Present status, distribution and relative abundance of IUCN Red-listed fish species of River Ganga

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Quarterly field sampling was conducted from 2016 to 2020 to understand the distribution and current status of IUCN Red-listed fish species along the entire stretch of River Ganga. During the study, 18 fish species belonging to 8 orders and 12 families were recorded under the IUCN Red list. Fishes belonging to the family Synodontidae contributed highest among the threatened group. The status of fish species have been categorized on the basis of IUCN Red list. Among 18 fish species, *Clarias magur* and *Tor putitora* were categorized as endangered, whereas *Wallago attu* and *Schizothorax richardsonii* were categorized as vulnerable. The present study suggests the necessary management plans and conservation strategies for these IUCN Red-listed fish species of River Ganga.

Keywords: Fish, IUCN Red list, relative abundance, River Ganga.

THE freshwater ecosystem provides the habitat of rich, sensitive, endemic biota and harbours around 6% of the total species[1]. India is considered as a hotspot of freshwater fish diversity and contributes a high number of the world's endemic biological resources[2,3]. Also, 11.7% of fish species in the world have been recorded from Indian waters[4] and 295 endemic fish species which are exclusively found in India are listed under IUCN[5].

River Ganga along with its tributaries supports extensive aquatic biodiversity and plays an important role in maintaining livelihood and nutritional security[6]. The riverine ecosystem has experienced habitat degradation of fish fauna due to anthropogenic activities like industrial pressure, pollution, overexploitation, illegal fishing activities, misuse of resources resulting in rapid biodiversity loss resulting in many threatened fish species[7]. Proper attention is needed for endemic fish diversity specifically those which are habituated under restricted distribution, otherwise, alteration of their habitats might lead to their disappearance[8]. In the present study, several fish species have been recorded under IUCN Red-list category[9] during a survey from 2016 to 2020. As these are economically prized fish, effective conservation and sustainable management plans should be implemented to restore the germplasm of fish species.

River Ganga was divided into three stretches based on its characteristics, viz. upper (Uttarakhand), middle (Uttar Pradesh and Bihar) and lower (West Bengal) stretches. Quarterly field sampling was done along the whole stretch of River Ganga to collect data on fish diversity and their abundance over a period of four years from April 2016 to March 2020. The sampling sites covered Uttarakhand, Uttar Pradesh, Bihar and West Bengal. Figure 1 shows the distribution pattern of the threatened fish species.

Eighteen sampling stations were selected along River Ganga, namely Tehri, Haridwar, Bijnour, Narora, Farukhabad, Kanpur, Allahabad, Varanasi, Buxar, Patna, Bhagalpur, Farakka, Berhampore, Balagarh, Tribeni, Godakhali, Diamond Harbour and Fraserganj (GIS map). The main river channels as well as adjacent landing centres were visited to collect fish samples. The samples were collected from the main river channels through experimental fishing by locally hired fishers. Various selective and non-selective gears like gill nets, seine nets, barrier and falling nets, cast nets, drag nets, bag nets and traps were used for fish catch. The fish specimens were identified using the taxonomic characteristics reported earlier[10–13]. Statistical analysis, i.e. one-way ANOVA followed by Duncan's multiple range test was carried out for studying the significance of relative abundance of different species using SPSS, version 22.

A total of 190 fish species representing 19 orders and 132 genera were recorded from the Ganga, of this 18 species belonging to 8 orders and 12 families were reported under IUCN Red-list. Threatened fish species under the IUCN Red list, recorded from River Ganga are mentioned in Table 1. Freshwater fish species were categorized by the National Bureau of Fish Genetic Resources (NBFGR), 2010 and their present status under IUCN Red-list was also documented (Table 2). Table 3 indicates the present status and distribution of these fish species in the entire stretch of River Ganga. Relative abundance of these species was analysed station-wise. The present study showed that the family Synodontidae contributed the highest (53.8%), followed by Cyprinidae (16.68%) and Siluridae (13.94%) (Figure 2).

Maximum threatened fish species (Table 3) were found in the middle stretch of River Ganga, viz. Buxar, Patna, Bhagalpur, Farakka, Berhampore and Balagrah followed by the upper stretch, viz. Bijnour and Narora. Among 18 fish species, *Clarias magur* and *Tor putitora* were under the endangered category, whereas *Wallago attu* and *Schizothorax richardsonii* were under the vulnerable category. The remaining 15 were recorded under the near threatened category of IUCN Red list. *Tor putitora*, *Bagarius yarrelli* and *Ompok pabo* were under the endangered category according to NBFGR, Lucknow[6], whereas five endangered, four vulnerable and two low risk near threatened fish species have been listed under Conservation Assessment and Management Plan[14].

