

# Pattern of Fish Biodiversity in Uttar Pradesh: Current Status and Challenges for Sustainable Management of Resources

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## Introduction

Conservation and sustainable utilization of natural resources are issues receiving increasing global attention. Fishes are the most diverse group of vertebrates, with 32,500 species (Froese and Pauly 2013) characterized by the great diversity of their morphology, physiology, ecology, life history and behavior. However, globally freshwater fishes are one of the most threatened taxonomic groups (Darwall and Vie, 2005) because of their high sensitivity to the quantitative and qualitative alteration of aquatic habits (Kang *et al.*, 2009). The main causes are well known, with the loss and degradation of habitat, prominent on lists of problems and threats. Many countries are now more effectively controlling water pollution, but improvements in aquatic communities are being restricted by habitat deficiencies in river channels and floodplains (Aarts *et al.*, 2004).

Conservation measures to mitigate the impact of the pressures have largely been slow and inadequate and as a result many of the species are declining rapidly. In India, the larger rivers though support rich biodiversity and offer livelihood and nutritional security but unfortunately they have been less studied from biodiversity management point of view except (Payne *et*

*al.*, 2004). The impact on fish and aquatic ecosystem are inherently difficult to predict where baseline information is absent. To contribute to the development of basic knowledge, studies of taxonomic diversity or species richness (the maximum number of taxa) should be supplemented, as far as possible, by studies of ecological diversity *i.e.*, variety of biological communities in a given area, to recapitulate the strategies developed by organisms in adaptation to the environmental conditions, and to look for species distribution pattern. There is also growing awareness of how aquatic biodiversity supports livelihood and sustainable development.

In India, most of the tributaries of the Ganges basin are controlled by barrages diverting flow for irrigation and as a result fish, catch has been declined, and thereafter, loss of species diversity have been reported (Das, 2007; Lakra *et al.*, 2011). Recent studies made in the some of the major tributaries of river Ganges basin in Northern India *viz.* Gomti, Ghaghara, Betwa and Gerua rivers revealed the presence of exceedingly rich species spectrum of threatened, migratory and commercially important fishes with a wide distribution of species, families and genera (Sarkar *et al.*, 2013a, Sarkar *et al.*, 2012, 2010, 2008; Lakra *et al.*, 2010; Joshi *et al.*, 2009;

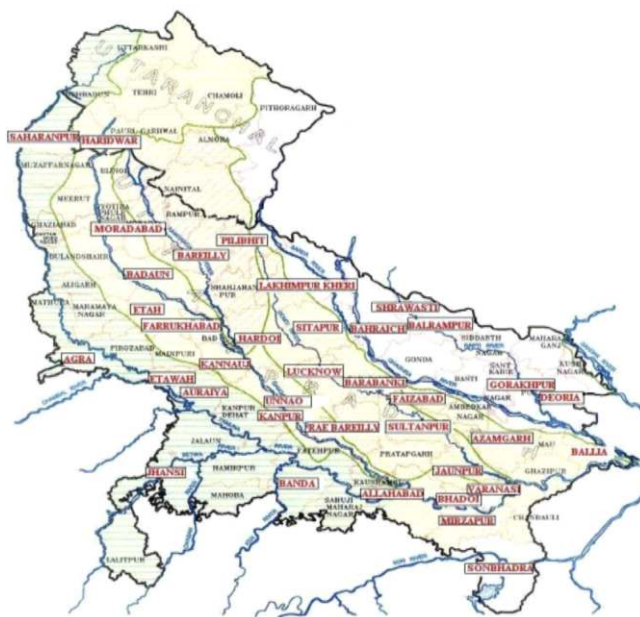
Atkore *et al.*, 2011). Presence of threatened fishes of regional conservation concern in those rivers needs for an urgent conservation and management measure to save them from further endangerment. Some notable studies addressing various potential threats on freshwater biodiversity have been conducted in the tributaries of Ganges basin in Northern India in recent years but the adequate information on drainage wise fish diversity pattern and their current spatio-temporal pattern is mostly lacking (Lakra *et al.*, 2010). Therefore, in view of rapidly changing environmental conditions there is an urgent need for the current state of knowledge about the fish biodiversity scenario, distribution, richness and threats for conservation management of rivers of the Ganges basin. This paper highlights concise information of freshwater fish biodiversity of Uttar Pradesh from primary and secondary data, analyzes the threats and identifies conservation issues.

