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International Journal of Fisheries Science and Research

Review Article

Empirical Assessment of Fish Diversity of Uttar Pradesh, India: Current Status, Implications and Strategies for Management

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Article Information

Received date: Mar 23, 2017
Accepted date: Apr 12, 2018
Published date: Apr 17, 2018

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Keywords Fish diversity; Biodiversity; Freshwater; River; Uttar Pradesh; India

Abstract

About 60-70% of world's biological resourcesis contributed by India, of which fish represents 80% of the global fishes. Uttar Pradesh blessed with vivid aquatic bioresources in innumerable forms contributes about 14.68% of Indian fish biodiversity with substantial scope of inland fisheries development and aquaculture. Ganga, the mighty river of this state reportsabout 265 freshwater species from its river system [1]. Besides, other rivers viz. Ramganga, Gomti, Ghaghara, Yamuna, Gandak, Kosi and Damodaract as reservoir of different fish stocks. In past, no study highlights the assessment of the fish biodiversity of this state in holistic way except by Khan (2000) who justreported a compilation of 129 fishes under 27 families [2]. To substantiate and revise the assessment, the fish diversity of this state was assessed by investigating these rivers, analyzing and documenting the information on different fisheries measurements including biology, distribution and conservation status. About 10,000 individuals were collected and the analysis of individuals revealed 126 fish species under 28 families and 74 genera nearly mitigating the earlier reports. The highest species diversity was recorded in the river Ganga (90) followed by Gerua (87) and then Gomati (68). 37 species were found common in Gomati, Ghaghara, Ganges, Son, Tons and Yamuna. Out of 90 species, 6 species were recorded from the river Ganga. In addition, the new distribution of a threatened torrent catfish Amblyceps mango is was recorded from the rivers Gomati, Ganga and Ramganga. The economical assessment unravels nearly 33% as ornamental, 87% as food and 10% as sport fishes.

Review

Fishes are the most diversified group among vertebrates, with ca. 33,600 species [3] characterized by their great diversity in morphology, physiology, ecology, life history and behavior. Almost 25% of the global vertebrate diversity accounted by fish is concentrated in the 0.01% of the earth's water. This tiny fraction of earth's water supports at least 100000 species out of approximately 1.8 million and almost 6% of all are described species [4]. It is often claimed that freshwater ecosystems arethe most endangered ecosystems in the world [5]. This particular vulnerability of freshwater to fish at global scale reflects the fact that both fishand freshwater are the need of humans and consequently they have been heavily impacted by theiruse and regulation. Asia supports over half of the global human population, with enormous consequent pressures on inland waters and freshwater fish biodiversity [4]. The freshwaters in India are one of the most exploited resources since past many years only for the commercial purpose. Though being economically viable, least attention is paid in the country for their sustainable management and restoration. In the recent years, changes in the land use patterns and divergent aspiration of people haveput the entire ecological integrity and physical entity of aquatic ecosystems is under threat. Due to increasing pressure and threats hampering the biodiversity of freshwater resources, worldwide freshwater fishes are one of the most threatened taxonomic of vertebrates assessed to date by the IUCN [6] and by other workers [4,7-9]. Becauseof their high sensitivity to the quantitative and qualitative alterations of aquatichabitats [10,11], limitations in the physiology, morphology and life history of species associated with environmental constraints persists [12-15]. Some of the major threats to freshwater fishes include: habitat modification, fragmentation, and destruction; invasive species; overfishing; environmental pollution; forestry practice; and climate change. In spite of these, since 1960 the water withdrawals from rivers and lakes have been doubled and nearly 70% of all water used worldwide is for agriculture that has taken a heavy toll on the world's freshwater biota in general causing many species of freshwater fish to become endangered [16]. Therefore, in the coming years there might be the possibilities of dislocation and disappearance of few fishes of commercial importance, if adequate species management was not adopted. To respond to these challenges causing loss to the pristine biodiversity of the earth, the Government of India has legalized the Biological Diversity Act 2002 (BDA 2002) and the Biological Diversity Rules (2004).