The most dominant fish was *Harpadon nehereus*, followed by *T. putitora* from the entire stretch of River Ganga (Figure 3). *Bagarius bagarius*, *Ailia coila*, *W. attu* and

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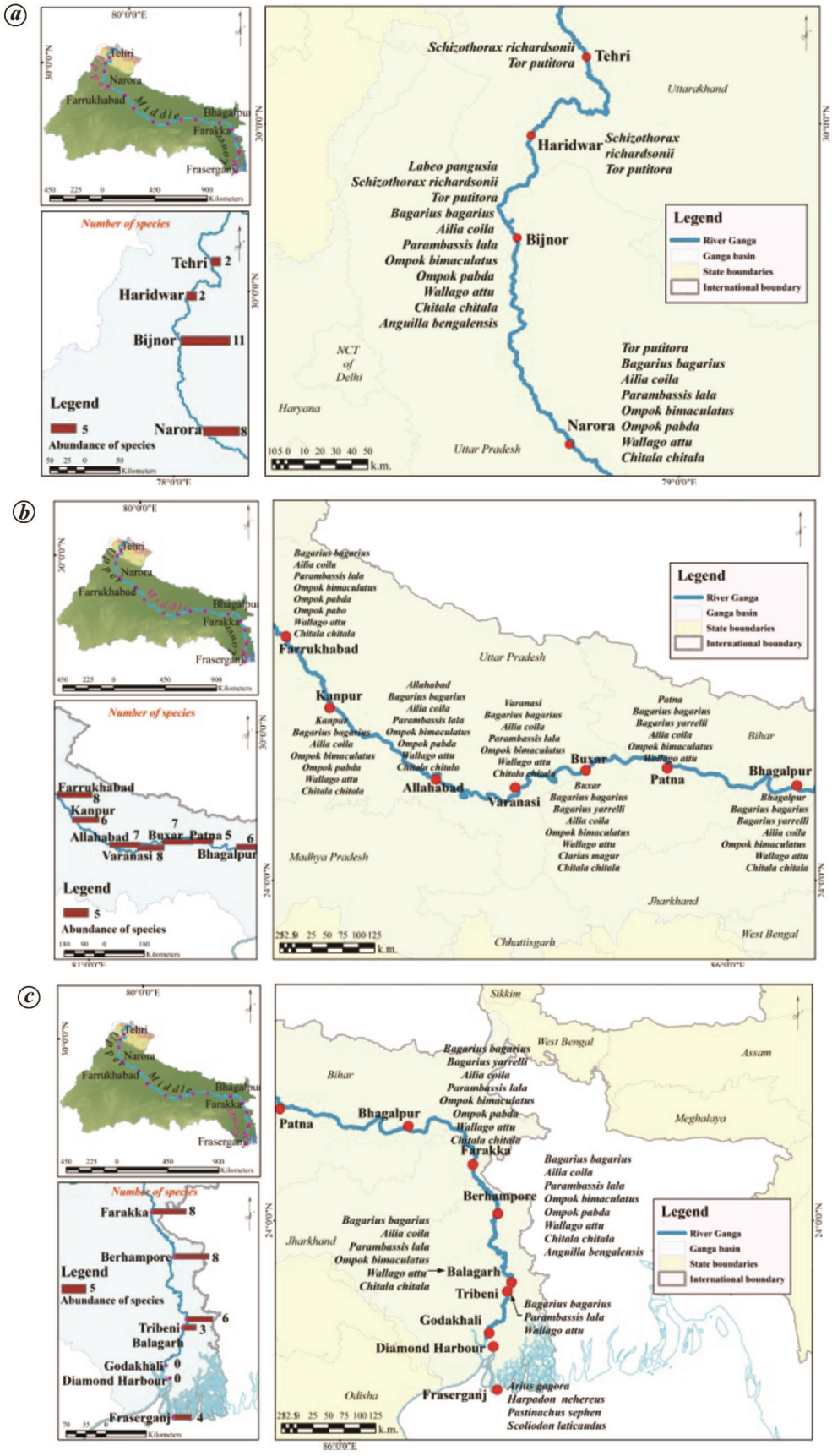

Figure 1. Distribution of threatened fish species in the (***a***) upper stretch, (***b***) middle stretch and (***c***) lower stretch of River Ganga.

