuria on the topic ‘Evaluation of antimicrobial activity of *de novo* designed peptides against fish bacteria’.
- Ankit Barola from Alpine Institute of Management and Technology, Dehradun completed his M.Sc. dissertation under the supervision of Dr. Amit Pande on the topic ‘Primary cell culture of *Schizothorax richardsonii* from fin explants’.
- Kanika Phartiyal from Graphic Era University, Dehradun completed her B.Tech. dissertation under the supervision of Dr. Amit Pande on the topic ‘Amplification of Toll like receptor-3 (TLR-3) ectodomain from *Schizothorax richardsonii*’.
- Piyush Bisht, student of B.Sc. Hons. (Microbiology) at Swami Shradhanand College, University of Delhi, received a one month hands-on training in fish cell culture and molecular techniques under the supervision of Dr. Amit Pande.

LINKAGES

ICAR-Directorate of Coldwater Fisheries Research promoted collaboration with the following national organizations and agencies during the period under report.

ICAR Institutes

- ICAR-National Bureau of Fish Genetic Resources, Lucknow
- ICAR-Central Institute of Fisheries Technology, Kochi
- ICAR-Central Institute of Fisheries Education, Mumbai
- ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar
- ICAR-Central Institute of Brackishwater Aquaculture, Chennai
- ICAR-Central Inland Fisheries Research Institute, Barrackpore
- ICAR Research Complex for NEH Region, Barapani
- ICAR- Indian Institute of Soil and Water Conservation, Dehradun
- ICAR- Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora
- ICAR- Indian Veterinary Research Institute, Izatnagar
- ICAR- Directorate of Foot and Mouth Disease, Mukteswar
- ICAR- Indian Agricultural Statistics Research Institute, New Delhi
- ICAR- Indian Agricultural Research Institute, New Delhi
- ICAR- National Institute of Animal Nutrition and Physiology, Bengaluru
- ICAR- National Bureau of Soil Survey and Land Use Planning, Nagpur

Central Agencies/Departments

- National Fisheries Development Board
- Department of Biotechnology
- Department of Science & Technology
- Science and Engineering Research Board

State Agencies/Departments

- Department of Fisheries, Sikkim
- Department of Fisheries, Uttarakhand
- Department of Fisheries, Himachal Pradesh
- Department of Fisheries, Jammu & Kashmir
- Department of Fisheries, Arunachal Pradesh
- Department of Fisheries, Meghalaya
- Department of Fisheries, Mizoram
- Department of Fisheries, Nagaland
- Department of Fisheries, Tamil Nadu
- Uttarakhand Council for Biotechnology

Universities & Colleges

- GB Pant University of Agricultural Science & Technology, Pantnagar
- GB Pant Institute of Himalayan Environment and Development, Almora
- College of Fisheries, SKUAS&T, Jammu & Kashmir
- Tamil Nadu Fisheries University
- Kerala University of Fisheries & Oceanography
- CSKHP Agricultural University, Himachal Pradesh
- Kumaun University, Nainital
- HNB Garhwal University, Srinagar
- Guwahati University, Assam
- Rajiv Gandhi University, Arunachal Pradesh
- Bhimrao Ambedkar Central University, Lucknow

AWARDS/HONOUR/RECOGNITION

- The Directorate received the 'Cashless ICAR Institute Award' for the year 2015-16 in February 2017. The award included a cash prize of Rs. 5 Lakhs.



Dr. A.K. Singh receiving the Award from Shri Radha Mohan Singh

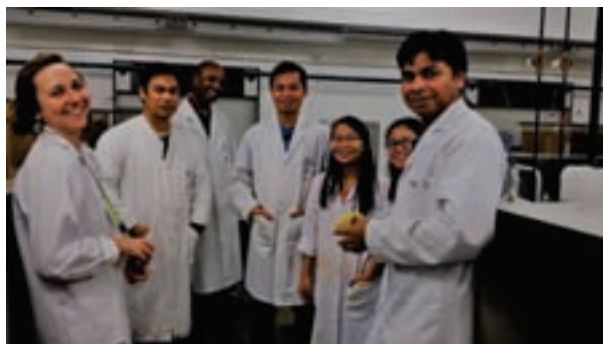
- Dr. A.K. Singh, Director, was awarded the 'Eminent Indian Zoologist Medal - 2017' by the Zoological Society of India in recognition of his outstanding research and academic contribution in the field of fish and fisheries science.



Dr. A.K. Singh receiving the Eminent Indian Zoologist Medal

- Mr. Sumanta Kumar Mallik, Scientist, received the VLIR-UOS Fellowship of Belgian Federal Government to attend a 3 months International training programme on 'Health Management in Aquaculture' hosted by the Faculty of Bio-Science Engineering, Department of Animal

Production, Laboratory of Aquaculture & Artemia Reference Center, Ghent University, Belgium. He participated in the above training during 15th September to 15th December, 2016.



Mr. Mallik with the other international participants at Ghent University

- Mr. Rajesh, M., Scientist, was awarded the prestigious Asian Fisheries Society Kanazawa Research and Travel Grant - 2016 for his Ph.D. research project. Subsequently, he attended the 11th Asian Fisheries and Aquaculture Forum held at Bangkok, Thailand during 3-7 August 2016 to receive the research grant and present the progress of the project.



Mr. Rajesh receiving the AFS Kanazawa Research Grant

- Dr. R.S. Patiyal, Sr. Scientist, received the best poster award for the poster presentation on 'Prioritized management strategies for conservation of endangered mahseer *Tor*

putitora in mid-Himalayan region, India, in the 1st International Agrobiodiversity Congress held at NASC complex, New Delhi during 6-9 November 2016.

- Dr. R.S. Haldar, ACTO, received a 'Certificate of Appreciation' from the Chief Managing Director, Jasingfaa Aqua Tourism Resort, Nagaon, Assam for the technical support rendered in the establishment of mahseer brood bank, artificial breeding and seed production of mahseer and other endemic species, on 5th July 2016.
- Mr. Rajesh, M., Scientist, won the second place (silver medal) in 800 m race and the third place (bronze medal) in 1500 m and 400 m track events in the ICAR zonal sports meet (North

zone) held at ICAR-NDRI, Karnal.

- Dr. Shaikhom Inaotombi Singh, SERB-National Post-Doctoral Fellow of the Directorate, received the 'Asia-Pacific Network for Global Change Research - Mitra Award' on the occasion of Indian Youth Poster Session at its 22nd joint Inter-Governmental meeting and scientific planning group meeting hosted by the Ministry of Environment, Forest and Climate Change, Government of India in New Delhi during 24-27 April 2017. The award recognizes him as an outstanding young scientist conducting global change research in Asia-Pacific region for his work on the possible adaptation strategies of aquatic planktonic organisms on the change of climate in the lakes of the central Himalayas.



Mr. Rajesh receiving the silver medal



Dr. Shaikhom receiving the Mitra award

12.1. Research Papers

- Akhtar, M.S., Ciji, A., Sarma, D., Rajesh, M., Kamalam, B.S., Sharma, P. and Singh, A.K. (2017). Reproductive dysfunction in females of endangered golden mahseer (*Tor putitora*) in captivity. *Animal Reproduction Science* 182, 95-103.
- Baruah, D. and Singh, N.D. (2017). Adopted methodologies for livelihood support through fish farming at high altitudes of Chug village (Dirang circle) of Arunachal Pradesh. *Journal of Krishi Vigyan* 5(2), 108-115.
- Bashir, A., Bisht, B.S., Mir, J.I., Patiyal, R.S. and Kumar R. (2016). Morphological, molecular characterization and taxonomic status of *Triplophysa marmorata* and *Triplophysa kashmirensis* (Cypriniformes: Nemacheilidae) from Kashmir valley, India. *Rev. Biol. Trop.* 64(2), 473-482.
- Belwal, K., Thakuria, D., Dighe, V., Pande, V. and Pande, A. (2016). Molecular cloning and expression profile of toll like receptor-3 from an Indian coldwater fish, *Schizothorax richardsonii* (Gray). *Animal Biotechnology* DOI:10.1080/10495398.2016.1217874.
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- Dash, P., Avunje, S., Tandel, R.S., Sandeep, K.P. and Panigrahi, A. (2017). Biocontrol of luminous vibriosis in shrimp aquaculture: a review of current approaches and future prospects. *Reviews in Fisheries Science* 25(3), 245-255.
- Inaotombi, S., Gupta, P.K. and Mahanta P.C. (2016). Influence of abiotic factors on the spatio-temporal distribution of rotifers in a subtropical lake of western Himalaya. *Water Air Soil Pollution* 227, 50.
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- Ingole, N.A., Ram, R.N., Kumar, P., Ranjan, R. and Shankhwar, A.K. (2015). Advance application of geospatial technology for fisheries perspective in Tarai region of Himalayan state of Uttarakhand. *Sustainable Water Resources Management* 1, 181-187.
- Ingole, N.A., Ram, R.N., Nain, A.S. and Kumar, P. (2016). Temporal geomorphological changes