India has ninth position in terms of freshwater megabiodiversity [17]. The Indian subcontinent occupying a position at the confluence of three bio geographic realms, viz., the Palaeartic, Afro-Tropical and Indo-Malayan exhibits a great variety of ecological habitats and harbors rich fish faunal diversity [18-20]. The riverine fishery ofthis country exhibits great species diversity in terms of composition, abundance and phylogeny. India contributes nearly 60-70 % of world's biological resources of which fish represents 80% of the global fishes. The Indian fish population represents 11.72% of species, 23.96% of genera, 57% of families and 80% of the global fishes. According toa recent database of ICAR- National Bureau of Fish Genetic Resources, Lucknow, India (NBFGR) reports 3535 finfishes of which 3035 are native and 500 are exotic fishes from India representing 46 orders, 252 families and 1,018 genera. Out of 3035 native fishes, 1016 are fresh, 113 are brackish and 1906 are marine water species [21]. Figure 1 shows the total native and freshwater fishes reported from Indian waters in different years. On the contrary, Fishbase (2017) reports only about 974 freshwater fishes from India. In India, a significant portion of the freshwater fish production is still based on the harvest from wild population [22] and diversity of the fishes in the major rivers were primarily focused on the catch data of major taxonomic groups at spatial scale [23,24]. The information on fish biodiversity containing species abundance, distribution, migration and methods for conservation prioritization is lacking [25,26] except few studies [27,28].

The state Uttar Pradesh located between 23052'-31028'N latitude and 77004'-84038'E longitude is the most populated and one of the largest states of India blessed with vivid aquatic resources. The state contributes about 14.11% of the national fish biodiversity and fishery resources in the state are available in plenty in the form of rivers and their tributaries, reservoirs, wetlands, lakes, ponds and tanks that exhibit rich genetic and ichthiyological diversity and offer considerable scope for inland fisheries development and aquaculture [29]. The state has quite diverse physiography and the fish fauna in this region ranges from tiny fishes to large fishes from clean water fishes (carps) to marshy inhabitants (live fishes) and from upland cold water denizen to warm plain water dwellers. Out of 7,20,000 ha. of water resources, the rivers of this state occupy 28,500 km and a few lakh hectares of paddy fields, out of which, a small portion is amenable to fish farming. Over years, these resources in the state are facing threats in the form of runoff from agricultural and urban areas, invasion of exotic species, creation of dams, water diversion, habitat destruction which have already been identified as the greatest challenges to the freshwater environments [30,31]. The other threats to the freshwater environments in this state are urban development and resource-based industries destroying the natural habitats. Besides these, the continuous increase in pollution both in air and water, sedimentation and erosion and climate change are posing threats to these freshwater resources due to which the fish biodiversity of the state is getting affected and catch in wild is reducing. Therefore, in such changing conditions, it is imperative to have the comparative assessment on the fish biodiversity of this region for sustainability and posterity of the imperiled freshwater fishes. Ganga, the mighty river of this state reportsabout 265 freshwater species from its river system [1]. Besides, other rivers viz. Ramganga, Gomti, Ghaghara, Yamuna, Gandak, Kosi and Damodaract as reservoir of different fish stocks. No study in the past highlights the assessment of the fish biodiversity of this state in holistic way except by Khan (2000) who reported 129 fishes under 27 families in the form of a checklist [2]. To substantiate this, the fish diversity of this state was assessed under a study in the project mode titled "Germplasm exploration, assessment and documentation of the Freshwater fish diversity of Uttar Pradesh" funded by Uttar Pradesh Biodiversity Board, Lucknow was done in the major rivers and their tributaries of Uttar Pradesh State. The project included fish samplingand diversity assessment in the rivers Ganga, Ramganga, Gomti, Gerua, Ghaghara, Sharda, Rapti, Son, Tons, Yamuna and its tributaries Chambal, Ken and Betwa. About 10,000 individuals were collected from these rivers. The analysis of individualsrevealed 126 fish species under 28 families and 74 genera nearly mitigating the earlier report of 129 fishes belonging to 27 families recorded from plains of Uttar Pradesh [2]. The highest species diversity was recorded in the river Ganga (90) followed by Gerua (87) and then Gomati (68). 37 species were found common in Gomati, Ghaghara, Ganges, Son, Tons and Yamuna. Out of 90 species, 6 species were recorded from the river Ganga. An evaluation about the utilization pattern of 126 species fishes revealed that out of 126 fish species, 33% are ornamental, 87% potential food and 10% potential sport fishes [29]. The river Gomati showed higher species diversity compared to the earlier that reports 56 species [28]. A total of six exotic fish species viz. Oreochromis mossambicus, Cyprinus carpio, Hypopthalmicthys molitrix, Ctenopharyngodaon idellus, Oreochromis mossambicus, Clarias gariepinus and Pterygoplichthys disjunctivus, (a newly reported exotic in India) was recorded from this state against to ten exotic species reported from the river Ganga [32]. A new distribution record of a threatened torrent catfish *Amblyceps mangois* (family Amblycipitidae) was documented from the rivers Gomati, Ganga and Ramganga for the first time in the northern plains of Uttar Pradesh. Species like Puntiussarana, Labeopangusia, Securiculagora, Mystuscavasius, Mystusbleekeri, Amblypharyngodonmola showed higher percentage of relative abundance in the Ganges. Concomitantly, the river Betwa contributed about 76% of the species diversity in Northern India itself whereas the total fish diversity of 63 species was reported covering entire stretch in Uttar Pradesh and Madhya Pradesh. Moreover, 87 species from river Gerua of the Katerniaghat Wildlife Sanctuary was found similar as compared to earlier report by Sarkar et al. (2008) [33]. Cyprinidae was reported as the most dominated family (52 species) followed by Bagariadie (10 species), Sisoridae (8 species) and Channadiae (6 species). Out of 27 families recorded, the highest family was recorded in Ganga, followed by the rivers Ghaghra, Gerua, Gomati and Betwa. The river Gomati reported 16 families of which 14 families were recorded in the river Ganga and all these 16 families were found evenly distributed. On

