Conservation and development of fish genetic resources — Mission of the National Bureau of Fish Genetic Resources

The National Bureau of Fish Genetic Resources (NBFGR) based in Lucknow, is India's premier organization devoted to conservation and sustainable development of fish genetic resources.

Set up in December 1983 in Allahabad and moved to Lucknow in 1994, the NBFGR taps cutting-edge technologies and mobilizes national co-operation to:

- collect, catalogue and document fish genetic resources;
- maintain and preserve fish genetic material to conserve endangered fish species;
- evaluate indigenous and exotic fish species; and
- ensure Intellectual Property Protection relating to fish genetic resources.

The infrastructure

The 52-hectare complex on which NBFGR stands (inaugurated by Prime Minister Atal Behari Vajpayee in June, 1999) houses laboratories; farm facilities (broodstock rearing ponds, nursery ponds, breeding ponds, a live fish gene bank, data banks); an Information Technology provider known as ARIS (Agriculture Research Information Service) cell which contains hardware, software and networking facilities and a Geographic Information System or GIS lab; an Intellectual Property Rights training cell; an extension and training cell; a fully automated library that provides electronic access to several databases and to top journals in agriculture, plant sciences, fisheries, aquaculture and ecology.

An International Centre for Fish DNA Barcoding was established in 2006. A microbiology lab was developed and equipped for disease diagnostics. An Aquaculture Research & Training Unit focuses on quality fish seed production technologies and on training both farmers and department personnel. It is presently being upgraded, with a special emphasis on catfish, carp and freshwater prawn.

Other infrastructure includes an aquarium, a hatchery complex and a fish museum, to be expanded into a National Fish Museum. Besides, a research unit of the NBFGR was set up in Cochin in 1994 at the Central Marine Fisheries Research Institute, Kochi.

NBFGR is run by a staff of 79 including 26 scientists, a research manager and 26 technical support personnel.

Director of the National Bureau of Fish Genetic Resources, Lucknow, Dr W. S. Lakra has implemented several innovative programmes in aquatic genetic resources conservation including DNA barcoding of fish and marine life and the concept of a 'State Fish'.

A graduate of Delhi University, with an MSc and PhD from H.N.B. Garhwal University, Dr Lakra has been principal scientist and head of the department of genetics and biotechnology at the Central Institute of Fisheries Education, Mumbai, where he helped initiate India's first master's and PhD programmes in fish genetics and biotechnology. He also helped establish a Centre of Fish Molecular Genetics and Biotechnology. He organized several HRD programmes in fish biotechnology and the first national conference on the subject in 2000.

Dr Lakra has authored or edited 20 books, published more than 120 research papers and guided several research students.

Widely traveled, he has visited Canada, Norway, France, Australia, China, Singapore, Bangladesh, Korea, Malaysia, Thailand and Taiwan. He has been an expert member of the international review team for the genetic improvement and biodiversity programme of the WorldFish Centre, Malaysia. He has made significant contributions in fish genetics, biodiversity conservation and aquaculture biotechnology through research, teaching, extension, research management and infrastructural development.

Dr Lakra has won several honours, including the M. S. Swaminathan Best Indian Fisheries Scientist Award. He is founder president of the Aquatic Biodiversity Conservation Society and regional chair of the Global Consortium of Barcoding of Life (CBOL).

The why and how of NBFGR

Before describing the achievements of the NBFGR, which is now about 26 years old, one first needs to clarify the scientific and development rationale of a knowledge-intensive, technology-intensive and research-intensive organization like the NBFGR, and its methodology.

Rationale: Fisheries and aquaculture are crucial for India's food production and food security. Fisheries and aquaculture also relate directly to poverty alleviation and economic uplift – since thousands of fisherfolk and farmers depend on fisheries for their livelihoods. Fisheries and fish products also feed the pharmaceutical industry and other industries.

But fish resources everywhere – not just in India and worldwide – seem to be dwindling and are under pressure. Some resources are in danger of extinction. Making fisheries sustainable demands better planning, sounder management strategies, and better knowledge of India's rich aquatic biodiversity.

A majority of the genetic resources for food still come from the wild, because of the low domestication level in fisheries, in contrast to animal farming and agriculture.

Threats to our aquatic biodiversity are many and varied – over-exploitation of resources, habitat alteration, construction of dams, introduction of non-native species etc.

Conservation and management of India's fish and aquatic resources call for holistic approaches to knowledge and to documentation, hence the relevance and role of the NBFGR.

Methodology

NBFGR carries out multi-disciplinary research, develops research tools and disseminates information – in biology, genetics, molecular biology, biotechnology, etc. It studies habitats and inventories the resources. It taps remote sensing and GIS

applications. Result: databases that strengthen knowledge and provide insights on our fish and aquatic resources.