- in Nanak Sagar reservoir (India) using satellite data. *Current World Environment* 11(2), 458-465.
- Ingole, N.A., Ram, R.N., Nain, A.S. and Kumar, P. (2016). Study of horizontal zonation of water quality characteristics and productivity status of Nanak Sagar reservoir of Uttarakhand, India. *Indian Journal of Ecology* 43(2), 418-425.
 - Joshi, M., Ingole, N.A., Bisht, H.C.S. and Pandey, N.N. (2016). General and relative growth studies in formulated feed of fresh water prawn *Macrobrachium assamensis peninsularis* (Tiwari) from Kumaon Himalaya, Uttarakhand. *Current World Environment* 11(3), 916-925.
 - Kumar, A., Singh, R. and Pandey, N.N. (2016). Isolation of pathogenic fungi from the major cultivated coldwater fish species and their environment in Kumaon region of Uttarakhand. *Indian Journal of Animal Research* 24, 1-3.
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 - Mohanty, B.P., Sankar, T.V., Ganguly, S., Mahanty, A., Anandan, R., Chakraborty, K., Paul, B.N., Sarma, D., Dayal, J.S., Mathew, S., Asha, K.K., Mitra, T., Karunakaran, D., Chanda, S., Shahi, N., Das, P., Das, P., Akhtar, M.S., Vijayagopal, P. and Sridhar, N. (2016). Micronutrient composition of 35 food fishes from India and their significance in human nutrition. *Biol. Trace Elem. Res.* DOI:10.1007/s12011-016-0714-3.
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 - Patiyal, R.S. and Mir, J.I. (2017). Length-weight relationships of 21 fish species from the upland Ganga river basin tributaries of central Indian Himalaya. *Journal of Applied Ichthyology* DOI:10.1111/jai.13386.
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 - Sarma, D., Das, R., Akhtar, M.S., Ciji, A., Sharma, N.K. and Singh, A.K. (2016). Morpho-histological and ultra-architectural changes during early development of endangered golden mahseer *Tor putitora*. *Journal of Fish Biology* 89(4), 2038-2054.
 - Saxena, N., Patiyal, R.S., Dubey, K. and Tiwari, V.K. (2016). Population dynamics and reproductive biology of *Barilius bendelisis* (Cyprinidae: Cypriniformes) from river Gaula, central Indian Himalaya. *Rev. Biol. Trop.* 64(3).
 - Shahi, N., Singh, A.K., Sahoo, M., Mallik, S.K. and Thakuria, D. (2017). Molecular cloning, characterization and expression profile of kisspeptin1 and kisspeptin1 receptor at brain-pituitary-gonad (BPG) axis of golden mahseer,

Tor putitora (Hamilton, 1822) during gonadal development. *Comp. Biochem. Physiol. Part B* 205, 13-29.

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- Sharma, P., Tang, S., Mayer, G.D. and Patino, R. (2016). Effects of thyroid endocrine manipulation on sex-related gene expression and population sex ratios in zebra fish. *General and Comparative Endocrinology* 235, 38-47.
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12.2. Technical/Popular Articles

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- Baruah, D. (2017). Matsya-dhan ki kheti ka dharohar hai: apatani pathar. *Himjyoti*, ICAR-DCFR, 34-35.
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- Chandra, S., Patiyal, R.S. and Joshi, M. (2016). Sha-phasaliya matsya palan dwara gaon ke sanshadhano ka upyog. *Himjyoti*, ICAR-DCFR, 36-38.
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- Khuswaha, V., Kumar, R., Naagpure, N.S. and Patiyal, R.S. (2016). Matsya janan dravya sanrakshan: ek aavshyak kadam. *Himjyoti*, ICAR-DCFR, 65-67.
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- Mallik, S.K., Shahi, N., Chandra, S., Tandel, R.S. and Singh, A.K. (2016). Bacterial flora in rainbow trout farms of Indian Himalaya: strategy for control of pathogenic bacteria in farming. *ENVIS Newsletter on Himalayan Ecology* 13(2), 6-7.
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- Patiyal, R.S., Joshi, A. and Kamalam, B.S. (2016). Uttarakhand rajaya ke Kumoun shetra me matisayiki ka paridrasya. *Himjyoti*, ICAR-DCFR, 14-17.
- Patiyal, R.S., Kumar, P., Chandra, S. and Rajesh, M. (2016). Uttarakhand mesajavati machaleyo ki isthati, prakar, mahatva evam vyapar ki sambhavanaye. *Himjyoti*, ICAR-DCFR, 1-3.

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- Singh, A.K. (2016). Prospects and potential of coldwater fisheries and aquaculture. Souvenir, *National seminar on Aquaculture Diversification: The way forward for Blue Revolution*, ICAR-CIFA, Bhubaneswar, 39-51.
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- Singh, A.K. (2017). Fisheries and aquaculture in Indian Himalayan region: opportunities and priorities. Souvenir, *National seminar on Priorities in Fisheries and Aquaculture*, ICAR-CIFRI, Kolkata, 94-102.
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- Zaidi, S.G.S., Kulkarni, B.G. and Pandey, A.K. (2016). Copper toxicity to different developmental stages of giant freshwater prawn, *Macrobrachium rosenbergii* (De man). Proceedings, *International seminar on Recent trends and Experimental approaches in Science, Technology and Nature*, Society for Science & Nature, Lucknow, 75.
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12.3. Books/Book chapters

- Sarma, D., Singh, A.K. and Akhtar, M.S. (2016). Mahseer in India: resources, breeding, propagation, conservation, policies and issues. *ICAR-DCFR publication*, Bhimtal, India, ISBN-978-81-931230-0-3, 1-168.
- Singh, A.K. (2017). Research and development endeavours on hill fishery resources management and aquaculture for livelihood support. In: Sinha, V.R.P., Krishna, G., Keshavnath, P. and Kumar, N.R. (Eds.), *Social entrepreneurship in aquaculture*. Narendra Publishing House, New Delhi, 173-182.

12.4. Bulletins/Magazines/Pamphlets

- Baruah, D. and Sarma, D. (2016). Mahseer in recreational fisheries and eco-tourism in India. *Bulletin No. 26*, ICAR-DCFR, Bhimtal, 1-40.
- Pandey, N.N. and Chandra, S. (2016). Aquaculture prospects of introduced improved Hungarian strain of common carp in Himalyan region. *ICAR-DCFR publication*, Bhimtal, 1-18.
- Patiyal, R.S. and Joshi, A.K. (2016). Him Jyoti. *ICAR-DCFR magazine* (Hindi), 1-89.
- Sahoo, P.K., Siva, C., Ali, S., Singh, L., Kumar, R. and Singh, A.K. (2016). Mitochondrial genomics of Schizothoracid fishes. *Bulletin No. 25*, ICAR-DCFR, Bhimtal, 1-19.

- Sarma, D. and Pandey, N.N. (2016). Fish culture in hills. ICAR-DCFR leaflet (Hindi).

12.4. Abstracts

- Barat, A., Singh, L., Sharma, L., Sumer, S., Siva, C., Laskar, M.A. and Singh, A.K. (2016). Studies on the genetic diversity of chocolate mahseer (*Neolissochilus hexagonolepis*) populations using mitochondrial genes. *1st International Agrobiodiversity Congress*, 6-9 November, New Delhi.
- Belwal, K., Saxana, A. and Pande, A. (2017). Identification and *in silico* analysis of dsRNA dependent protein kinase (PKR) of *Schizothorax richardsonii*. *XXX Annual convention of Indian Association of Veterinary Microbiologists, Immunologists and Specialists in Infectious Diseases*, 10-12 February, Nagpur.
- Kamalam, B.S., Rajesh, M., Akhtar, M.S., Ciji, A., Sharma, P. and Singh, A.K. (2016). Captive rearing and nutrition of *Schizothorax richardsonii*: first observations. *1st International Agrobiodiversity Congress*, 6-9 November, New Delhi.
- Kumar, R., Sahoo, P.K. and Barat, A. (2017). Characterization of p53 tumor suppressor gene from liver transcriptome library of golden mahseer, *Tor putitora*. *National seminar on Priorities in Fisheries and Aquaculture*, 11-12 March, Bhubaneswar.
- Mohanty, B.P., Ganguly, S., Mitra, T., Mahanty, A., Patra, S., Karunakaran, D., Raman, R.K., Parida, P.K., Abdulla, T., Behera, P., Anandan, R., Dayal, J.S., Chakraborty, K., Paul, B.N., Sarma, D., Mathew, S., Asha, K.K., Akhtar, M.S., Shahi, N., Sridhar, N., Sankar, T.V. and Das, B.K. (2017). Fish would be an important player in eradicating protein hunger. *National seminar on Priorities in Fisheries and Aquaculture*, 11-12 March, College of Fisheries, Rangeilunda, Odisha.
- Pandey, N.N., Kumar, P., Patiyal, R.S. and Singh, A.K. (2016). Polyculture of exotic carp in film lined ponds: prospects of livelihood security in mid-Himalayan region. *PAF 3rd congress on Social Entrepreneurship in Aquaculture*, 27-29 April, Mumbai.
- Patiyal, R.S., Singh, A.K., Chandra, S. and Kumar, P. (2016). Managing endangered species: suggestions for prioritizing management strategies for conservation of *Tor putitora* in mid-Himalayan region, India. *1st International Agrobiodiversity Congress*, 6-9 November, New Delhi.
- Rajesh, M., Kamalam, B.S., Akhtar, M.S., Sharma, P., Ciji, A. and Singh, A.K. (2016). Effect of nutritional status on growth response in Indian snow trout *Schizothorax richardsonii*. *11th Asian Fisheries and Aquaculture Forum*, 3-7 August, Bangkok, Thailand.
- Sahoo, P.K., Kumar, R., Rawat, S., Sharma, R. and Siva, C. (2016). The complete mitochondrial genome of two ornamental *Schistura* species and their phylogeny. *1st International Agrobiodiversity Congress*, 6-9 November, New Delhi.
- Saxana, A., Belwal, K., Chauhan, A. and Pande, A. (2017). Interferon induced Mx protein from Indian snow trout *Schizothorax richardsonii* (Gray) lacks critical functional features unlike its mammalian homologues. *6th International conference on Biotechnology and Bioengineering and 2017 International conference on Advances in Biomedicine and Biomedical Engineering*, 26-28 September, Germany.
- Sharma, L., Kumar, R., Siva, C., Sahoo, P.K. and Barat, A. (2017). Identification and characterization of SSRs in chocolate mahseer (*Neolissochilus hexagonolepis*) and their usage in population study. *National seminar on Priorities in Fisheries and Aquaculture*, 11-12 March, Bhubaneswar.
- Singh, L., Sahoo, P.K., Ali, S., Singh, A.K. and Barat, A. (2016). Studies on genetic diversity using mitochondrial genes in brown trout (*Salmo trutta fario*) populations in India. *1st International Agrobiodiversity Congress*, 6-9 November, New Delhi.