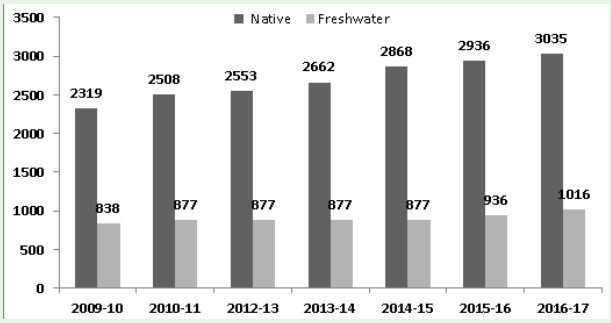

Figure 1: Native and freshwater fishes reported from Indian waters in different years.

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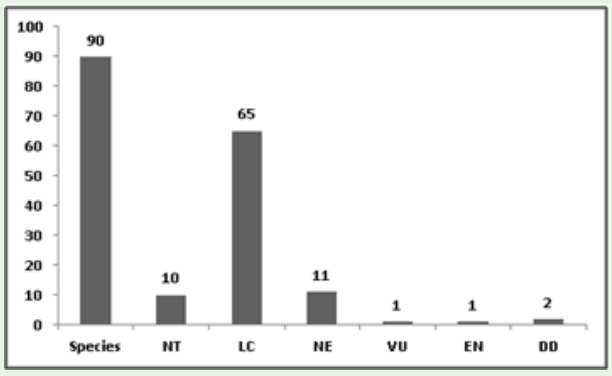

Figure 2.1: Conservation status of species reported from Ganga as per IUCN Red List Criteria 2012.

the contrary, the river Gerua reported 12 families and Betwa reported 8 families.The IUCN Red List Criteria 2012 was usedto assess the threatened status of the species of selected rivers under study. Figure 2 (2.1 to 2.5) presents the conservation status of the fish species in the selected rivers. The river Ghaghra that reported 62 fish species, the conservation status of most of the species was found Least Concern (LC).