## Aquatic Resources in Uttar Pradesh

The state of Uttar Pradesh in North India, lies between 77°5'-84°38'E and 23.0° 52'-30° 24'N covering a geographical area of 240927 square kilometer or 7.33 percent of land area of the country and divided into seventy five districts. The state comprises of four major ecological zones namely Terai (foothills of Himalaya), Gangetic Plain, Vindhyan and Semi-arid region. Uttar Pradesh being a land locked state having vast freshwater resources such as river, lakes, reservoirs, ponds and tanks.

### Riverine resources

The extensive network of rivers constitutes one of the major fishery resources of the state. The drainage pattern is dominated and controlled by river Ganga system recognized as the master stream of the state. Its total length is about 2,525 kms of which 1450 kms is in Uttar Pradesh and Uttaranchal. The most important tributaries are Yamuna on the right side and Ram Ganga, Gomti and Ghagra on the left side. Yamuna is 1376 Sq. km long basin, covering an area of 320 lakh Sq. km of which 61750 Sq. Km. lies in U.P. The important tributaries of Yamuna are Chambal, Sind, Betwa, Dhasan, Baghin and Ken. These rivers contribute 79 billion cubic m of water every year into the main stream. The Gomti has its length



Drainage map of Uttar Pradesh

of 940 Km and contributes 7.39 billion cu m of water per year to main river Ganga. The Ghaghra contributes the largest amount of water per annum to the entire Ganga basin, (94.4 billion cu m,). Its total area is 1, 27,950 sq km of which 49,750 sq km lie in Uttar Pradesh. Its other important tributaries are Saryu, Rapti and Gandak.

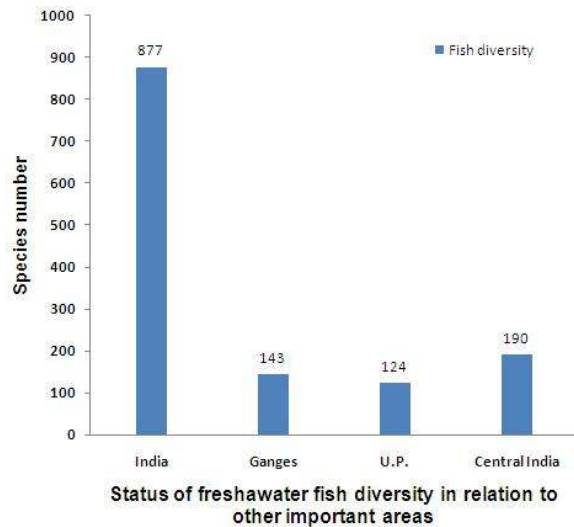
### Reservoir, wetland and pond resources

In Uttar Pradesh, sixty reservoirs, with an area of 1,18,103 ha, are distributed among 15 districts. The four large reservoirs viz., Rihand, Matatila, Kalagarhand Sardasagar occupy 71, 196 ha. Sonbhadra district with 52,000 ha has the largest area under reservoirs on account of the imposing presence of Rihand reservoir. Uttar Pradesh is also one of the prominent zones of wetland resources of the country. These wetlands are extremely diversified in their size, shape, depth, gaseous contents, nutrient status, biotic diversity, and aquatic weed infestation and production status. Total pond area in Uttar Pradesh is about 1.61 lakh ha.

### Freshwater Fish Biodiversity

Documenting and characterizing biodiversity is a vital and basic step in order to assure its sustainable development and conservation. Therefore, inventories





of freshwater fish diversity in India are being progressively updated and analyzed with several new discoveries however; a well-defined number of existing fish species remains to be determined. At present, 32,500 fish species are listed in the global FishBase and for Asian continent; at least **3,553 species of native freshwater fishes are currently recognized** and of these **877 occur within India**. At present, 2553 species of finfish have been recorded in the database developed by NBFGR, Lucknow of which 877 from freshwater, 113 brackish water and 1,563 are from marine environment, excluding 291 exotic species with information on their taxonomic position and other biological information (Jena and Sarkar 2012, NBFGR database 2013). **Total fish biodiversity of U.P. contributes approximately 14.11% of the national fish biodiversity**. In earlier studies, the significant contribution in exploring freshwater fish fauna of Uttar Pradesh was made by Srivastava (1968). He recorded 87 fish species from U.P. and 117 species from Bihar. In a similar study, 92 species was described from the Ganges main channel within Uttar Pradesh plains by Sarkar *et al.*, (2012). In other studies 87 species from river Gerua and Ghagra (Sarkar *et al.*, 2008) are reported. A recent study by Sarkar *et al.*, (2012) reports the **Gangetic system alone accounting 143 species of fish contributes about 20% of freshwater fish of the total fishes reported in India**. In addition, some of the major tributaries of river Ganges