Table 1. Threatened fish species under the IUCN Red list in the Ganga river stretch

Order	Family	Species	IUCN category	CAMP, 1998	NBFGR, 2010
Cypriniformes	Cyprinidae	*Tor putitora* (Hamilton 1822)	EN	EN	EN
	Cyprinidae	*Schizothorax richardsonii* (Gray 1832)	VU	VU	NA
	Cyprinidae	*Labeo pangusia* (Hamilton 1822)	NT	LRnt	NA
Siluriformes	Sisoridae	*Bagarius bagarius* (Hamilton 1822)	NT	VU	NA
	Sisoridae	*Bagarius yarrelli* (Sykes 1839)	NT	NA	EN
	Ailiidae	*Ailia coila* (Hamilton 1822)	NT	VU	NA
	Ariidae	*Arius gagora* (Hamilton 1822)	NT	NA	NA
	Siluridae	*Ompok bimaculatus* (Bloch 1794)	NT	EN	NA
	Siluridae	*Ompok pabda* (Hamilton 1822)	NT	EN	NA
	Siluridae	*Ompok pabo* (Hamilton 1822)	NT	NA	EN
	Siluridae	*Wallago attu* (Bloch & Schneider 1801)	VU	LRnt	NA
	Clariidae	*Clarias magur* (Hamilton 1822)	EN	VU	NA
Perciformes	Ambassidae	*Parambassis lala* (Hamilton 1822)	NT	NA	NA
Osteoglossiformes	Notopteridae	*Chitala chitala* (Hamilton 1822)	NT	EN	NA
Anguilliformes	Anguliidae	*Anguilla bengalensis* (Gray 1831)	NT	EN	NA
Aulopiformes	Synodontidae	*Harpadon nehereus* (Hamilton 1822)	NT	NA	NA
Myliobatiformes	Dasyatidae	*Pastinachus sephen* (Fabricius 1775)	NT	NA	NA
Carcharhiniformes	Carcharhinidae	*Scoliodon laticaudus* (Müller & Henle 1838)	NT	NA	NA

IUCN, International Union for Conservation of Nature; CAMP, Conservation Assessment and Management Plan; NBFGR, National Bureau of Fish Genetic Resources; EN, Endangered; VU, Vulnerable; NT, Near threatened; LRnt, Low risk near threatened; NA, Not assessed.

Table 2. Fish species categorized by NBFGR, 2010 and their present status under IUCN

Species	NBFGR, 2010	Present report and IUCN status
Garra lamta	EN	NR
Tor mosal	EN	NR
Amblyceps mangois	EN	LC
Chaca chaca	EN	LC
Chagunius chagunio	EN	LC
Hemibagrus menoda	EN	LC
Himantura fluviatis	EN	NR
Ilisha megaloptera	EN	LC
Nangra nangra	EN	NR
Sisor rabdophorus	EN	LC
Tor tor	EN	NR
Badis badis	VU	LC
Botia dario	VU	LC
Crossocheilus latius latius	VU	LC
Garra gotyla gotyla	VU	LC
Gonialosa manmina	VU	LC
Pangasius pangasius	VU	LC
Pangio pangia	VU	LC
Puntius chola	VU	LC
Puntius sarana	VU	LC
Puntius vittatus	VU	NR
Rhinomugil corsula	VU	LC
Sicamugil cascasia	VU	LC
Silonia silondia	VU	LC
Sperata aor	VU	LC
Tenualosa ilisha	VU	LC

Chitala chitala were found nearly in the entire stretch. The threatened fishes like *A. coila*, *Ompok bimaculatus* and *W. attu* were highly significant ($P < 0.05$) at Bhagalpur, whereas, the relative abundance of single fish species were found significantly high at specific station like *T. putitora* ($P < 0.05$) at Tehri, *S. richardsonii* ($P < 0.05$) at Haridwar, *B. yarrelli* ($P < 0.05$) at Buxar, *Parambassis lala* ($P < 0.05$) at Farakka, *B. bagarius* ($P < 0.05$) at Balagarh, *C. chitala* ($P < 0.05$) at Berhampore and *Harpadon nehereus* ($P < 0.05$) at Fraserganj stretch of River Ganga.

The status of fishes being threatened is a major concern nationwide, particularly in the Ganga. From the present study, a total of 190 (104 freshwater and 86 brackishwater) fish species were recorded from River Ganga, of which 18 are categorized under IUCN Red list. Earlier 143 freshwater fish species were reported from the Ganga, among which 29 (10 fish species were endangered and 19 were vulnerable) were under the Red list[15]. Compared with previous studies, the status of eight fish species, viz. *B. bagarius*, *C. chitala*, *Labeo pangusia*, *O. pabo*, *S. richardsonii*, *T. putitora*, *Ompok pabda* and *Bagarius yarrelli* is still found under 'threatened' category in the present study. However, 18 species, viz. *Amblyceps mangois*, *Chagunius chagunio*, *Eutropiichthys vacha*, *Garra gotyla gotyla*, *Gonialosa manmina*, *Hemibagrus menoda*, *Heteropneustes fossilis*, *Puntius chola, Rhinomugil corsula*, *Sisor rabdophorus*, *Tenualosa ilisha*, *Sperata aor*, *Botia dario*, *Sicamugil cascasia*, *Puntius sarana*, *Crossocheilus latius latius*, *Pangasius pangasius* and *Silonia silondia* were under 'least concern'. The remaining three fish species, i.e. *T. tor*, *Glyptothorax telchitta* and *Nangra nangra* have not been reported during the present study from the entire stretch of River Ganga. According to Roshith *et al.*[16], 155 fish species were reported from the freshwater tidal stretch of Ganga. Among them, 19 were recorded under 'threatened' category, including 16 vulnerable and 4 endangered species categorized by NBFGR. Lakra *et al.*[6] documented 120 freshwater species, of which 14 were under the category of endangered and 17 vulnerable. From the findings of Lakra *et al.*[6] including *T. tor*