What are the achievements of NBFGR?

1. Development of databases

A database has been developed on India's fish diversity, comprising information on 2 245 indigenous and 291 exotic finfishes.

The database provides information on a) classifications,
b) nomenclature: scientific name, synonyms, local names in different regional languages, common name in English, c) distribution in India and abroad (global distribution),
d) habitat: coldwater, warmwater, brackishwater and marine,
e) commercial importance: food fishes, sports fishes, ornamental fishes, cultivable fishes, etc,
f) maximum and minimum size,
g) morphological features including key identification features like fin formula, h) status: endangered, vulnerable, threatened, rare, indeterminate (based on IUCN criteria), and i) images: studio photographs, diagrams and digital.

Every finfish has been given a distinctive five-digit code. The first three digits relate to the genus, the last two digits show the species. Thus each species has a unique code. All the information related to a particular species can be retrieved by this unique code.

The database is being updated for shellfishes. The present information covers 1 655 molluscan, 923 crustacean, 43 echinoderm and 350 species of marine ornamental fishes. Information has also been collected on marine shellfishes of India – prawns, lobsters, crabs, gastropods, bivalves, cephalopods, turtles, crocodiles, whales, dolphins, porpoises, sea cows, sponges, corals, sea cucumbers, sea urchins and seaweeds. Work is in progress to incorporate genetic information as an important component of the database. The work is also being extended beyond the taxonomic diversity of fishes.

Under a collaborative programme, 31 new fish species from the northeast and the Western Ghats have been identified and described. More unexplored regions are to be surveyed to describe germplasm resources in future. Attempts are being made to develop databases on a GIS format. Policy makers envisage a database that will provide integrated information concerning habitat, distribution and other available information.

Database: 'Fish Chromosome World'

A database named 'Fish Chromosome World' in digital interactive format has been published by NBGFR. It contains karyomorphological information on 126 finfish species from 34 families and nine orders. The fish species and its locality are classified, information is provided on the chromosome number, the chromosome formula, authors and references. Photographs of metaphase spreads and/or

karyotypes of fish species are provided. The database can be accessed on NBFGR's official website **www.nbfgr.res.in**.

2. Genetic Characterization

DNA Barcoding of Indian fishes

With the help of sophisticated equipment acquired for genetic characterization (major facilities include an automated karytyper, a DNA sequencing and genotyping system), the NBFGR has initiated a comprehensive programme on DNA barcoding. This is a species identification programme – being developed for the first time in India – for all marine and freshwater fishes of India.

The work on DNA barcoding of Indian fishes was initiated in July 2005, at NBFGR, as the lead centre for the Indian region working group of FISH-BOL. An international training programme on "DNA Barcoding of Marine Life" was conducted at NBFGR from 16 to 21 April 2007. Trainees and resource personnel from Canada, Australia, Kenya, Tanzania and South Africa participated.

Under the DNA barcoding programme, comprehensive sample collections are being obtained. DNA barcodes were prepared for 742 sequences (DNA barcodes) of 244 species.

Genotyping and Genetic Diversity Analysis

The NBFGR identifies appropriate genetic markers which make possible the quantification of genetic variability at intra and inter-specific levels. Expertise has been developed for various classes of markers – cytogenetic, allozyme, DNA including RAPD, mtDNA, RFLP – and microsatellites. These markers are used to generate information and data on prioritized fish species to study inter-specific and intra-specific variation.

Species-specific diagnostic markers

Unambiguous description of a species is important for conservation. Molecular markers are invaluable tools to complement conventional tools in resolving taxonomic ambiguities. Species-specific diagnostic markers have been developed to detect hybridization and introgression in Indian major carp hatchery and wild populations. The markers included allozyme and mtDNA haplotypes.

NBFGR has a very strong cytogenetic data base for about 200 fish species and stocks within species which will help to resolve ambiguities between different species or varieties. This in turn will help plans for conservation strategies of endangered species and their utilization in fish breeding programmes.

NBFGR has characterized several fish species such as *Labeo rohita, Catla catla* and *Cirrhinus mrigala*; endangered mahseer species, including *Tor khudree, T. mussullah, T. tor, T. putitora*, *Schizothorax richardsonii*; and commercially important catfishes like *Clarias batrachus*, *Heteropnuestes fossilis,* etc. Variations have been reported for the first time between *Clarias batrachus* and exotic *C. gariepinus* using cytogenetic markers like C- and NOR banding.

Molecular markers in endangered and commercial fish species

At intra-specific levels, variations are assessed within and between populations. Such studies provide precise information on the stock structures of prioritized endangered and commercial fish species. This is vital for planning rehabilitation of endangered fishes and for genetic improvement of cultivable species.