Rich fish diversity in Uttar Pradesh

basin in viz. Gomti, Ghaghara, Betwa, Ramganga, Ken and Gerua rivers also harbors the rich species spectrum of threatened, migratory and commercially important fishes with a wide distribution of species, families and genera (Sarkar *et al.*, 2013b, Sarkar *et al.*, 2012, Sarkar *et al.*, 2010; Lakra *et al.*, 2010; Mishra *et al.*, 2012, Joshi *et al.*, 2009; Sarkar *et al.*, 2008; Atkore *et al.*, 2011). The above published report on fish diversity shows distribution of 62 species in river Ghagra, 63 species in river Betwa, 68 species in river Gomti, 57 species in river Ken, 43 species from Ramganga river, 46 species from Samaspur Bird Sanctuary in Uttar Pradesh. Sarkar *et al.*, (2007) reported a significant increase in species richness, presence of several threatened species, and distinct stocks in the water bodies of the wildlife-protected areas than the fished areas of a lotic water body.

However, as large parts of freshwater riverine areas in this state are as yet unexplored, we do not have an idea of the extent of drainage wise fish diversity, species composition, distribution and threats in the present scenario under rapidly changing aquatic environment. Recent studies in other tropical rivers of India revealed that the threatened species recorded in the drainage basins were facing various anthropogenic disturbances and their lower abundance could be reached to the extinction for those rivers in near future (Lakra *et al.*, 2011).

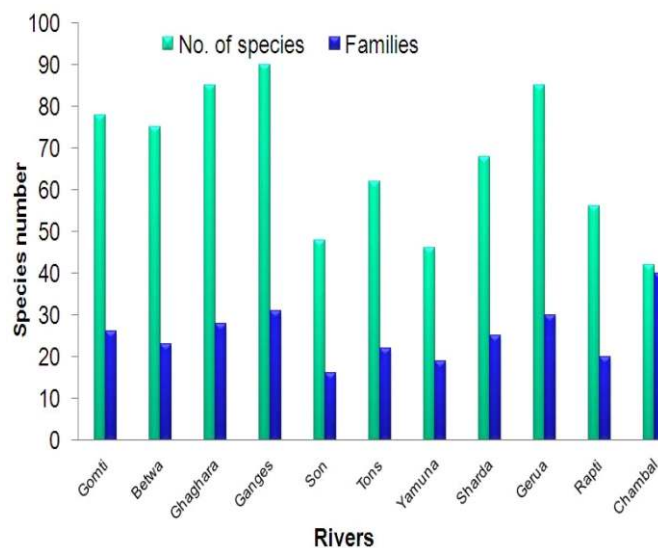
So far exotics are concerned, total of six exotic fish



species viz. *Oreochromis mossambicus*, *Cyprinus carpio*, *Hypophthalmichthys molitrix*, *Ctenopharyngodon idellus*, *Oreochromis mossambicus*, *Clarias gariepinus* and *Pterygoplichthys disjunctivus* distributed in the tributaries of river Ganga basin (Sarkar *et al.*, 2012). Although a total of ten exotic species were reported from River Ganga in a recent study by Sarkar *et al.*, 2011. However, their occurrence in the tributaries of the River Ganga basin in North India has been described here for the first time. Moreover, in the main stream of River Ganga the repopulating trend of *C. carpio* in degrading water of the river (Sarkar *et al.*, 2011) has come up to conserve rich fish genetic resources before it faces a major alteration. Additionally, a number of cold water genera like species which were never reported in northern plains were described indicating new distribution which might be due to climate change since other studies showed perceptible shifts in many of the freshwater fishes in River Ganga (Vass *et al.*, 2009; Sarkar *et al.*, 2011).

### Recent exploration and assessment of fish diversity

Efforts have been made recently in bringing together the studies of fish diversity in Northern India, particularly in the tributaries of Ganges which have been studied quite extensively with regard to its freshwater fish diversity and is known to have considerably rich diversity comprising threatened, migratory and commercially important fishes. As far as we know, no broad general synthesis of fish diversity, distribution and composition of the fish fauna of several rivers/other water bodies has yet been published to date except Sarkar *et al.*, (2013). In a research project carried out by the authors under Uttar Pradesh State Biodiversity Board sponsored project, extensive explorations were done in the 12 main rivers, 7 tributaries, including reservoirs and lakes/taals in Uttar Pradesh. Altogether, a total 124 of native species and seven exotics species belonging to 26 families have been described. Overall, high species diversity (92 species) were recorded from river Ganges followed by 85 species in Ghaghara, 78 species in Gomti, 75 in Betwa, 68 in Sharda, 62 in Tons, 60 in Ramganga, 63 in Rapti, 52 in Chambal and 50 species in Sone, respectively.



