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**Dinesh Kumar**

College of Fisheries, Acharya  
Narendra Deva University of  
Agriculture and Technology,  
Kumarganj, Ayodhya, Uttar  
Pradesh, India

**Ashish Kumar Maurya**

College of Fisheries, Karnataka  
Veterinary Animal and Fisheries  
Sciences University, Mangalore,  
Karnataka, India

**Laxmi Prasad**

College of Fisheries, Acharya  
Narendra Deva University of  
Agriculture and Technology,  
Kumarganj, Ayodhya, Uttar  
Pradesh, India

**CP Singh**

College of Fisheries, Acharya  
Narendra Deva University of  
Agriculture and Technology,  
Kumarganj, Ayodhya, Uttar  
Pradesh, India

**KV Radhakrishnan**

College of Fisheries, Central  
Agricultural University, Tripura,  
India

**SR Somasekara**

College of Fisheries, Karnataka  
Veterinary Animal and Fisheries  
Sciences University, Mangalore,  
Karnataka, India

**Corresponding Author:****Dinesh Kumar**

College of Fisheries, Acharya  
Narendra Deva University of  
Agriculture and Technology,  
Kumarganj, Ayodhya, Uttar  
Pradesh, India

## Fish biodiversity and its diversity indices in the Himalayan River Ghaghara at Northern India

**Dinesh Kumar, Ashish Kumar Maurya, Laxmi Prasad, CP Singh, KV Radhakrishnan and SR Somasekara**

### Abstract

The fish biodiversity and diversity indices were studied in the Himalayan River Ghaghara, a principal tributary of the mighty River Ganga for a period of one year (August 2016 to July 2017) based on data collected from three locations representing the upper, middle and lower reaches of the river. A total of 71 fish species belonging to 25 families and 49 genera were recorded and the catch composition showed predominance of fishes of the family Cyprinidae contributing 35% followed by Bagridae (10%) and Channidae (6%). The IUCN status of the fishes showed the golden mahseer (*Tor putitora*) as endangered (EN) while 2 species are vulnerable (VU) and 5 are nearly threatened (NT). The Shannon-Weiner Index (H) and the Simpson's index of diversity (D) were found to have highest values for the site A-2 (values 3.786 and 0.974 respectively). The Evenness index varied from 0.754 to 0.847 and calculated maximum also for site A-2 while Margalef index was calculated maximum for Site A-1 as 8.198. The major threats to fishes in this river is attributed to overexploitation of fishery resources, invasion of exotic species in the aquatic ecosystem and pollution. Stringent management measures should be adopted for sustainable exploitation and conservation of fish resources of River Ghaghara.

**Keywords:** Catch composition, diversity indices, fish biodiversity, Ghaghara River, threat

### 1. Introduction

Biodiversity conservation is one of the major issues throughout the world and aquatic environments are serious threats to both diversity and ecosystem stability and therefore, it is necessary to protect and develop research and systematic conservation planning to protect freshwater biodiversity<sup>[1]</sup>. Worldwide, freshwater fishes are the most diverse of all vertebrate groups, but are also the most highly threatened through anthropogenic activities such as river management works, dam building, and land use change in the watersheds<sup>[2, 3, 4, 5]</sup>. Overexploitation occurs around the world with the use of more and more refined fishing equipment, and the decrease of many fish stocks has been documented as a result of expanding fisheries<sup>[6, 7]</sup>. Illegal fishing using dynamite, pesticides, electrofishing, etc. are also major threats to fish biodiversity all over the world<sup>[8]</sup>. There is an increasing concern worldwide for the loss of aquatic ecosystems and associated biodiversity<sup>[9]</sup>, particularly for riverine landscapes<sup>[10]</sup>.

India is one of the mega biodiversity countries in the world and occupies the ninth position in terms of freshwater biodiversity<sup>[11]</sup>. The rivers in India harbor one of the richest fish genetic resources in the world<sup>[12]</sup>. Unfortunately, only limited research has been carried out in India to assess the fish diversity patterns and even, the tributaries of the mighty river Ganga basin, though support rich biodiversity and offer livelihood and nutritional security, have been less studied<sup>[13]</sup>. The present study is undertaken to assess the fish diversity in River Ghaghara, a perennial trans-boundary river originating on the Tibetan plateau near Manasarovar Lake with the use of certain biodiversity indices. The study would give an understanding on the status of exotic and native fish abundance, diversity, richness and threats to the fish species, to quantify the impact of anthropological activities on fish diversity and aquatic health of Ghaghara River. The findings from the study will benefit the planning and management of fish community structure and conservation of natural resources.