The species similaritybetween the rivers Gerua, Sharda, Rapti, Tons, Chambal, Yamuna, Son, Ganges, Ghaghara, Betwa and Gomti (Figure 3) shows that the rivers Gerua and Sharda possess the same similarity as the rivers Chambal and Son on the Euclidean scale. The river Yamuna possess species similarity with the rivers Chambal and Son. Similarly, Tons has species similarity with the rivers Yamuna, Chambal and Son. The river Ganga has species similarity with Tons and river Ghaghra has species similarity with Tons and Ganga river. The river Betwa has species similarity with Ghaghra, Ganga and Tons rivers. The river Gomati showed the species similarity with Rapti, Gerua and Sharda rivers.

Further Sisorid catfish of genus Glyptothorax widely distributed and have nearly 40 nominal species reported from India [1,34,35], the three species of this genus *G. telchitta*, *G. cavia* and *G. conirostris* from the northern plains of Uttar Pradesh earlier were recorded first time from the tributaries of northern plains in the Ganges basin that shows the new bio geographical distribution of these species [36]. The specimens of these species were collected during experimental

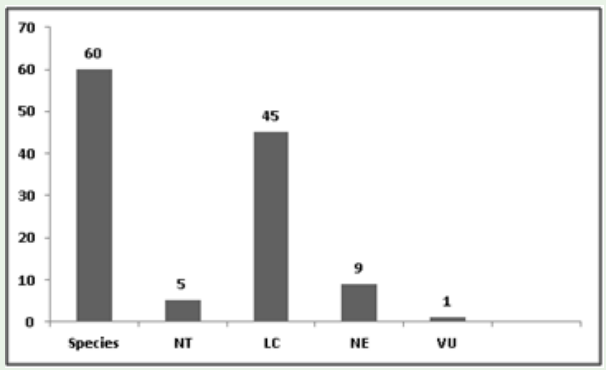

Figure 2.2: Conservation status of species reported from Ramganga as per IUCN Red List Criteria 2012.

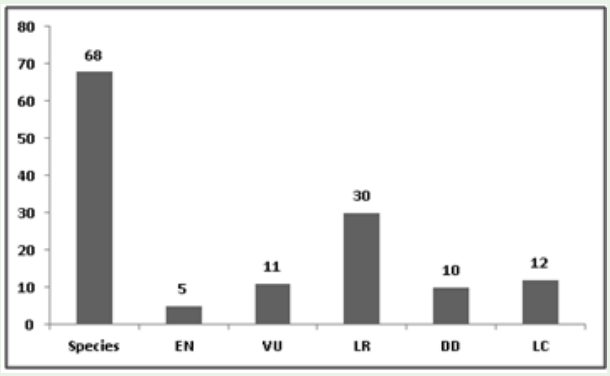

Figure 2.3: Conservation status of species reported from Gomati as per IUCN Red List Criteria 2012.

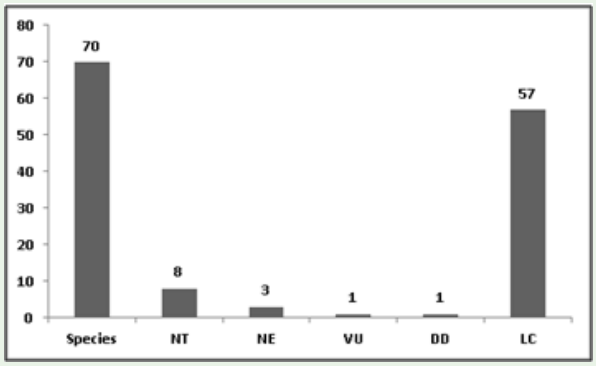

Figure 2.4: Conservation status of species reported from Son and Tons as per IUCN Red List Criteria 2012.

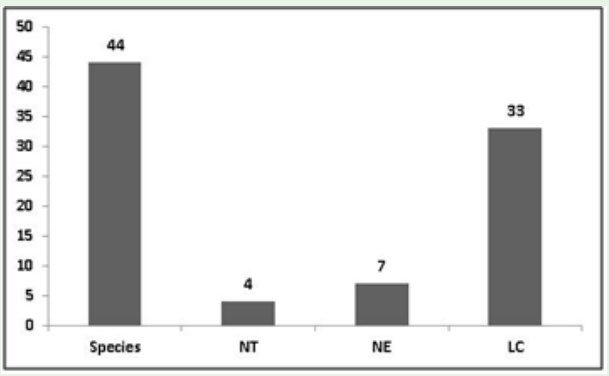

Figure 2.5: Conservation status of species reported from Chambal as per IUCN Red List Criteria 2012.

fishing between 2010 and 2012 under the project. *G. conirostris* were collected from the Ganges at Roorkee district while *G.cavia* and *G. telchitta* were captured from the river Gomati at Pilibhit district.