Comparative diversity of fishes in the tributaries of Ganga basin



Some threatened fishes of Uttar Pradesh

Some commercially important carps are *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*, *L. calbasu*, *L. bata*, *L. fimbriatus*, *C. reba*, and *Puntius sarana*. Catfishes are important groups contributing significantly to the riverine and reservoir catches. These are *Speratta aor*, *S. seenghala*, *Wallago attu*, *Pangasius pangasius*, *Silonia silondia*, *Bagarius bagarius*, *Rita rita* and *Eutropiichthys vacha*. Finfishes adapted to swampy areas owing to their accessory respiratory organs are known as air-breathing fishes and featherbacks. Murrels and other important species of the group are *Channa striatus*, *C. marulius*, *C. punctatus*, *Clarias batrachus*, *Heteropneustes fossilis*, *Anabas testudineus*, *Chitala chitala* (State fish of Uttar Pradesh) and *Notopterus notopterus*.





Species showing new distribution in Uttar Pradesh

The above explorations showed new biogeographical distribution of the several freshwater fishes from the Ganga basin. These include Eel loach, *Pangio pangia*, small silurids like *Glyptothorax conirostris*, *Glyptothorax telchitta*, *Glyptothorax cavia*, *Schistura rupicola* and *Amblyceps mangois*. This shifting revealed the changes in the hydrology as well as increase in water temperature possibly due to global warming (Kannan & James, 2009).

With emerging demand of fish for consumption, aquarium and sport, it is important to evaluate species on the basis of its utilization. Evaluation of the utilization pattern of fishes in U.P., it appears that out of **124 species** nearly **33% are considered as ornamental fishes**, nearly **87% are potential food fishes** and **10%** may be listed under **potential sport fishes**. The species described from different rivers and tributaries were assessed under various categories as per IUCN (2012) and a total of 10 species were found included as near threatened (NT), one as vulnerable (VU), 78 as least concern (LC), two as data deficient (DD) whereas 34 species were not evaluated (NE). However, the conservation assessment (Lakra *et al.*, 2010) of the freshwater fishes of India enlisted 120 freshwater fishes of the country under threatened category, of which 27 species are distributed in Uttar Pradesh.

## Fish Habitat

Rivers and their fauna should rank among the highest conservation priorities because of the extent that river habitats and species have been diminished. Reviews of the magnitude of river impacts (Nilsson *et al.*, 2005) consistently show major losses of large intact, free-



Fish habitat diversity

flowing rivers. The main causes are well known with the loss and degradation of habitat number one on problem and threat lists. Fish appear to be good indicators of the status of aquatic communities and river environments, and fish are often a key element in environmental planning. Definitions of habitat needs for large river fishes are important to local people, waterway managers, conservationists and government agencies striving to maintain quality conditions in large rivers. Habitat inventory and assessment of the rivers of Uttar Pradesh was done by few workers which resulted in significant variations in the physiochemical environmental conditions among the rivers and their tributaries. Overall for Gangetic fishes, specific studies aimed at determining the habitat requirements for the fishes at different life stages well as that of breeding grounds are very few and detailed information is yet to be gathered for their role in maintaining ecological integrity of the freshwaters. Some of the pioneering work has shown correlation between variation in habitat characteristics such as substrate type, flow pattern, riparian vegetation, fish cover, disturbance in riparian corridors, water quality and natural barriers like big water-falls with species diversity (Sarkar and Bain 2007, Sarkar *et al.*, 2012; Gupta *et al.*, 2012, Dubey *et al.*, 2012).

Three classes of habitat used by groups of fish species classified as conservation and management priorities were developed for the Gerua River (Sarkar and Bain 2007) in the Ganges River basin. Specific studies

aiming to determining the habitat requirements for the fishes in some of the important rivers like Gomti, Ghagra, Ken and Betwarivers were assessed and detailed information gathered for their role in maintaining ecological integrity. In river Gomti, the most numerous and diverse group of fish were recorded associated with deep depositional habitats. In river Ken and Gomti, water depth played a crucial role for the fish assemblages was found maintained due to presence of water refugia at some stretches of the river (Dubey *et al.*, 2012; Sarkar and Bain 2007). The necessary endangered fish habitat information required can be rapidly acquired and effectively utilized by using modern techniques of remote sensing and geographic information system.