Research on two important Indian major carps, *Labeo rohita* and *Catla catla,* indicates a substructure population for these two species. The study has identified genetic stocks of rohu and catla across its natural range of distribution in India using allozyme and microsatellite DNA markers.

Genotoxicity assays

An increasing number of genotoxic chemicals like pesticides and heavy metals are being released into the aquatic environment. These imperil not merely aquatic biodiversity but human health as well. The Bureau has developed strong skills for studying the genotoxic effect in fishes through a battery of test systems like the micronuclei test, the chromosome aberration test, the sister chromatid exchange (SCE) assay and the comet assay. Such studies not only help determine the safe level of genotoxicants in water bodies but also help remedial measures to conserve our rich aquatic biodiversity.

3. *In situ* conservation

The *in situ* conservation programmes of the NBFGR cover protected areas and fish sanctuaries, the traits of prioritized species, evaluation of the impact of exotic fishes on natural populations, development of assays for genotoxicity, etc.

Such conservation efforts cannot be meaningful without people's participation through mass awareness programmes. Local bodies and fishing communities must be sensitized about conservation programmes.

'State fish': A novel approach to fisheries conservation

Under this initiative, the Directorate of Fisheries of each Indian state was encouraged to adopt one fish

species as a 'State Fish' on the lines of the National Animal/National Bird. So far, 15 states have responded to this initiative with 'State Fish' declarations. The idea is that conservation of these species will be researched and reviewed as a matter of priority, with technical help available from NBFGR. An operational farm in each state will be devoted to the 'State Fish' for developing a gene bank and broodstock and propagation protocol. Eventually, strategies can be developed for field level conservation programmes.

Life history traits of natural populations of prioritized fishes

Studies on life history traits of fish populations are essential for planning conservation and management of a species. Such studies have been scanty so far. Parameters like fecundity, size at first maturity, gonadosomatic index, age and growth, length-weight relationship, oocyte size frequency profile, food and feeding habits, etc. are crucial for examining any stock. Of the 587 freshwater species reported in India, more than 100 species have potential for culture. NBFGR is conducting studies to generate life history data of endangered and commercially important fishes in the North East and in the Western Ghats, to facilitate sustainable management and conservation.

Fish sanctuaries and protected areas

Very few sanctuaries for aquatic resources – necessary for *in-situ* conservation – exist today. Aquatic sanctuaries including marine protected areas would not only help conserve biodiversity but also rejuvenate fisheries.

Captive propagation of threatened fishes

Captive breeding programmes are a principal tool to compensate for declining fish populations, and supplement and enhance yields of wild fisheries. Culture, breeding and larval rearing technologies have been practiced for decades for major carps, but they do not exist for many other freshwater fish species with commercial potential.

At NBFGR, efforts to develop protocols of captive breeding and larval rearing for non-conventional species in collaboration with fish farmers have shown remarkable success. This may pave the way for commercializing the technology and transferring it to fish farmers, fish traders and fish entrepreneurs.

Community participation in conservation

India's northeast is a hot spot of freshwater biodiversity. The natural resources of northeast states harbour 267 fish species – approximately one third of India's freshwater fishes. It is essential to prevent unlimited exploitation of untapped wild germplasm resources and put in place a strategy for sustainable utilization of resources. NBFGR has undertaken a comprehensive project for development and conservation of fisheries in the northeast states with community participation.

4. *Ex situ* conservation and gene banking

Gene banking is a powerful *ex situ* conservation tool. NBFGR is the primary organization in India for fish gene banking programmes. These are made possible through a repository of biological materials and a live gene bank. This envisages the development of fish sperm cryopreservation protocols and collection of tissue accessions and voucher specimens from Indian fish species.

Fish sperm cryopreservation

Species- specific sperm cryopreservation protocols have been developed for 17 species. Continuous improvement in protocols has provided hatching success ranging from 65 percent to 100 percent of the control value for different species.

Tissue banking

A new thrust is being given to tissue banking, which enables long-term storage of material. Tissue repository accessions are being made with an emphasis on the endemic fish resources of hot spot areas such as the Western Ghats and the northeastern states. Nearly 12 000 tissue accessions for fish species, collected across the country, are maintained in the tissue bank. NBFGR plans to establish linkages so that the tissue bank houses accessions of all the fish germplasm resources.

Live Gene Bank

A live gene bank has been established at the Bureau in Lucknow comprising *T. putitora*, *Barilius spp., Garra spp., Labeo dayochilus, L. calbasu, Wallago attu, Chitala chitala, Channa marulius* and *L. Bata.* At the regional level, two live genebanks have been established in Guwahati. More species are being introduced in the system so that a suitable package of breeding and cultural practices can be developed.