- Singh, R., Pandey, N.N., Tiwari, V.K., Gupta, M. and Singh, A.K. (2016). Breeding and seed production of *Chagunius chagunio* (Hamilton-Buchanan, 1822) in captivity for aquaculture diversification. *1st International Agrobiodiversity Congress*, 6-9 November, New Delhi.
- Zaidi, S.G.S., Pandey, N.N. and Patiyal, R.S. (2016). Prospects of ornamental fish culture in Uttarakhand towards livelihood security of rural people. *PAF 3rd congress on Social Entrepreneurship in Aquaculture*, 27-29 April, Mumbai.

12.5. NCBI Submissions

- Akhtar, M.S., Rajesh, M., Ciji, A., Kamalam, B.S. and Singh, A.K. *Schizothorax richardsonii* hsp 70 mRNA partial cds. (MF135245).
- Belwal, K., Saxana, A. and Pande, A. Interferon regulatory factor-3 (IRF3) mRNA from *Schizothorax richardsonii* (KX775963).
- Belwal, K., Saxana, A. and Pande, A. *Schizothorax richardsonii* double stranded RNA dependent protein kinase (PKR) (KX447496).
- Ciji, A., Rajesh, M., Akhtar, M.S., Kamalam, B.S., Sharma, P., Dash, P. and Singh, A.K. *Schizothorax richardsonii* cyp19b (brain type) mRNA complete cds. (MF135230).
- Ciji, A., Rajesh, M., Akhtar, M.S., Kamalam, B.S., Sharma, P., Dash, P. and Singh, A.K. *Schizothorax richardsonii* growth hormone mRNA partial cds. (MF135243).
- Ciji, A., Rajesh, M., Akhtar, M.S., Kamalam, B.S., Sharma, P., Dash, P. and Singh, A.K. *Schizothorax richardsonii* growth hormone receptor mRNA partial cds. (MF135244).
- ICAR-Directorate of Coldwater Fisheries Research, *Schizothorax richardsonii* intestinal metagenome of captive fish fed low protein diet (BioSample: SAMN06646444; SRA: SRS2094413; Bioproject: PRJNA380713).
- ICAR-Directorate of Coldwater Fisheries Research, *Schizothorax richardsonii* intestinal metagenome of captive fish fed high protein diet (BioSample: SAMN06646455; SRA: SRS2094412; Bioproject: PRJNA380713).
- ICAR-Directorate of Coldwater Fisheries Research, *Schizothorax richardsonii* intestinal metagenome of wild collected fish (BioSample: SAMN06646419; SRA: SRS2094414; Bioproject: PRJNA380713).
- Kamalam, B.S., Rajesh, M., Akhtar, M.S., Ciji, A., Sharma, P., Pandey, N.N. and Singh, A.K. *Schizothorax richardsonii* hepatic lipase mRNA, partial cds. (MF118761).
- Kamalam, B.S., Rajesh, M., Akhtar, M.S., Ciji, A., Sharma, P., Pandey, N.N. and Singh, A.K. *Schizothorax richardsonii* carboxypeptidase B-like mRNA, partial cds (MF118758).
- Kamalam, B.S., Rajesh, M., Akhtar, M.S., Ciji, A., Sharma, P., Pandey, N.N. and Singh, A.K. *Schizothorax richardsonii* ghrelin mRNA, complete cds. (MF118760).
- Kamalam, B.S., Rajesh, M., Ciji, A., Akhtar, M.S., Sharma, P., Pandey, N.N. and Singh, A.K. *Schizothorax richardsonii* alpha-amylase mRNA, partial cds. (MF118757).
- Kamalam, B.S., Rajesh, M., Ciji, A., Akhtar, M.S., Sharma, P., Pandey, N.N. and Singh, A.K. *Schizothorax richardsonii* trypsin mRNA, partial cds. (MF118762).
- Kamalam, B.S., Rajesh, M., Ciji, A., Akhtar, M.S., Sharma, P., Pandey, N.N. and Singh, A.K. *Schizothorax richardsonii* chymotrypsin B-like mRNA, partial cds. (MF118759).
- Rajesh, M., Akhtar, M.S., Ciji, A., Kamalam, B.S. and Singh, A.K. *Schizothorax richardsonii* myogenic factor 6 mRNA, partial cds. (MF135239).
- Rajesh, M., Akhtar, M.S., Ciji, A., Kamalam, B.S. and Singh, A.K. *Schizothorax richardsonii* myogenin mRNA, partial cds. (MF135241).
- Rajesh, M., Akhtar, M.S., Ciji, A., Kamalam, B.S., Giri, A.K. and Singh, A.K. *Schizothorax richardsonii* mTOR mRNA, partial cds. (MF135246).

- Rajesh, M., Akhtar, M.S., Ciji, A., Kamalam, B.S., Thakuria, D. and Singh, A.K. *Schizothorax richardsonii* myoD mRNA, complete cds. (MF135240).
- Rajesh, M., Kamalam, B.S., Akhtar, M.S., Ciji, A. and Singh, A.K. *Schizothorax richardsonii* myogenic factor 5 mRNA, partial cds. (MF135238).
- Rajesh, M., Thakuria, D., Akhtar, M.S., Ciji, A., Kamalam, B.S. and Singh, A.K. *Schizothorax richardsonii* myostatin1 mRNA, partial cds. (MF135242).
- Siva, C., Kumar, R., Sharma, L., Barat, A. and Sahoo, P.K. The complete mitochondrial genome of *Schistura reticulofasciata* (KY379150).
- Siva, C., Kumar, R., Sharma, L., Barat, A. and Sahoo, P.K. The complete mitochondrial genome of *Schistura sikmaiensis* (KY379151).

PARTICIPATION IN CONFERENCE/ SYMPOSIA/WORKSHOP/MEETING

13.1. Participation in Conference/ Symposia/Workshop

- A. Barat attended the '1st International Agrobiodiversity Congress 2016' held at ICAR-NASC complex, New Delhi during 6-9 November 2016 and presented a poster on 'Studies on the genetic diversity of chocolate mahseer (*Neolissochilus hexagonolepis*) populations using mitochondrial genes.'
- A. Barat attended the national seminar on 'Priorities in Fisheries and Aquaculture' organized at College of Fisheries, Berhampur, Odisha during 11-12 March 2017 and delivered an oral presentation on 'Characterization of p53 tumor suppressor gene from liver transcriptome library of golden mahseer, *Tor putitora*'.
- A.K. Singh attended the '1st International Agrobiodiversity Congress 2016' held at ICAR-NASC complex, New Delhi during 6-9 November 2016 and delivered an oral presentation on 'Status, potential and challenges to the important fish germplasm viz-a-viz aquaculture and fishery management in coldwater region, India.'
- A.K. Singh attended the 'PAF 3rd Congress on Social Entrepreneurship in Aquaculture' organized by Pillay Aquaculture Foundation and Indian Fisheries Association at ICAR-CIFE, Mumbai during 27-29 April 2016, and chaired a technical session and delivered an invited lecture.
- A.K. Singh attended the ICAR Vice Chancellors and Directors conference organized at New Delhi during 15-16 February 2017 and also participated in a meeting held at SMD Fisheries Science.
- A.K. Singh attended the national conference on 'Conservation and Institutional Development on Mahseer' held at Devi Ahilya University, Indore during 9-11 September 2016 and delivered an invited talk.
- A.K. Singh attended the national seminar on 'Aquaculture Diversification: the way forward for Blue Revolution' organised at ICAR-CIFA, Bhubaneswar during 1-3 December 2016, as guest of honour at the inaugural session, chaired a technical session and delivered an invited lecture.
- A.K. Singh attended the national symposium on 'Zoonotic Diseases and their Preventive Measures' held at Chaudhary Charan Singh University, Meerut on 16th March 2017, as guest of honour, chaired a technical session and delivered an invited lecture.
- A.K. Singh participated in the 'World Fisheries Day' meet organized by Department of Animal Husbandry Dairying & Fisheries, Ministry of Agriculture and Farmers Welfare, Govt. of India, New Delhi on 21st November 2016, and chaired a technical session.