### 2. Materials and Methods

#### 2.1 Study Area

Ghaghara River, one of the major tributary of Ganga river system in northern India has been

selected for the present study. The river rises at an altitude of about 3,962 metres in the southern slope of the Himalayas in Tibet, in the glaciers of Mapchachungo. The total length of this River up to its confluence with the Ganges at Revelganj in Bihar is 1,080 km. The period of the study was one year from August 2016 to July 2017. Three study sites have been selected along the entire stretch of river Ghaghra and they were selected in such a way that site A-1 (Girijapuri barrage) represent upper reaches, A-2 (Ghaghara Ghat) represent middle and the site A-3 (Faizabad) represent lower reaches of the river. The exact locations of sampling stations were recorded using Global Positioning System (GPS).

## 2.2 Fish sampling and Data Collection

Experimental fishing was done using the expertise of local and skilled fishermen engaged in fishing. Fishes were collected using gill nets, cast nets and drag nets of different mesh sizes. Photographs were taken well before preserving the fishes in formalin as it decolorizes the fish on long preservation. Specimens brought to the laboratory were fixed in separate jars according to the size of species, in the freshly prepared formalin solution. Smaller fishes were directly placed in the formalin solution while the larger ones were given an incision on the abdomen before fixing for better penetration of the preservative. The bottles/jars with collected fish specimens were labeled giving proper serial numbers, exact locality from where collected, date of collection, and the

local name of fish used in that region. All the samples were counted and measured for total length (TL) with a digital caliper to the nearest 0.1 cm and body weight (BW), using a digital balance to the nearest 0.1 gm. Taxonomic identification of the fishes were carried out following authentic literatures such as Talwar and Jhingran<sup>[14]</sup>, Jayaram<sup>[15, 16]</sup>, and Nath and Dey<sup>[17]</sup>. Nearby fish markets and fish landing centers receiving fish catch from the sampling sites of the river were also surveyed to monitor presence of any fish species not encountered in the experimental fishing conducted. Data regarding threats faced by the fish fauna were recorded by both primary (direct observations and interactions with local stakeholders and fishermen) and secondary sources/information. The fishes were categorized based on their conservation status as endangered (EN), vulnerable (VU), low risk (LR), least concern (LC), data deficient (DD), near threatened (NT) and not evaluated (NE) species following IUCN.

## 2.3 Data Analysis

The Relative Abundance (RA) of species is a component of biodiversity and refers to how common or rare a species is relative to other species in a defined location or community. Relative abundance is the percent composition of an organism of a particular kind relative to the total number of organisms in the area.

$$\text{Relative abundance was calculated as (RA)} = \frac{\text{Number of individuals of a species}}{\text{Total number of individuals of all the species}} \times 100$$

## 2.4 Biological Indices

**Shannon-Weiner Index (H):** Shannon index (H) was calculated by following formula (40):

$$H = -\sum (ni/N) \log_2 (ni/N)$$

Where,  $H$  = Shannon-Wiener index of diversity,  $ni$  = total numbers of individuals of species and  $N$  = total number of individuals of all the species.

**Evenness (Pielou Index) (E):** This expresses how evenly the individuals are distributed among the different species. Pielou's evenness index is commonly used.

$$E = H'_{max} / \log S$$

Where:  $H'_{max}$  = maximum value of Shannon's index and  $S$  = total number of species

$E$  is constrained between 0 and 1. The less variation in communities between the species, the higher  $E$  is.

**Simpson's Diversity Index (1-D):** It represents the probability that two individual organisms randomly selected from a sample will belong to different species. The value of this index also ranges between 0 and 1, the greater the value, the greater the sample diversity.

**Margalef's Diversity Index (H):** This index is used for small samples. It can be measured as:

$$H = S - 1 / \ln N$$

Here,

$H$  = Margalef's index

$S$  = Number of species

$N$  = Total number of individuals

## Statistical analysis

All the diversity indices were performed using PAST software version 4. 02.