Major Threats and Conservation Status

The threats to global freshwater biodiversity have already been identified byseveral workers. Their combined and interacting influences have resulted in population declines and range reduction of freshwater biodiversity worldwide [4]. The fish biodiversity of

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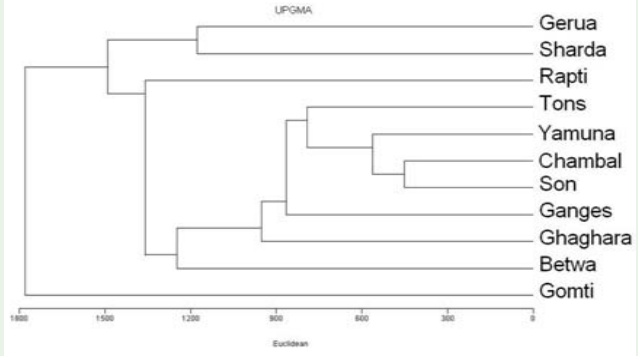

Figure 3: Species similarity dendogram using Jacccard index expression.

Uttar Pradesh highlights that the freshwater resources in Uttar Pradesh are currently experiencing an alarming decline in fish biodiversity to the greater extent due to experiencing of different type of threats. Construction of series of barrages and dams without taking the aquatic biodiversity of the river system in considerations in the upper Ganges from Rishikesh to Narora [37] and the Tehri dam constructed in the hills of Uttarakhand has considerably reduced the water flow and have shown detrimental effects on physical attributes and destruction of feeding, spawning, and migration routes of mahseer [38]. Large number of industries located in the Ganga basin discharge enormous amounts of toxic wastes to the Ganges that has put the fish fauna of the Ganges system on risk. The severe impacts of industrial effluents disposed into the river have resulted in fish kills reported from time to time [39,40]. Bioaccumulation of heavy metals was observed in fishes in the lower stretch of the river and at Varanasi [41-43], at Kanpur [44] in the middle stretch of river Ganga [45,46]. Further, residues of organochlorine pesticides, including HCH, DDT, Endosulfan and their metabolites are reported in the water of the middle stretch [47]. River Ganga has five major stretches, the upper stretch (Tehri to Kanauj), middle stretch (Kanpur to Patna), lower stretch (Sultanpur to Katwah), estuarine stretch (Nabadwip to Diamond harbour/Roychowk) and marine stretch (Haldia to Sagar). The middle stretch was reported to be heavily polluted with heavy metals and pesticides. A book titled "Toxicity analysis of Ganga River water using fish bioassay" authored by Huma Vaseem from Lambert Academic Publishing (2017-01-16) is a research work highlights significant contribution in the field of aquatic toxicology. The book presents detrimental effects of pollution and its reflection in the physiology of aquatic organisms of the river Ganga. From these studies it is evident that abundance and distribution of fish fauna in river Ganga and its tributaries is becoming hazardous. A serious thinking is therefore required regarding threat status of certain fish species. In spite of the reports of high concentration of heavy metals and pesticides in water as well as fish of the river Ganga, no attempts have been made so far for the detailed elucidation of their adverse effects on the health status of fish fauna. Sarkar et al. 2011 provided the conservation assessment of fishes of river following IUCN Red List Criteria [32]. Of the recorded 143 freshwater fish species, about 20% of fish species in Ganges were assessed as threatened category. The author reported more number of threatened fishes in upper stretch (26%) followed by lower (23%) and middle (20%). Recently, Sarkar et al. (2010) while studying fish biodiversity of river Gomti categorizesthe fishes under different threatened categories. Not much published literature is available on the threat status of fish species of this region but from the studies it is fact that population of some species is constantly going down and there is an urgent need to safeguard the same. In this respect, attempts have been made by NBFGR to assess the threat status of Indian freshwater fishes at national and regional level for conservation and posterity [48]. As per recent conservation status of 123 fish species from this state, 5 are under endangered and 18 under vulnerable. Some of the endangered freshwater fish species are Chitala chitala, Tor tor, T. putitora, Sisor rhabdiformes, Ilisha megaloptera, Hemibagrus menoda, and Ompok pabo. Earlier to that NBFGR organized a workshop that estimated a total of 227 Indian freshwater fishes were threatened based on the IUCN Red list Categories of 1994. The species that suffered much are Indian long fin eel (Anguilla bengalensis), the redfinned Mahseer, the catfish (Rita pervimentata), Chitala (Notoptrus chitala), smaller fishes like Indian Hatchet fish (Chela laubuca), Scarletbanded Barb (Puntis amphibious), Indian Tiger Barb (Puntis filamentous) to name a few.