Dr. A.K. Singh as guest of honour at BBAU, Lucknow

- A.K. Singh participated in the national consultation on 'Higher Fisheries Education' organized by ICAR-CIFE, Mumbai on 16th December 2016.
- A.K. Singh participated in the National Science Day event organized at Babasaheb Bhimrao Ambedkar Central University, Lucknow on 28th February 2017, as the guest of honour and delivered an invited lecture.
- B.S. Kamalam attended the '1st International Agrobiodiversity Congress 2016' held at ICAR-NASC complex, New Delhi during 6-9 November 2016 and presented a poster on 'Captive rearing and nutrition of *Schizothorax richardsonii*: first observations'.
- D. Sarma attended the '1st International Agrobiodiversity Congress 2016' held at ICAR-NASC complex, New Delhi during 6-9 November 2016 and presented a poster on 'Nutrient composition of five snow trout (*Schizothorax spp.*) species'.
- D. Sarma participated in the workshop on 'Competency development program for the HRD nodal officer of ICAR Institute' organized at ICAR-NAARM, Hyderabad during 23-25 February 2017.
- N.N. Pandey participated in the write-shop on 'Culture and breeding protocols of freshwater fishes' organized by National Fisheries Development Board, Hyderabad, during 27-29 September 2016.
- P.K. Sahoo attended the '1st International Agrobiodiversity Congress 2016' held at ICAR-NASC complex, New Delhi during 6-9 November 2016 and presented a poster on 'Studies on genetic diversity using mitochondrial genes in brown trout (*Salmo trutta fario*) populations in India'.
- R. Singh and K. Kunal participated in the 'Agrobiodiversity seminar' organized by ICAR-NBPGR regional center, Bhowali at Dharchula, Uttarakhand on 20th October 2016.
- R. Singh attended the '1st International Agrobiodiversity Congress 2016' held at ICAR-NASC complex, New Delhi during 6-9 November 2016 and presented a poster on 'Breeding and seed production of *Chagunius chagunio* (Hamilton-Buchanan, 1822) in captivity for aquaculture diversification'.
- R.S. Haldar attended the national seminar on 'Aquaculture diversification: the way forward for blue revolution' organized at ICAR-CIFA, Bhubaneswar during 1-3 December 2016.
- R.S. Haldar participated in the 'PAF 3rd Congress on Social Entrepreneurship in Aquaculture' organized at ICAR-CIFE, Mumbai during 27-29 April 2016.
- R.S. Haldar participated in the 'XIII Agricultural Science Congress' held at University of Agricultural Sciences, Bengaluru during 21-24 February 2017.
- R.S. Haldar participated in the 2nd national student convention on 'Innovative approaches for academic excellence in higher fisheries education' organized at ICAR-CIFE, Mumbai during 3-5 March 2017.
- R.S. Patiyal attended the '1st International Agrobiodiversity Congress 2016' held at ICAR-NASC complex, New Delhi during 6-9 November 2016 and presented a poster on 'Managing endangered species: suggestions for prioritizing management strategies for conservation of *Tor putitora* in mid-Himalayan region, India'.
- R.S. Patiyal and D. Baruah participated in the 'International Angling Event' held at Pancheswar, jointly organized by Uttarakhand Tourism and Kumaon Mandal Vikas Nigam Ltd., Nainital during 24-26 October 2016.
- Rajesh, M., attended the 11th Asian Fisheries and Aquaculture Forum held at Bangkok, Thailand, during 3-7 August 2016 and delivered an oral presentation on 'Effect of nutritional status on growth response in Indian snow trout *Schizothorax richardsonii*'.

- Siva, C., attended the '1st International Agrobiodiversity Congress 2016' held at ICAR-NASC complex, New Delhi during 6-9 November 2016 and presented a poster on 'The complete mitochondrial genome of two ornamental *Schistura* species and their phylogeny'.

13.2. Participation in Meeting

- A. Barat participated in the review meeting of ICAR network projects convened at NASC, New Delhi during 3-4 November 2016, and presented the progress made under the outreach activity on 'Fish genetic stock'.
- A.K. Singh attended the 19th meeting of the national committee on 'Introduction of exotic aquatic organisms into Indian waters' convened by Joint Secretary (Fisheries) at Krishi Bhawan, New Delhi on 25th June 2016.
- A.K. Singh attended the 52nd Academic council meeting of ICAR-CIFE, convened at Mumbai on 18th November 2016.
- A.K. Singh attended the interactive meeting of Directors of all ICAR Fisheries Institutes on 9th June 2016 and the subsequent interface meeting with Department of Animal Husbandry Dairying & Fisheries, Ministry of Agriculture and Farmers Welfare, Govt. of India on 10th June 2016 at ICAR headquarters, New Delhi.
- A.K. Singh attended the techno-policy meeting on doubling farmers' income, convened at G.B. Pant University of Agriculture & Technology, Pantnagar on 22nd and 29th March 2017, and delivered a presentation on strategic approaches for doubling farmers' income from fisheries and aquaculture in Uttarakhand.
- A.K. Singh participated in the 20th meeting of the national committee on 'Introduction of exotic aquatic species into Indian waters' convened under the chairmanship of Joint Secretary (Fisheries) at Krishi Bhawan, New Delhi on 23rd December 2016.
- D. Sarma, as a special invitee, attended the 11th EB meeting on 'Cumulative impact assessment

and carrying capacity study in the upper reaches of river Ganga and its tributaries in Uttarakhand state' organized by the Ministry of Environment, Forest and Climate Change, Govt. of India at Indira Paryavaran Bhawan, New Delhi during 8-9 September 2016.

- D. Sarma participated in the review meeting of ICAR network projects convened at NASC, New Delhi during 3-4 November 2016, and presented the progress made under the outreach activity on 'Nutrient profiling and evaluation of fish as a dietary component'.
- N. Shahi attended the review meeting of All India Network Project on Fish Health at ICAR-Central Institute of Brackishwater Aquaculture, Chennai on 6th December 2016.
- N. Shahi participated in the review meeting of All India Network Project on Fish Health at ICAR headquarters, New Delhi during 3-4 November 2016.
- N.N. Pandey attended the meeting and seminar of Indo-Norwegian joint working group at Krishi Bhawan, New Delhi on 8th April 2016.
- N.N. Pandey attended the review meeting and workshop of National Mission for Sustaining the Himalayan Ecosystems organized at ICAR-VPKAS, Almora on 4th July 2016.
- N.N. Pandey attended the techno-policy meeting on doubling farmers' income, convened at G.B. Pant University of Agriculture & Technology, Pantnagar on 22nd and 29th March 2017, and presented the draft action plan of ICAR-DCFR for doubling the cold water fish farmers' income by 2022.
- N.N. Pandey participated in the review meeting of ICAR network projects convened at NASC, New Delhi during 3-4 November 2016, and presented the progress made under the outreach activity on 'Fish feed'.
- R.S. Halder participated in the 'Industry Meet' organized by ICAR-CIFE, Mumbai on 4th March 2017.

- R.S. Tandel attended the FAO-ICAR meeting on establishment of a national network of veterinary labs for AMR at Kolkata during 7-8 March 2017.

13.3. Lectures/Talks delivered

- A. Pande delivered a keynote lecture on 'Biotechnology in coldwater fish health' at the national conference of SAP-UGC on 'Plants and Environment' organized by Department of Botany, Kumaun University, Nainital during 27-28 March 2017.
- A.K. Singh delivered an invited lecture on 'Approaches for sustainable development of coldwater fisheries and aquaculture' in the PAF 3rd Congress on Social Entrepreneurship in Aquaculture organized at ICAR-CIFE, Mumbai during 27-29 April 2016.
- A.K. Singh delivered an invited lecture on 'Diversified approaches for sustainable development of coldwater fisheries and aquaculture' in the national seminar on 'Aquaculture diversification: the way forward for blue revolution' organized at ICAR-CIFA, Bhubaneswar during 1-3 December 2016.
- A.K. Singh delivered an invited lecture on 'Sex determination in fishes' in the National Science Day event organized at Babasaheb Bhimrao Ambedkar Central University, Lucknow on 28th February 2017.



Dr. A.K. Singh lecturing at BBAU, Lucknow

- A.K. Singh delivered an invited talk on 'Resurrection of mahseer fishery in India: policies, issues and consilience' in the national conference on 'Conservation and Institutional Development of Mahseer' held at Devi Ahilya University, Indore, during 9-11 September 2016.
- A.K. Singh delivered an invited talk on 'Sheetjal matsya paalan evam matsyiki neelikranti ke paripekshya mein vikas ke path per' in the World Fisheries Day meet organized by Department of Animal Husbandry Dairying & Fisheries, Ministry of Agriculture and Farmers Welfare, Govt. of India, New Delhi on 21st November 2016.
- A.K. Singh delivered the keynote address and theme presentation in the national interactive meet on 'Mahseer in recreational fisheries and ecotourism in north-east India', organized by ICAR-DCFR at Nagaon, Assam during 1-2 October 2016.
- D. Sarma delivered an invited talk on 'Breeding biology, nutrient quality and conservation of golden and chocolate mahseer' in the national conference on 'Developing strategies and institutions for mahseer conservation in India' organized by School of Biotechnology, Devi Ahilya University, Indore during 9-11 September 2016.
- D. Sarma delivered an invited talk on 'Culture of lesser known fish species with commercial importance of north-east India' in the training organized by National Fisheries Development Board, Hyderabad at NIRD, Guwahati on 16th July 2016.
- D. Sarma delivered an invited talk on 'Ornamental fishes in north-east India and its prospects for commercial farming' in the NFDB sponsored training organized at Guwahati University on 17th July 2016.

- N.N. Pandey delivered an oral presentation on the 'Scope and prospects of trout farming in Sikkim' in the national workshop organized by College of Fisheries, Tripura at Gangtok.
- P. Dash delivered a lecture on 'Water quality management in aquaculture' in the hands-on training programme on 'Breeding and hatchery management of mahseer' organized by ICAR-DCFR for state fisheries officials at Bhimtal during 1-6 July 2016.
- R.S. Haldar delivered a lecture on 'Breeding and seed production techniques of mahseer' in the hands-on training programme on 'Breeding and hatchery management of mahseer' organized by ICAR-DCFR for state fisheries officials at Bhimtal during 1-6 July 2016.
- R.S. Haldar delivered a lecture on 'Culture and breeding of mahseer' in the model training course on 'Hill fish farming for the upliftment of rural economy in NEH region' organized by ICAR-DCFR at the Directorate of Fisheries, Govt. of Mizoram, Aizawl during 2-9 December 2016.
- R.S. Haldar delivered a lecture on 'Culture and breeding of rainbow trout' in the model training course on 'Hill fish farming for the upliftment of rural economy in NEH region' organized by ICAR-DCFR at the Directorate of Fisheries, Govt. of Mizoram, Aizawl during 2-9 December 2016.
- R.S. Haldar delivered a lecture on 'Present status and future perspective of coldwater fisheries in India' to the M.F.Sc. and Ph.D. students at the Department of Fishery Economics and Statistics, Faculty of Fishery Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata on 8th September 2016.

LIBRARY & INFORMATION SERVICES

The library and documentation unit of the ICAR-Directorate of Coldwater Fisheries Research serves as a repository of scientific and technical literature and provides latest information in the field of fisheries, aquaculture and allied aspects.