## 3. Results and Discussion

A total of 71 fish species belonging to 25 families and 49 genera were recorded from the 3 sampling stations in Ghaghara River in the present study. This is inclusive of most of the the commercially important and other small sized fishes available in the River. Our research brought out more fish species than Mishra *et al.*,<sup>[18]</sup> who reported 62 fish species but less fish species than Srivastava<sup>[19]</sup> who reported 111 fish species from this river.

The catch composition of the fishes showed Cyprinidae as the most dominant family contributing 35% with 25 species. Other important families included Bagridae (10%) with 7 species, Channidae (6%) with 4 species and Siluridae (4%), Sisoridae (4%), Anabantidae (4%) and Mastacembelidae (4%) with 3 species each. Mishra *et al.*,<sup>[18]</sup> (2011) reported that Cyprinidae was the most abundant family contributing 30.6% of fish fauna followed by Bagridae (9.7%), Siluridae and Schilbeidae (6.5% each) in Ghaghra River.

The IUCN status of the fishes represent that out of 71 fishes in the river 59 were found as Least concern (LC), 5 as near threatened (NT), 3 as not evaluated (NE), 2 as vulnerable (VU), 1 data deficient (DD) and 1 as endangered (EN).

The Shannon-Weiner Species richness Index found site A has maximum species richness with a total of 58 species (1046 individuals) followed by Site B with 52 species (751

individuals) and Site C with 47 species (696 individuals). The Simpson's index of diversity ( $1 - D$ ) was calculated as 0.974 for Site B maximum among all sites indicating highest diversity at Site B. Shannon index of the fishes did not showed much variation and found to be highest for Site B and calculated as 3.786 again indicating highest diversity in terms of both richness and evenness among all the sites. The same for Site A and Site C was found as 3.779 and 3.642, respectively. Evenness index varies from 0.754 (Site A) to 0.847 (Site B) and the same for Site C was calculated as 0.812. The evenness index of site B was a little higher compared to other sites that indicate the frequencies of

dominant species present at this site. Margalef index was calculated maximum for Site A as 8.198 indicating highest species richness. The same for Site B and Site C was 7.702 and 7.028 respectively.

The major threats of fisheries management in the river is attributed to overexploitation of fishery resources, invasion of exotic species, uncontrolled water pollution from direct and indirect sources, and destructive fishing methods. It is important to implement stringent management measures by strict enforcement of law, in order to prevent stock depletion and species loss from Ghaghara River.