Strategies to Meet Conservation Goals

Biodiversity and conservation are regarded as one of the major issues to enable sustainable use of natural resources.The conservation success of the fish biodiversity in any state or region depends on the acceptance and active participation of the local state authorities, statutory bodies and local people. Under river basin management policy, as proposed by the Ramsar Convention, water abstraction should be such that it maintains the normal flow of the river in low-flow seasons without affecting the hydrological functioning of the river system and aquatic life. Protection of freshwater biodiversity is perhaps the ultimate conservation challenge as it is influenced by upstream draining network, the surrounding land, the riparian zone and - in the case of migrating aquatic fauna-downstream reaches [4]. It is necessary that for implementation of long term conservation initiatives, local people of the area may be involved with interest and they must be educated and aware about the importance of natural resources in their livelihood. The local people may be offered for alternative sources for their livelihood rather wholly depending on the fish biodiversity resources. Moreover, eco development plans, creation of protected areas and supply of biomass outside the protected area are the other strategies which might be adopted to provide the safeguard and sustain the fish biodiversity.Though the UP fisheries act 1948 provides the obnoxious acts related to protection of the freshwater fishes, its enforcement and impingement in the different context of fisheries is rare. This act describes the geographical limit of applicability, repugnant in subject or context, prohibition and licensing of fishing, prohibition on sale of fishes, penalties and power to exercise to compound certainoffences. There is a need to modify and scale up the fisheries act of this region by restoring the lost protections and including the modern safeguard measures. The act does not cover the provisions for protection of fish habitat and protection of all fishes that has the inter-dependent relationships of different fish species in an ecosystem. It is also worth to mention here that the waterbodies viz. wetlands, lakes, ponds, beels and reservoirs that regulate the flow of water and indirectly control the movement of genetic resources are terrestrial in nature and provide static genetic resources while on the contrary rivers, streams and tributaries are dynamic in nature traversing interstate boundaries thereby provide complexity in fish biodiversity management. Therefore, issue arises for interstate exchange and conservation of fish germplasm resources

in such dynamic waterbodies for sustainable management. The governance structure of regulating biological resources in India is federal in nature where state and center work in coordination.River is a central subject while water resources are state subject and the resources in the water being state subject bring out the complexity of the dynamic system forgovernance and sustainable conservation. The constitutional provisions fall into three categoriesto regulate and govern river and its resources. In the Constitution, Water is included in List-II at Entry 17[3] , since rivers traverse two to 3 states and thus, often become a source of dispute between states. State List, subject to the provision of Entry 56[4] of List-I i.e. Union List.[5]. Fisheries as such come under List-II entry 21[6], while fishing and fisheries beyond territorial waters comes under entry 57 of List-I. Fish is defined under Article 2(i)[7] by U.P. Fisheries Act, 1948 that includes, fish, turtles, dolphins, aquatic plants of fisheries, whale and fish in all states in its life-history. The broad definition treats fish equally with Turtles, dolphins, aquatic plants and whale. Starting from the ground level the ponds, lakes, beels and wetlands come under the jurisdiction of the state government.

Acknowledgement

Authors are grateful to Director, ICAR-National Bureau of Fish Genetic Resources, Lucknow for providing the facility to accomplish the work and Uttar Pradesh Biodiversity Board for providing the financial support to the project.

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