During the year 2016-17, the Directorate subscribed 12 online International journals, 5 Indian journals and procured 225 scientific and 356 Hindi books of both Indian and foreign authors. Some of the important journals subscribed during the year were Nature, Fish and Fisheries, Reviews in Aquaculture, Journal of Fish Biology, Journal of Fish Diseases, Aquaculture Research, Aquaculture Nutrition, Mitochondrial DNA, Journal of Aquatic Animal Health, Journal of Applied Ichthyology and Current Science. All the articles of the 12 subscribed online journals were downloaded and soft copies were added to the e-inventory of the library. The current holding of the library includes 5761 books, 1693 volumes of foreign journals, 536 volumes of Indian journals and above 9000 other publications. The library provides services to scientists and other staff of the institute, as well as scholars, researchers, students and other persons from local organizations interested in scientific literature on coldwater fisheries and allied subjects. The total expenditure incurred by the library during the year under report was Rs. 42,98,148. The total revenue generated through sale of in-house publications was Rs. 47,000.

Library automation

Important activities of the library such as cataloguing and retrieval have been computerized using TLS software. The records of books, journals, bulletins and other documents have been entered in the database. The barcoding of books and periodicals are actively being done. The digitization work of the institute publications has been completed.

Information services

The library provides facility to access free online downloads of publications and articles of many international and national journals through www.cera.jece.in. The library is further continuing its efforts in collection, processing and disseminating scientific/technical information to the potential users. The library has provided many scanned reprints of offline/back volume research articles to various distant users/researchers of NARS through DDR (document delivery request), an online document delivery service of J-gateplus under CeRA of ICAR.

Reprography services

The library maintained active reprography services by producing departmental publications and providing required photocopies in black and colour to scientists, research scholars as well as other research organizations, on request.

Exchange Services

The library maintained exchange relationship with various research organizations and institutes of national and international repute. The annual reports, newsletters, special publications and technical bulletins published from time to time have been mailed to more than 250 organizations, institutions and fishery agencies.

Documentation section

The documentation section of the library is entrusted with the responsibility concerning the publication of scientific bulletins, brochures, pamphlets, annual reports and newsletters. During the reporting period, this section published two annual reports 2015-16 (Hindi and English), two bulletins and two newsletters of the Directorate.

DISTINGUISHED VISITORS

- Shri S.S. Ahluwalia, Honourable Minister of State for Agriculture and Farmers Welfare, Govt. of India, visited ICAR-DCFR, Bhimtal on 2nd March 2017. He visited the laboratories and farm facilities of the Directorate and was appraised about the various research and development activities carried out. The Honourable minister appreciated all the scientific efforts and emphasized the Prime Minister's mission on doubling the profit of farmers by increasing productivity through technological interventions and simultaneously reducing the cost of fish production.



Shri S.S. Ahluwalia visiting the farm facility at Bhimtal

- Dr. T. Mohapatra, Secretary (DARE) and Director General (ICAR) visited the Directorate on 2nd July 2016. He interacted with the scientists while visiting the laboratories and farm facilities, and encouraged them to translate their research efforts into fruitful technologies. Besides, he inaugurated the mahseer broodstock rearing facility developed in the hatchery complex at Bhimtal, launched a short-term training programme for fisheries officers on 'Mahseer breeding and hatchery management' and released three publications of ICAR-DCFR.



Dr. T. Mohapatra inaugurating the mahseer brood bank facility

- Shri Ajay Tamta, Honourable Minister of State for Textiles and Member of Parliament, visited the farm facilities at ICAR-DCFR Field Centre, Champawat on 20th May 2016. He was appraised about the various research, extension and developmental activities undertaken in the Directorate's field centre.



Shri Ajay Tamta visiting the farm complex at Champawat

- Shri Chhabilendra Roul, Additional Secretary (DARE) and Secretary (ICAR) visited the Directorate on 28th May 2016, discussed with all the scientists and staff about several issues related to research and administration. He also inaugurated the molecular biochemistry laboratory at Bhimtal.



Shri C. Roul visiting the farm complex at Bhimtal

- Shri S.K. Singh, Additional Secretary and Financial Advisor (DARE/ICAR) visited the Directorate on 30th April 2016. He observed all the facilities and encouraged all the scientists and staff to contribute to the development of the sector.



Shri S.K. Singh observing the fish stock

- Dr. J.K. Jena, Deputy Director General (Fisheries, ICAR) visited the Directorate on 31st May 2016 and 2nd July 2016. He inaugurated the renovated aquarium and fish nutritional



Dr. J.K. Jena inaugurating the aquarium facility

physiology laboratory at Bhimtal. He also keenly interacted with all the scientists about the individual research projects undertaken and gave valuable suggestions for improvement.

- Dr. B.S. Bisht, Director, Birla Institute of Applied Sciences, Bhimtal and former Vice-Chancellor, GBPUAT, Pantnagar visited the Directorate on 24th September and 3rd December 2016.
- Dr. R.K. Singh, Director, ICAR-IVRI, visited the Directorate on 28th May and 2nd July 2016.
- Dr. A. Pattanayak, Director, ICAR-VPKAS, visited the Directorate on 2nd July 2016.
- Dr. B. Pattnaik, Director, ICAR-DFMD, visited the Directorate on 28th May and 2nd July 2016.
- Dr. S.C. Dubey, Director, ICAR-NBPGR, visited the Directorate on 2nd July 2016.
- Dr. M. Sinha, Former Director, ICAR-CIFRI, Barrackpore and Chairman, RAC visited the Directorate during 24-25 March 2017.
- Dr. S. Raizada, Assistant Director General (Inland Fisheries), ICAR, New Delhi and Member, RAC/IMC visited the Directorate during 24-25 March 2017.
- Dr. S.C. Mukherjee, Former Joint Director, ICAR-CIFE, Mumbai and Member, RAC visited the Directorate during 24-25 March 2017.
- Dr. A.K. Sahu, Former Principal Scientist, ICAR-CIFA and Member, RAC visited the Directorate during 24-25 March 2017.
- Dr. H.C.S. Bisht, Professor, Department of



RAC members visiting the farm facility at Bhimtal

Zoology, Kumaon University, Nainital and Member, RAC visited the Directorate during 24-25 March 2017.

- Dr. Mark Everard, Environmentalist and Associate Professor, University of the West of England visited the Directorate during June 2016 and delivered a lecture on ecosystem services with respect to golden mahseer recreational fishing.
- Dr. S.K. Verma, Principal Scientist and In-charge, ICAR-NBPGR regional station, Bhowali visited the Directorate on 24th September 2016.
- Dr. R.S. Chauhan, Professor, G.B. Pant University of Agriculture and Technology, Pantnagar visited the Directorate on 24th September 2016.



Dr. Mark Everard interacting with researchers

- Dr. Dinesh Sati, Consulting Geologist, Dehradun visited the Directorate on 24th September 2016.

IMPORTANT COMMITTEES

16.1. Members of Research Advisory Committee

Dr. M. Sinha, Former Director, ICAR-CIFRI & Former Advisor, Department of Fisheries, Tripura Raghurir Sadan, District Judge's Compound, Civil Lines, Gorakhpur-273001, Uttar Pradesh.	Chairman
Shri T.D. Bhutia, Addl. Director (Fisheries), Dept. of Animal Husbandry, Livestock & Fisheries Services, Government of Sikkim, Krishi Bhawan, Tadong, Sikkim.	Member
Dr. S.C. Mukherjee, Former Joint Director, ICAR-CIFE, 187 A, Sahid Nagar, Bhubaneswar-751007, Odisha.	Member
Dr. A.K. Sahu, Former Principal Scientist, ICAR-CIFA, 16, Bhimpur Duplex Colony, Bhubaneswar-751020, Odisha.	Member
Dr. H.C.S. Bisht, Professor, Department of Zoology, Kumaon University, DSB campus, Nainital-263001, Uttarakhand.	Member
Dr. S. Raizada, Asst. Director General (Inland Fisheries), ICAR, Krishi Anusandhan Bhawan-II, New Delhi-110012.	Member
Dr. A.K. Singh, Director, ICAR-DCFR, Bhimtal.	Member
Dr. N.N. Pandey, Principal Scientist, ICAR-DCFR, Bhimtal.	Member Secretary

16.2. Members of Institute Management Committee

Dr. A.K. Singh, Director, ICAR-DCFR, Bhimtal.	Chairman
Dr. S. Raizada, Asst. Director General (Inland Fisheries), ICAR, KAB II, New Delhi.	Member
Shri G.B. Oli, Secretary & Director of Fisheries, Govt. of Uttarakhand, Secretariat, Subhash Road, Dehradun-248001, Uttarakhand.	Member
Shri R.P.S. Bali, Director, Directorate of Fisheries, Govt. of Jammu & Kashmir, Nowabad Canal Road, Jammu, Jammu & Kashmir.	Member
Dr. R.S. Chauhan, Head of Department (Aquaculture) College of Fisheries, GBPUAT, Pantnagar, Uttarakhand.	Member
Dr. A.B. Pandey, Principal Scientist, ICAR-Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh.	Member
Dr. Raj Narayan, Principal Scientist & Head, Directorate of Mushroom Research, Solan, Himachal Pradesh.	Member

Dr. J.K. Bisht, Principal Scientist, ICAR-VPKAS, Almora, Uttarakhand.	Member
Dr. S.K. Verma, Principal Scientist & Head, NBPGR Regional Station-Bhowali, Niglat, Nainital-263132, Uttarakhand.	Member
Shri Kunal Kalia, F&AO, ICAR HQ, Krishi Bhawan, New Delhi-110001.	Member
Shri Vipin Pandey, M/s Shilpi photo studio, Haldwani-263139, Uttarakhand.	Member
Shri Pradeep Bisht, 416, Hiranagar, Haldwani-263139, Uttarakhand.	Member
Shri R.S. Negi, Administrative Officer, ICAR-DCFR, Bhimtal.	Member Secretary