Fig 1: Map showing sampling stations of Ghaghara River

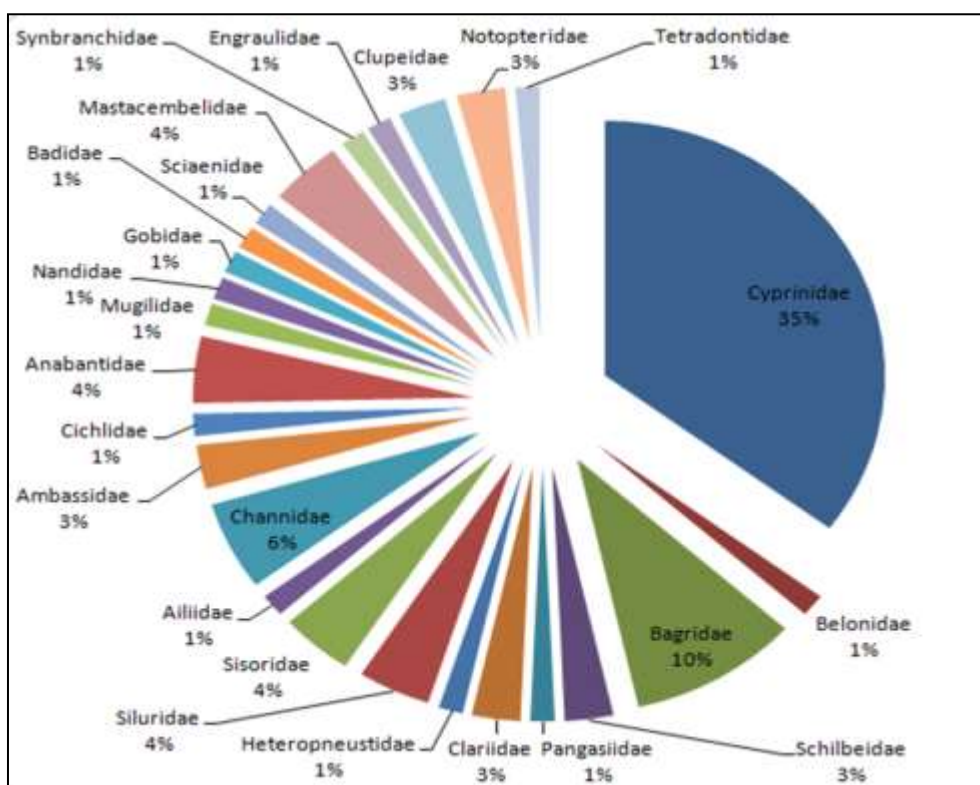


Fig 2: Catch composition per family of fishes in Ghaghara River

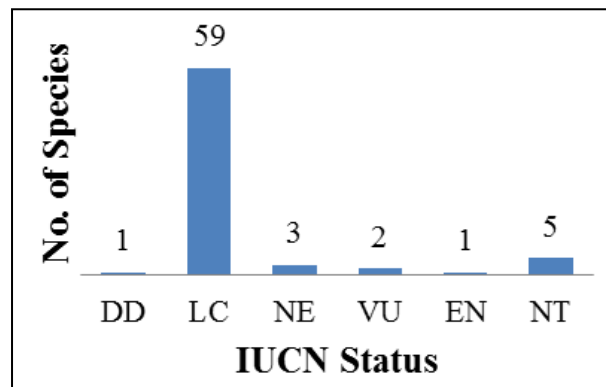


Fig 3: IUCN Status of the Fishes in Ghaghara River

Table 1: Fish species diversity of the River Ghaghara together with their IUCN status

Family	Species	A1	A2	A3	Total	IUCN Status
Cyprinidae	<i>Hypophthalmichthys nobilis</i> *	5	0	0	5	DD
	<i>Aspidoparia morar</i>	23	13	11	47	LC
	<i>Cirrhinus reba</i>	18	8	10	36	LC
	<i>Catla catla</i>	6	9	0	15	LC
	<i>Laubuka laubuca</i>	62	25	0	87	LC
	<i>Cirrhinus mrigala</i>	8	7	13	28	LC
	<i>Ctenopharygodon idella</i> *	0	3	5	8	NE
	<i>Cyprinus carpio</i> *	9	10	14	33	VU
	<i>Devario devario</i>	19	0	0	19	LC
	<i>Devario aequipinnatus</i>	24	0	0	24	LC
	<i>Hypophthalmichthys molitrix</i> *	21	0	6	27	NT
	<i>Labeo bata</i>	17	12	5	34	LC
	<i>L. calbasu</i>	5	14	8	27	LC
	<i>L. dyocheilus</i>	9	0	0	9	LC
	<i>L. goniis</i>	9	0	4	13	LC
	<i>L. rohita</i>	14	6	3	23	LC
	<i>Ostiobrama cotio</i>	12	39	4	55	LC
	<i>Puntius chola</i>	0	13	24	37	LC
	<i>Pethia conconius</i>	2	15	0	17	LC
	<i>P. sarana</i>	0	12	7	19	LC
<i>P. sophore</i>	18	0	15	33	LC	
<i>Pethia ticto</i>	33	7	9	49	LC	
<i>Raiamas bola</i>	38	29	0	67	LC	
<i>Salmostoma bacaila</i>	62	17	18	97	LC	
<i>Tor putitora</i>	8	0	0	8	EN	
Belonidae	<i>Xenentodon cancila</i>	17	22	8	47	LC
Bagridae	<i>Sperata aor</i>	9	20	0	29	LC
	<i>Sperata seenghala</i>	0	5	18	23	LC
	<i>Mystus cavasius</i>	5	9	23	37	LC
	<i>M. vittatus</i>	7	21	16	44	LC
	<i>M. bleekeri</i>	0	8	17	25	LC
	<i>M. tengra</i>	7	8	21	36	LC
Schilbeidae	<i>Rita rita</i>	19	7	13	39	LC
	<i>Silonia silondia</i>	0	0	24	24	LC
	<i>Eutropiichthys vacha</i>	43	28	12	83	LC
Pangasiidae	<i>Pangasius pangasius</i>	9	4	0	13	LC
Clariidae	<i>Clarias batrachus</i>	1	0	2	3	LC
	<i>Clarias gariepinus</i> *	0	7	9	16	LC
Heteropneustidae	<i>Heteropneustes fossilis</i>	10	28	29	67	LC
Siluridae	<i>Wallago attu</i>	12	0	21	33	VU
	<i>Ompak bimaculatus</i>	0	11	6	17	NT
	<i>Ompak pabda</i>	5	8	0	13	NT
Sisoridae	<i>Gagata cenia</i>	18	23	32	73	LC
	<i>Sisor rhabdophorus</i>	5	0	0	5	LC
	<i>Bagarius bagarius</i>	6	10	19	35	NT
Ailiidae	<i>Clupisoma garua</i>	0	13	21	34	LC
Channidae	<i>Channa punctatus</i>	20	17	8	45	LC
	<i>C. striata</i>	13	4	7	24	LC
	<i>C. marulius</i>	9	0	7	16	LC
	<i>C. orientalis</i>	0	9	0	9	NE