5. Exotics and Quarantine

The use of exotic species for fisheries and aquaculture diversification has been practiced since the middle of the 19th century. Many such introductions have been successful; but some others have resulted in highly publicized failure and generated controversies over the protection of native biodiversity and the spread of pathogens and disease.

Quarantine and health certification programmes form an integral part of broad strategies at national and international levels to protect the natural environment and native fauna from the deleterious impacts of exotic species or pathogens. NBFGR is upgrading facilities and expertise to safeguard indigenous fish genetic resources from exotic diseases and to develop effective protocols for fish quarantine,

The microbiology laboratory of NBFGR has developed rapid diagnostic capability for detecting the 11 eleven fish OIE-listed

pathogens using molecular and immunological tools. NBFGR has achieved success in developing monoclonal antibodies against *L. rohita.* A programme to develop fish cell lines from Indian carp and catfish species has been undertaken at NBFGR. Significant success has been achieved in developing cell cultures from *C. gariepinus* and *L. rohita*. These efforts can lay the foundation for a dedicated facility to screen import and export of live aquatic animals for exotic pathogens as well as pathogens of national concern and for health certification relating to all import and export of live aquatic animals.

NBFGR actively disseminates research tools and information to researchers and students. Besides publishing original research papers in peer-reviewed journals, national as well as international, NBFGR has been regularly conducting training programmes in fish biotechnology, molecular marker development and analysis, genotoxicity assays and disease diagnostics and reporting.

How has NBFGR helped contribute to Food safety and security?

Molecular Diagnostic Capability to identify the 11 OIE-listed Fish and Shellfish Diseases/Pathogens has been developed at the NBFGR, This will help in border and post-border quarantine of live aquatic animal import consignments.

Fish traders are now more conscious of risks associated with the import of exotics. Guidelines for Aquatic Exotics Introduction have been approved by the government. Trans-boundary movement of live aquatic animals has become safer, and a better scientific decision support system now exists to evaluate proposals for import and export of aquatic animals through databases and molecular diagnosis.

Awareness programmes organized recently by NBFGR in Chennai and Mumbai on fish introductions and quarantine have sensitized people in both the public and private sectors to the harm to biodiversity that haphazard introduction of alien species can cause.

Human Resources Development

The technologies and techniques developed by NBFGR are being disseminated to end users through training, demonstrations and publications.

Many training programmes have been organized on techniques developed in the laboratories relating to taxonomy, molecular markers, genotoxcity assays, diagnostic detection and confirmation of OIE diseases. Researches from ICAR and other institutes, from universities, colleges and fisheries departments have benefited from these programmes.

Technologies on culture and management practices are being disseminated to state fisheries officer and also directly to fish farmers.

Impact on policy-making in fisheries and aquaculture

NBFGR is not a capture or culture based fishery institute. Its technologies are an outcome of its work on germplasm conservation. Its clients are scientists and fisheries officers of state governments, the Ministry of Agriculture, the general public and to some extent, fish farmers. A few examples:

Scientific inputs on exotics and quarantine: Inputs were provided to the Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture, on the proposal for import of ornamental fish *Betta splendens* (fighting fish) from Malaysia, the import of 18 species of ornamental fishes by a Tuticorin-basd firm, and of 23 species by a Chenai-based firm, the introduction of exotic shrimp brood stock *Litopenaeus vannamei* by two private firms, and on MPEDA's proposals for import of 39 ornamental fishes to India.

This year NBFGR was identified as the nodal institute for all matters concerning introduction of exotic fish germplasm. State governments have been advised to furnish quarterly aquatic animal disease reports to NBFGR, who will process, compile and prepare reports to be submitted to OIE.

Preparation of National Strategic Plan: A National Strategic Plan on 'Exotics and Quarantine of Aquatic Animals' and Guidelines on 'Introduction of Aquatic Exotics and Quarantine' prepared by NBFGR have been approved by the Ministry of Agriculture.

International partnerships and collaborative programmes

The NBFGR collaborates with several international organizations. For example, with the Worldfish Centre, Malaysia on fish germplasm. With the Natural Resource Center, Australia and Auburn University, USA, on molecular markers and genetic characterization. With the US Fish and Wildlife Service on capacity-building in ***in situ*** conservaton programmes. With the WIPO, Switzerland, on International Property Rights.

The future of NBFGR

In the matter of conservation of natural resources, while the developed countries enjoy the technological edge, it is the developing countries that have the resources. Transboundary exchange of germplasm and information for use in product development are essential.

Explorations from new areas such as the deep seas and biodiversity-rich areas like the northeast and the Western Ghats are likely to result in the discovery of new fish species. A national repository of fish genetic material needs to be established and a a national fish museum.

To tackle the problem of the dearth of qualified fish taxonomists, the NBFGR proposes to establish a Center of Excellence on Fish Taxonomy and Molecular Genetics.