16.3. Members of Prioritization Monitoring & Evaluation Cell

Dr. N.N. Pandey, Principal Scientist	In-charge
Dr. Shahnawaz Ali, Scientist	Member
Dr. Kh. Victoria Chanu, Scientist	Member
Sh. Amit Kumar Saxena, Sr. Technical Assistant	Technical support
Smt. Susheela Tewari, Private Secretary to Director	Secretarial assistance

16.4. Members of Prioritization Monitoring & Evaluation Committee

Dr. A.K. Singh, Director	Chairman
Dr. A. Barat, Principal Scientist & In-charge, Molecular Genetics & Biotechnology	Member
Dr. D. Sarma, Principal Scientist & In-charge, Resource Assessment & Management, Extension & Training	Member
Dr. Prem Kumar, Principal Scientist & In-charge, Agricultural Knowledge Management Unit	Member
Dr. S. Chandra, Senior Scientist & In-charge, Field Centre, Champawat	Member
Dr. R.S. Patiyal, Senior Scientist & In-charge Institute Technology Management Unit	Member
Dr. N.N. Pandey, Principal Scientist & In-charge, Aquaculture and Nutrition & PME cell	Member Secretary

16.5. Members of Institute Technology Management Committee

Dr. A.K. Singh, Director	Chairman
Dr. A. Barat, Principal Scientist	Member
Dr. P.K. Sahoo, Principal Scientist	Member
Dr. Laxmi Kant, Principal Scientist, ICAR-VPKAS, Almora	External Member
Dr. Prem Kumar, Principal Scientist	Member
Dr. Shahnawaz Ali, Scientist	Member

Dr. M.S. Akhtar, Scientist	Member
Dr. R.S. Patiyl, Senior Scientist	Member Secretary

16.6. Members of Institute Technology Management Unit

Dr. Prem Kumar, Principal Scientist	Overseer
Dr. R.S. Patiyl, Senior Scientist	In-charge
Dr. Shahnawaz Ali, Scientist	Member

16.7. Members of Agricultural Knowledge Management Unit

Dr. Prem Kumar, Principal Scientist	In-charge
Sh. S.K. Mallik, Scientist	Member
Dr. M.S. Akhtar, Scientist	Member
Sh. R.S. Tandel, Scientist	Member
Sh. A.K. Saxena, Sr. Technical Assistant	Technical support

16.8. HYPM, PERMISNET, PIMS, MIS & FMS

Dr. Prem Kumar, Principal Scientist	Nodal Officer
Sh. A.K. Saxena, Sr. Technical Assistant	Technical support

16.9. Library Advisory Committee

Dr. A.K. Singh, Director	Chairman
Dr. D. Sarma, Principal Scientist	Member
Dr. N.N. Pandey, Principal Scientist	Member
Dr. Deepjyoti Baruah, Senior Scientist	Member
Dr. M.S. Akhtar, Scientist & I/c Library	Member Secretary
Sh. R.S. Negi, Administrative Officer	Member
Sh. B.C. Pandey, Asst. Fin. & Acc. Officer	Member

16.9. Institute Joint Staff Council

Official side	
Dr. A.K. Singh, Director	Chairman
Dr. A. Barat, Principal Scientist	Member
Dr. Suresh Chandra, Senior Scientist	Member
Sh. R.S. Negi, Admin. Officer	Member
Sh. B.C. Pandey, Asst. Fin. & Acc. Officer	Member
Smt. Khilawati Rawat, Asst. Admin. Officer	Member Secretary
Staff side	
Sh. P.C. Tewari, Admin. Assistant	CJSC Member
Sh. J.C. Bhandari, Admin. Assistant	Member
Sh. R.K. Arya, Technical Assistant	Member
Sh. Manoj Kumar, Skilled supporting staff	Member
Sh. Mangla Prasad, Skilled supporting staff	Member

16.10. Institute Biosafety Committee

Dr. A. K. Singh, Director, ICAR-DCFR, Bhimtal.	Chairman
Dr. A. K. Tiwari, Principal Scientist & Head, Division of Standardization, ICAR-IVRI, Izatnagar.	DBT Nominee
Dr. A. B. Pandey, Principal Scientist & Head, Division of Virology, ICAR-IVRI, Mukteshwar.	Outside Expert
Dr. A. K. Sharma, Principal Scientist, ICAR-IVRI, Mukteshwar.	Outside Expert
Col. (Dr.) C. S. Rawat, MBBS, DPH, FRIPHH	Biosafety Officer
Dr. A. Barat, Principal Scientist, ICAR-DCFR, Bhimtal.	Member
Dr. Neetu Shahi, Scientist, ICAR-DCFR, Bhimtal.	Member
Dr. Dimpal Thakuria, Scientist, ICAR-DCFR, Bhimtal.	Member
Dr. Amit Pande, ICAR National Fellow, ICAR-DCFR, Bhimtal.	Member Secretary

17.1. Obituary

It is with great sadness, we report the demise of Dr. P.C. Mahanta, Former Director of ICAR-DCFR (2007-2012), on 17.10.2016. May his departed soul rest in peace and we pray that the Almighty God will give strength and comfort to his bereaved family. Memories of his strong leadership and hard work will continue to inspire us and his legacy will remain forever.



Dr. P.C. Mahanta, Former Director, ICAR-DCFR

17.2. Joining

The following newly recruited Agricultural Research Service scientists and administrative officer joined the Directorate during the reporting period April 2016 to March 2017.

Dr. Raghvendra Singh, Scientist (Aquaculture), joined on 1st April 2016.

Shri Raja Aadil Hussain Bhat, Scientist (Fish Health), joined on 11th April 2016.

Shri Kishor Kunal, Scientist (Fisheries Resource Management), joined on 11th April 2016.

Shri Parvaiz Ahmad Ganie, Scientist (Fisheries Resource Management), joined on 11th April 2016.

Shri Ravindra Singh Negi, Administrative Officer, joined on 17th November 2016.

17.3. Promotions

Dr. Prem Kumar was promoted to the post of Principal Scientist (Fish & Fishery Sciences) under CAS of ICAR, with effect from 3rd October 2014.

17.4. Transfers

Shri Y.S. Dhanik, Administrative Officer, was promoted to the post of Senior Administrative Officer and transferred to ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, by the Council. He was relieved from the Directorate on July 2016.

Shri Vijoy Kumar Singh, Sr. Technical Assistant, was transferred to ICAR-National Bureau of Fish Genetic Resources, Lucknow, by the Council. He was relieved from the Directorate on 30th July 2016.

PERSONNEL

Staff list as on 31.03.2017

18.1. Research Management		
	Dr. A. K. Singh	Director
18.2. Scientific Staff		
1.	Dr. P. K. Sahoo	Principal Scientist (Fish & Fishery Science)
2.	Dr. Ashoktaru Barat	Principal Scientist (Fish Genetics & Breeding)
3.	Dr. Debajit Sarma	Principal Scientist (Fish & Fishery Science)
4.	Dr. Amit Pande	ICAR National Fellow (Biotechnology-Animal science)
5.	Dr. Nityanand Pandey	Principal Scientist (Aquaculture)
6.	Dr. Prem Kumar	Principal Scientist (Fish & Fishery Science)
7.	Dr. Suresh Chandra	Senior Scientist (Fish Pathology)
8.	Dr. R. S. Patiyl	Senior Scientist (Fish Genetics & Breeding)
9.	Dr. S. G. S. Zaidi	Senior Scientist (Aquaculture)
10.	Dr. Deepjyoti Baruah	Senior Scientist (Fish & Fishery Science)
11.	Dr. Shahnawaz Ali	Scientist (Aquaculture)
12.	Sh. Sumanta Kumar Mallik	Scientist (Aquaculture)
13.	Dr. Neetu Shahi	Scientist (Biotechnology-Animal Science)
14.	Dr. Md. Shahbaz Akhtar	Scientist (Fish & Fishery Science)
15.	Dr. Dimpal Thakuria	Scientist (Biochemistry-Animal science)
16.	Dr. Kh. Victoria Chanu	Scientist (Biochemistry-Animal science)
17.	Dr. Ciji Alexander	Scientist (Fish Nutrition)
18.	Dr. Biju Sam Kamalam, J.	Scientist (Fish Nutrition)
19.	Sh. Rajesh M	Scientist (Fish Nutrition)
20.	Sh. Tandel Riteshkumar Shantilal	Scientist (Fish Health)
21.	Sh. Abhay Kumar Giri	Scientist (Aquaculture)
22.	Smt. Pragyan Dash	Scientist (Aquaculture)
23.	Dr. Prakash Sharma	Scientist (Fish Nutrition)
24.	Sh. Siva, C.	Scientist (Fish Genetics & Breeding)
25.	Dr. Raghvendra Singh	Scientist (Aquaculture)
26.	Sh. Kishor Kunal	Scientist (Fisheries Resource Management)
27.	Sh. Parvaiz Ahmad Ganie	Scientist (Fisheries Resource Management)
28.	Sh. Raja Aadil Hussain Bhat	Scientist (Fish Health)

18.3. Technical Staff

1.	Dr. R. S. Halder	Assistant Chief Technical Officer
2.	Sh. Amit Kumar Joshi	Sr. Technical Officer
3.	Sh. Baldev Singh	Sr. Technical Officer
4.	Sh. Santosh Kumar	Technical Officer
5.	Sh. Ravinder Kumar	Technical Officer
6.	Sh. Amit Kumar Saxena	Sr. Technical Assistant
7.	Sh. Gopal C. Arya	Sr. Technical Assistant
8.	Sh. Hansa Dutt	Sr. Technical Assistant
9.	Sh. T. M. Sharma	Technical Assistant
10.	Sh. R. K. Arya	Technical Assistant
11.	Sh. Partha Das	Sr. Technician
12.	Sh. Manoj Kumar Yadav	Driver (Sr. Technician)