## Threats

The freshwater resources of North India are currently experiencing an alarming decline in fish biodiversity due to various anthropogenic activities. Destructive fishing methods, habitat alteration, entry of exotic species, use of poison, and water diversion, poor vegetation cover in the river banks, siltation, water abstraction, and low water velocity have been affected the overall fish diversity to large extent. Evidently, this will prove hazardous to the abundance and distribution of fish fauna in river Ganga and its tributaries. Water pollution has become a great menace to the aquatic fish fauna almost in all the major rivers. There is ample evidence that recent climate changes have affected a broad range of organisms with diverse geographical distributions. Climate change is likely to produce profound modifications to the structure and functioning of the aquatic ecosystem and has the potential to affect freshwater ecosystem use by fishes through habitat alteration and will result changes in the distribution and abundance of species. Thus, towards restoring of the critical habitats of the fishes in these rivers research efforts should immediately be translated into social and political actions as early as possible.

## Management perspectives

In the Ganges basin alone, exploitations such as indiscriminate and illegal fishing, pollution, water abstraction and invasion of exotic species are represent just some of the problems that affect both ecosystem

health and biodiversity stability (De Silva and Abery 2007, Sarkar *et al.* 2011). Assessing the condition of River Ganges basin ecosystem is extremely important, yet it is an immense challenge. For the protection of aquatic resources, flora and fauna of the rivers and tributaries, there is needed to remove various stresses on the aquatic resources. Some of the suggested measures are:

- Exploration of aquatic resources, strengthening the taxonomic capacity base.
- Expanding and updating inventory of the fish fauna, and evaluation.
- Prioritization of potential sites through GIS and ground validation.
- Ex-situ conservation and Live Gene Bank.
- Conservation aquaculture for food and ornamental fishes.
- Development of a state specific aquaculture and fisheries enhancement model.
- Research efforts enhancement on biodiversity, conservation biology and captive breeding.
- Molecular genetic studies (DNA barcoding) and stock identification.
- Ranching and stock enhancement of indigenous fish yearlings.
- Impact assessment of exotic species and disease management.
- Public awareness campaign including people's participation and HRD.
- Climate change and implications in freshwater fisheries.
- Legislative framework for protection of riverine fish diversity.
- Administrative mechanism for policy implementation through peoples participation.
- Indigenous knowledge and biodiversity conservation model involving stakeholders and environmentalists.

## Potential areas of research

Although the state and central government have already taken several measures to conserve the freshwater fish biodiversity, more conservation programme is needed in order to retain as many of the natural ecological processes and functions of the natural

waterbodies as possible. The Govt. of India has legislated the Biological Diversity Act (2002) and Biological Diversity Rules (2004), which aims at conservation of our natural heritage and ensures the sharing of benefits of the utilization of biological resources in an equitable manner. In India, the National Bureau of Fish Genetic Resources, Lucknow is the nodal Institution under Indian Council of Agricultural Research, for collection, cataloguing, and documentation of fish genetic resources using operational strategies of partnership and cutting edge technologies. Innovative approaches to fish conservation programme by declaring a State Fish has been adopted with action plans (Lakra and Sarkar 2011). There is need to harmonize biodiversity conservation and river valley projects. State government should play an important role and technical group may be established for recommending the means to facilitate fish migration.

Biological characters of the many species are still unknown and therefore studies are needed. Restoring the natural stocks of the species should be a priority, which includes ensuring minimum flow requirements

and revival of lost breeding grounds and thereby restoring the failed recruitment process. This may be achieved by negotiation with the stockholders so that the required flow and depth of the rivers are maintained. In addition, restoration of floodplain and associated wetlands should be a priority for conservation because floodplains play an integral part of riverine ecosystem. Floodplains serve as breeding and nursery grounds for several species. Towards restoring those critical habitats, research efforts should be translated into social and political actions as early as possible. Efforts should be made to check the sediment flow by extensive plantation of native trees, shrubs, etc on the riverbank and adjoining catchment area. An ecosystem approach of fish conservation is a new management of fish community in many countries. Therefore, information on the role of species diversity is the functioning of ecosystems should be incorporated into comprehensive environmental management policies. Capacities for the assessment, study and systematic observation and evaluation of biodiversity need to be reinforced. The participation and support of local communities are elements essential to the success of such an approach.

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