Ambassidae	<i>Ambassis nama</i>	27	17	31	75	LC
	<i>Parambassis raga</i>	28	16	41	85	LC
Cichlidae	<i>Oreochromis niloticus*</i>	5	0	2	7	LC
Anabantidae	<i>Anabas testatudineus</i>	11	18	7	36	LC
	<i>Colisa lalius</i>	26	10	0	36	LC
	<i>C. fasciatus</i>	19	23	0	42	LC
Mugilidae	<i>Rhinomugil corsula</i>	23	0	5	28	LC
Nandidae	<i>Nandus nandus</i>	0	5	19	24	LC
Gobidae	<i>Glossogobius giuris</i>	53	19	0	72	LC
Badidae	<i>Badis badis</i>	36	0	0	36	LC
Sciaenidae	<i>Sciaena coitor</i>	11	25	0	36	LC
Mastacembelidae	<i>Mastacembalus armatus</i>	23	8	32	63	LC
	<i>Macrognathus pancalus</i>	0	20	31	51	LC
	<i>Macrognathus aculeatus</i>	19	28	0	47	NE
Synbranchidae	<i>Monopterusuchia</i>	17	0	0	17	LC
Engraulidae	<i>Setipina phasa</i>	9	24	0	33	LC
Clupeidae	<i>Gonialosa manmina</i>	41	28	0	69	LC
	<i>Gadusia chapra</i>	49	0	25	74	LC
Notopteridae	<i>Chitala chitala</i>	0	7	9	16	NT
	<i>Notopterus notopterus</i>	11	0	25	36	LC
Tetradontidae	<i>Tetradoncutitia</i>	1	2	0	3	LC
Total Individuals		1046	751	696	2493	

**Table 2:** BiodiversEity Indices of Fishes in Ghaghara River

	SITE -A	SITE-B	SITE-C	OVERALL
<b>Number of Species</b>	<b>58</b>	<b>52</b>	<b>47</b>	<b>71</b>
Individuals	1046	751	696	2493
Simpson (1-D)	0.971	0.974	0.969	0.981
Shannon (H)	3.779	3.786	3.642	4.061
Evenness(e <sup>H/S</sup> )	0.754	0.847	0.812	0.816
Margalef	8.198	7.702	7.028	8.951

#### 4. Conclusion

The results obtained in the study provides an authentic database on the freshwater fish diversity of Ghaghara river. Cyprinidae followed by Bagridae and Channidae were the dominant fish groups. Presence of exotic fishes introduced legally have promising results in aquaculture system but species like *Oreochromis niloticus*, *Clarias gariepinus* and *Aristichthys nobilis* in natural waters may cause significant and superfluous effects on indigenous fish biodiversity. Since the river also has endangered, near threatened and vulnerable fish fauna, it can be used as high priority area for implementing appropriate conservation and management measures.

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