18.4. Administrative Staff

1.	Sh. Ravindra Singh Negi	Administrative Officer
2.	Sh. Harish Ram	Asstt. Admn. Officer
3.	Sh. B. C. Pandey	Asstt. Fin. & Acc. Officer
4.	Smt. Khilawati Rawat	Asstt. Admn. Officer
5.	Smt. Susheela Tewari	Private Secretary
6.	Sh. P. C. Tewari	Assistant
7.	Sh. J. C. Bhandari	Assistant
8.	Sh. Arun Khulbe	Assistant
9.	Sh. Ankesh Kumar Sinha	Assistant
10.	Sh. Pratap Singh Bisht	UDC
11.	Smt. Munni Bhakt	UDC
12.	Sh. Hansa Singh Bhandari	LDC

18.5. Skilled Supporting Staff

1.	Sh. Ravinder Kumar	Skilled Supporting Staff
2.	Sh. Om Raj	-do-
3.	Sh. Sunder Lal	-do-
4.	Sh. Dharam Singh	-do-
5.	Sh. Pooran Chandra	-do-
6.	Sh. Manoj Kumar	-do-
7.	Sh. Kuldeep Kumar	-do-
8.	Sh. Bhola Dutt Mouni	-do-
9.	Smt. Basanti Devi	-do-
10.	Sh. Mangla Prasad	-do-
11.	Sh. Sushil Kumar	-do-

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शीतजल मात्स्यकी अनुसंधान निदेशालय के अधिदेश के अन्तर्गत तकनीकी हस्तांतरण, प्रौद्योगिकी के प्रयोग तथा संयुक्त अनुसंधान गतिविधियों के माध्यम से पर्वतीय क्षेत्रों में शीतजल मात्स्यकी संसाधनों का सतत् प्रबन्धन करना है। वर्ष 2016-17 में निदेशालय के अन्तर्गत भिन्न गतिविधियों का संचालन किया गया जो इस प्रकार है :

संसाधन मूल्यांकन एवं प्रबन्धन

- प. रामगंगा नदी में मत्स्य समूह के वास स्थलों के स्तरों तथा उनकी विविधता का मूल्यांकन करने के पश्चात यह पता चला कि प्रजातियों का वितरण अनुदैर्घ्य आधार पर है साथ ही प्रजातियों की विविधता, समृद्धि और विपुलता, वृद्धि ऊँचाई के साथ साथ कम होती जाती है।
- हिमालयी पर्वतीय झीलों में ईको-जैविकी के अन्तर्गत किये गये अध्ययन के अनुसार उत्तराखण्ड के मुनस्यारी स्थित महेश्वर कुण्ड में हैसपरोडायप्टोमस वंशीय एक नवीन कोपीपोड प्रजाति का पता चला है।
- जल के भौतिक रासायनिक मापदण्डों, अभिसंरचनात्मक सुविधाओं तथा अन्य सुविधाओं के आधार पर हिमाचल प्रदेश के कुल्लू एवं किन्नौर तथा जम्मू एवं कश्मीर के लेह एवं कारगिल में जी.आई.एस आधारित मत्स्य-पालन स्थलों के उपयुक्त मानचित्र तैयार किये गए। इसी प्रकार जल-जीव जन्तुओं की विविधता पर प्राथमिक एवं द्वैतियक आँकड़ों का प्रयोग कर के सिन्धु, सतलज जान्सकर, व्यास, चिनाब तथा पश्चिमी हिमालय क्षेत्र के स्योकिन जैसे प्रमुख नदियों के लिए जी. आई. एस के आधार पर मत्स्य जैव-विविधता के मानचित्र तैयार किए गये।
- अरुणाचल प्रदेश में कामेंग की बर्फोली सहायक नदियों में शाइजोथोरेक्स रिचार्डसोनी प्रजाति के वास स्थलों की परिस्थितिकी, उनकी संख्या के स्तरों एवं अन्तर-विभेद आदि का अध्ययन किया जा रहा है।
- राष्ट्रीय मिशन के तहत हिमालयी पारिस्थितिकी तंत्र को बनाए रखने के लिए चयनित हिमालयी जल-

प्रणालियों में स्थानिय मछली के विस्थापन-मार्गों, विविधता, उनके अक्षांश वितरण एवं दस्तावेजों का डिजिटाइजेशन किया जा रहा है।

- राष्ट्रीय नेटवर्क परियोजना के अन्तर्गत गंगा नदी के ऊपरी सहायक नदियों से देशीय शीतजल मत्स्यों के लगभग 3400 नमूनों को एकत्रित किया गया। भीमताल तथा चम्पावत में शीतजल मत्स्य के जननद्रव्य भण्डारण केन्द्र स्थापित किया गया। बीज उत्पादन और संरक्षण के लिए गारा गोदयला का प्रजनन सफलतापूर्वक किया गया।

जलीय अनुसंधान एवं विकास

- पर्वतीय मत्स्य पालन हेतु प्रजाति विविधीकरण के लिए देशीय खाद्य मछलियों के पूर्ण मत्स्यपालन हेतु प्राथमिकता के आधार पर एक कार्यक्रम आयोजित किया गया।
- तालाबों में लेवियो पंगुसिया का प्रजनन एवं लार्वा का पालन-पोषण किया गया। बंगाना देवदेवी एवं ओस्टियोब्रामा देवदेवी के प्रजनन, जैविकी-प्रजनन तथा ओंटोजैनिक विकास का मूल्यांकन फार्म में किया जा रहा है। नदियों से एकत्र राइमस बोला के सामान्य एवं जैविक-प्रजनन का अवलोकन किया गया तथा इसके अतिरिक्त तालाबों में प्रजनित लार्वा का पालन-पोषण किया गया।
- पहली बार नियोलिस्सोचिलस हैक्सागोनोलिपिज, बेरिलियस बेंडेलिसिज तथा टौर चिलिनौयड का कांच के एक्वेरियम में लार्वा पालन एवं प्रजनन व्यवहार का अवलोकन किया गया।
- बिना जल विनिमय के रेता आधारित फिल्टर युक्त कांच मछली घर (एक्वेरियम) को सफलतापूर्वक विकसित किया गया और उसका प्रयोग माइनर कार्प (डायचिलस) व रेन्बो ट्राउट के लार्वा पालन एवं उसके अण्डों के उष्मायन हेतु किया गया।
- उच्च पर्वतीय स्थलों में पौलिथीन बिछाकर तालाबों/टैकों में कार्प पालन की संभावनाओं को देखा जा

रहा है। प्रारम्भिक अवलोकन से पता चला है कि इन क्षेत्रों में ग्रास कार्प और परिष्कृत कामन कार्प की वृद्धि बेहतर हो सकती है।

- ♦ तालाबों में सुनहरी महाशीर के जननांगों की परिपक्वता पर तापमान का प्रभाव देखा गया। उच्च तापमान में पालन करने पर मादा मछलियों में प्रोजेस्टोरान और ऐस्ट्राडील की सांद्रता उच्च थी। यद्यपि उनमें कुल इम्यूनोग्लोबुलिन और कौरटिसोल के प्लाज्मा स्तर में समवर्ती कमी देखी गयी। इसके अलावा तालाबों में सुनहरी महाशीर की परिपक्वता का आणविक मूल्यांकन हेतु एरोमाटेज ब्रेन *cyp19b* के दो आइसोफॉर्म की पूर्ण कोडिंग स्वीक्वेंसिंग कर उनका वर्गीकरण किया गया।
- ♦ जल स्रोतों से एकत्रित सुनहरी महाशीर के जननांग विकास स्तरों का अध्ययन किया गया है।
- ♦ स्नोट्राउट (शाइजोथोरेक्स रिचार्डसोनी) का लिपिड उपापचयी गतिशील रूप में पाया गया तथा पूरे शरीर की लिपिड सामग्री, प्लाज्मा, विसेरो-सोमैटिक इन्डेक्स और हेपोटोसाइट्स की मात्रा के संदर्भ में भोजन उपलब्धता का अभाव देखा गया।
- ♦ खाद्य-प्रोटीन के वर्गीकृत स्तरों पर विकास की प्रतिक्रिया के आधार पर रेन्बोट्राउट की उच्चतम आहार प्रोटीन आवश्यकता वास्तविक रूप में उच्च (45-50%) पायी गयी। यद्यपि इस प्रजाति के धीमी वृद्धि के लिए आहार का बहुत कम उपयोग (7-15 का F.C.R) अर्थात् कम भोजन ग्राह्यता को दोषी माना जा सकता है।
- ♦ स्नोट्राउट की वृद्धि एवं परिपक्वता प्राप्त करने के लिए तथा उपापचयी, पाचन से सम्बन्धित पूर्ण न्यूक्लियोटाइड स्वीक्वेंस मार्कर्स एवं DNA की फुल लेंथ करेक्तराइजेसन हेतु एक सुदृढ़ एवं कम खर्चीली RACE प्रविधि विकसित की गयी है।
- ♦ प्रमुख शीतजल मछलियों जैसे परिष्कृत हंगेरियन कामन कार्प (7.29 लाख जीरा), सुनहरी महाशीर (65000 जीरा), रेन्बोट्राउट (56000 जीरा), स्नोट्राउट (38000 जीरा) तथा सजावटी मछलियों का बीज उत्पादन किया गया। कार्प, महाशीर तथा सजावटी मछलियों के बीज उत्पादन से कुल 2.74 लाख राजस्व प्राप्त किया गया।

रोग निगरानी एवं स्वास्थ्य प्रबन्धन

- ♦ राष्ट्रीय रोग निगरानी कार्यक्रम के अन्तर्गत उत्तराखण्ड के 4 जिलों से 82 रेन्बोट्राउट तथा कॉमन कार्प की फार्म हैचरीयों तथा हिमाचल प्रदेश के 2 जिलों में सर्वेक्षण कार्य किया गया एवं मत्स्य नमूनों को एकत्र किया गया और संक्रमित मछलियों से बैक्टीरिया, जीवाणु, कवक एवं परजीवियों की जांच की गयी।
- ♦ भारतीय हिमालयी क्षेत्रों में चयनित ट्राउट फार्मों के लिए रोगजनक बैक्टीरिया, उनकी उपस्थिति, मौसमी वितरण एवं रेन्बोट्राउट में उनकी व्यापकता के लिए वाणिज्यिक प्रतिरोधी दवाओं के लिए एक व्यापक डाटाबेस विकसित किया गया है।
- ♦ स्नोट्राउट के Mx जीन और Mx प्रोमोटर के पूर्ण कोडिंग क्षेत्र की पहचान की गयी। क्लोन को वैक्टर में अभिव्यक्त किया गया तथा इसका अभिकर्मक और रिपोर्टर जीन की जांच के लिए प्लाज्मिड कन्स्ट्रक्शन में विकसित करने के लिए इस्तेमाल किया गया। PKR तथा IRF3 के स्नोट्राउट जैसे अन्य इंटरफेरॉन प्रेरित जीनों को भी पहचाना गया और क्लोन बनाया गया।
- ♦ तीन गैर रोगजनक बैक्टीरियल आइसोलेट्स- पैटोए एकेरीना, स्यूडोमोन सोरिजहेबिटान्स तथा फिक्लिबेसिलस ननहेन्सिस में हानिकारक एलिजिसीडल की सक्रियता पायी गयी।
- ♦ मत्स्य स्वास्थ्य पर अखिल भारतीय नेटवर्क परियोजना के अन्तर्गत मणिपुर और नागालैण्ड में 51 मत्स्य फार्मों से एक्वा-ड्रग्स और थेरेपीटिक्स के इस्तेमाल पर बुनियादी आंकड़े एकत्रित किए गए हैं। पर्वतीय मत्स्य पालन गतिविधियों में मत्स्य स्वास्थ्य प्रबन्धन के लिए आमतौर पर खाने वाला नमक, चूना और पोटेशियम परमैंगनेट का सर्वाधिक प्रयोग किया जाता है।

आणविक जननांकी एवं जैव प्रौद्योगिकी योगदान

- ♦ शाइजोथोरेक्स रिचार्डसोनी में ताप सहन क्षमता के लिए संभावित जीन मार्कर्स के रूप में SOCS-1a एवं SOCS-3a की पहचान की गयी है।
- ♦ SSR मार्कर्स एवं माइटोकॉन्ड्रिय जीन्स के प्रयोग द्वारा भौगोलिक रूप से अलग-अलग चौकलेट

महाशीर में हैप्लोटाइप विविधता, न्यूक्लियोटाइड विविधता, अनेक बहुरूपी स्थलों एवं आनुवंशिक भिन्नता का अध्ययन किया गया।

- ◆ सुनहरी महाशीर में एरोमोनाज हाइड्रोफीलिया संक्रमण का ट्रान्सक्रिप्टोन विश्लेषण करने से पता चला कि काम्पलिमेंट सिस्टम एंटीमाइक्रोबायल पेप्टाइड तथा स्ट्रेस रिलेटेड प्रोटीन की वजह से मछली में रोग-प्रतिरोधक क्षमता अधिक देखने को मिली।
- ◆ मत्स्य वायरल प्रोटीन से तीन नैनो पेप्टाइड प्रणालियां बनायी गयी और उनको संश्लेषित तथा शोधित किया गया।

महत्वपूर्ण घटनाएँ, विस्तार, गतिविधियाँ, प्रशिक्षण एवं विकास

- ◆ दिनांक 1-2 अक्टूबर 2016 को जासिंगफा एक्वा टूरिज्म रिजोर्ट, नौगांव, असम में भा. कृ. अनु. परि.-डी.सी.एफ.आर द्वारा “महाशीर इन रिकरिस्नल फिशरीज एण्ड ईको-टूरिज्म इन नार्थ इण्डिया” पर वैज्ञानिक एवं मत्स्य आखेटक (स्टेकहोल्डर) के लिए दो दिवसीय पारस्परिक राष्ट्रीय संगोष्ठी आयोजित की गयी।
- ◆ निदेशालय द्वारा चम्पावत केन्द्र में अपने नियमित रूप से आयोजित किए जाने वाले कार्यक्रमों के अन्तर्गत रेन्बो एवं कार्प पालन एवं उनके प्रजनन, मत्स्य स्वास्थ्य प्रबन्धन पर जन-जागरण कार्यक्रम, वैज्ञानिकों-कृषकों की परस्पर बैठक आदि आयोजित की गयी साथ ही स्थानीय ग्रामों को भी इन कार्यक्रमों में सम्मिलित किया।
- ◆ उत्तराखण्ड, सिक्किम व हिमाचल प्रदेश के किसानों को रेन्बो ट्राउट एवं कार्प के पालन से सम्बन्धित तकनीकी सहायता प्रदान की गयी तथा “मेरा गांव मेरा गौरव” योजना के अन्तर्गत अंगीकृत कृषकों को भी तकनीकी सहायता प्रदान की गयी।
- ◆ रैंचिंग कार्यक्रमों के माध्यम से भीमताल झील, महाकाली में पंचेश्वर, सरयू नदी की सहायक धाराओं आदि में सुनहरी महाशीर की अंगुलिकाओं को छोड़ा गया।
- ◆ जनजातीय उपयोजना कार्यक्रम के अन्तर्गत जम्मू एवं कश्मीर के लेह तथा उत्तराखण्ड के मुन्सियारी में जीविका के रूप में मत्स्य पालन को बढ़ावा दिया गया। इसके लिए विभिन्न प्रशिक्षण एवं जन-जागरण कार्यक्रम आयोजित किये गये। इन स्थलों में ओवा-हाउस, रेसवे का निर्माण किया गया तथा इस क्षेत्र के अंगीकृत कृषकों को मत्स्य बीज वितरित किये गये।
- ◆ उत्तर-पूर्वी गतिविधियों के अन्तर्गत मेघालय एवं नागालैण्ड में प्रमुख स्थानीय मछलियों के संरक्षण एवं प्रसार को प्रोत्साहित करने के लिए चौकलेट महाशीर की दो हैचरियां स्थापित की गयी। इसके अतिरिक्त जीरो घाटी में बीज एवं आहार की मांग के कारण एक छोटी कार्प हैचरी भी स्थापित की गयी। इसी प्रकार ट्राउट फीड के लिए एक्सट्रूडर/झायर मशीन याक अनुसंधान केन्द्र दिरांग, अरुणाचल प्रदेश में भी लगायी गयी। नागालैण्ड में पहली बार ट्राउट की खेती आरम्भ की गयी।
- ◆ निदेशालय के अनुसंधान एवं विकास सम्बन्धी गतिविधियों को विभिन्न कृषकों, हितधारकों आदि के सम्मुख देश भर में आयोजित विभिन्न 12 सम्मेलनों एवं संगोष्ठियों आदि के माध्यम से चर्चा की गयी।
- ◆ दो प्रशिक्षण कार्यक्रम “ब्रीडिंग एण्ड हैचरी मैनेजमेंट ऑफ महाशीर” तथा “हिल फिश-फार्मिंग फॉर द अपलिफ्टमेंट ऑफ रूरल इकोनोमी इन नार्थ-ईष्ट रिजन” क्रमशः उत्तराखण्ड एवं मिजोरम के राज्य मत्स्य विभाग के अधिकारियों के लिए आयोजित किये गये।
- ◆ कौशल विकास कार्यक्रम के तहत निदेशालय के वैज्ञानिकों, तकनीशियनों एवं प्रशासनिक वर्ग के कर्मचारियों, अधिकारियों को विशेष प्रशिक्षण कार्यक्रमों में भाग लेने के लिए प्रोत्साहित किया। इसी प्रकार विभिन्न शोध छात्रों की अनुसंधान परियोजनाओं को भी पर्यवेक्षित किया गया।
- ◆ निदेशालय में नए वैज्ञानिक वर्ग में डॉ. राघवेन्द्र, श्री किशोर कुणाल, श्री. आर. ए. एच. बट एवं श्री पी. ए. गनी के पदभार ग्रहण करने से अनुसंधानात्मक कार्यों को मजबूती प्राप्त होगी।
- ◆ रिपोर्ट अवधी के दौरान निदेशालय की शोध क्षमता के परिणाम स्वरूप राष्ट्रीय और अन्तराष्ट्रीय पत्रिकाओं में 30 शोध पत्र प्रकाशित किए गये।



ICAR-DCFR Field Centre, Champawat

An experimental fish farm of the Directorate is located at Chhirapani in Champawat district, Uttarakhand. This facility is involved in various research programmes, human resource development and extension activities. The primary research activities include breeding, seed production, culture and management of coldwater fishes such as rainbow trout, common carp and snow trout.

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Building and farm complex at ICAR-DCFR Field Centre, Champawat



Research and extension activities undertaken at ICAR-DCFR Field Centre, Champawat

Certificate of Registration



M14450915IN

This is to certify that the Quality Management System of

ICAR- DIRECTORATE OF COLDWATER FISHRIES RESEARCH

ANUSANDHAN BHAVAN, INDUSTRIAL AREA, BHIMTAL-263136,
DISTRICT NANITAL, UTTARAKHAND, INDIA

has been audited and conformed to be in accordance
with the requirements of

ISO 9001:2015

The Quality Management System is Applicable to :

DEVELOPING TECHNOLOGIES, STRATEGIES AND MODELS FOR
ASSESSMENT AND SUSTAINABLE UTILIZATION OF COLDWATER
FISHERIES RESOURCES

Certificate No: 17QAE56

Initial Registration Date: 22/06/2017

First Surveillance Date: 22/05/2018

Second Surveillance Date: 22/05/2019

Issuance Date: 22/06/2017

Date of Expiry*: 21/06/2020


DIRECTOR



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