Table 3. Relative abundance (mean ± SE) of IUCN Red-listed fish species of River Ganga

Station/ Species	Tehri	Haridwar	Bijnour	Narora	Farukha-bad	Kanpur	Allahabad	Varanasi	Buxar	Patna	Bhagal-pur	Farakka	Berham-pore	Balagarh	Tribeni	Goda-khali	D. Harbour	Fraser-ganj
Labeo pangusia	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Schizothorax richardsonii	0.000[b]	0.008 ± 0.0005[a]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]
Tor putitora	0.995 ± 0.002[a]	0.026 ± 0.001[b]	0.000[c]	0.000[c]	0.000[c]	0.000[c]	0.000[c]	0.000[c]	0.000[c]	0.000[c]	0.000[c]	0.000[c]	0.000[c]	0.000[c]	0.000[c]	0.000[c]	0.000[c]	0.000[c]
Bagarius bagarius	0.000[g]	0.000[g]	0.000[g]	0.000[g]	0.000[g]	0.000[g]	0.000[g]	0.000[g]	0.12 ± 0.002[b]	0.06 ± 0.002[c]	0.03 ± 0.002[e]	0.01 ± 0.001[f]	0.04 ± 0.002[d]	0.16 ± 0.002[a]	0.000[g]	0.000[g]	0.000[g]	0.000[g]
Bagarius yarrelli	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.02 ± 0.002[a]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]
Ailia coila	0.000[g]	0.000[g]	0.000[g]	0.000[g]	0.003 ± 0.0005	0.001 ± 0.0005	0.001 ± 0.0005	0.002 ± 0.0005	2.28 ± 0.002[c]	4.66 ± 0.005[b]	5.21 ± 0.005[a]	1.93 ± 0.002[d]	1.23 ± 0.002[f]	1.69 ± 0.002[e]	0.000[g]	0.000[g]	0.000[g]	0.000[g]
Parambassis lala	0.000[d]	0.000[d]	0.000[d]	0.001 ± 0.005[d]	0.000d	0.000[d]	0.000[d]	0.000[d]	0.000[d]	0.000[d]	0.000d	7.44 ± 0.002[a]	0.07 ± 0.002[c]	0.23 ± 0.002[b]	0.000[d]	0.000[d]	0.000[d]	0.000[d]
Ompok bimaculatus	0.000[f]	0 ± 0.003[f]	0.000[f]	0.000[f]	0.001 ± 0.003[f]	0.000[f]	0 ± 0.003[f]	0.000[f]	0.01 ± 0.002[e]	0.04 ± 0.002[b]	1.59 ± 0.002[a]	0.04 ± 0.002[b]	0.02 ± 0.002[d]	0.03 ± 0.002[c]	0.000[f]	0.000[f]	0.000[f]	0.000[f]
Ompok pabda	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ompok pabo	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wallago attu	0.000[h]	0.000[h]	0.000[h]	0.000[h]	0.016 ± 0.001[g]	0.001 ± 0.0005	0.000[h]	0.002 ± 0.001[h]	0.11 ± 0.002[b]	0.04 ± 0.002[e]	1.92 ± 0.002[a]	0.06 ± 0.002[d]	0.09 ± 0.002[c]	0.03 ± 0.002[f]	0.000[h]	0.000[h]	0.000[h]	0.000[h]
Clarias magur	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Arius gagora	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Chitala chitala	0.000[e]	0.000[e]	0.000[e]	0.000[e]	0.000[e]	0.000[e]	0.000[e]	0.000[e]	0.01 ± 0.002[d]	0.000[e]	0.04 ± 0.002[b]	0.02 ± 0.002[c]	0.12 ± 0.002[a]	0.000[e]	0.000[e]	0.000[e]	0.000[e]	0.000[e]
Anguilla bengalensis	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Harpadon nehereus	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000b	0.000[b]	0.000[b]	0.000[b]	1.27 ± 0.002[a]
Pastinachus sephen	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scoliodon laticaudus	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.000[b]	0.37 ± 0.002[a]

[a–f]Statistical variation of relative abundances of fish species among stations.

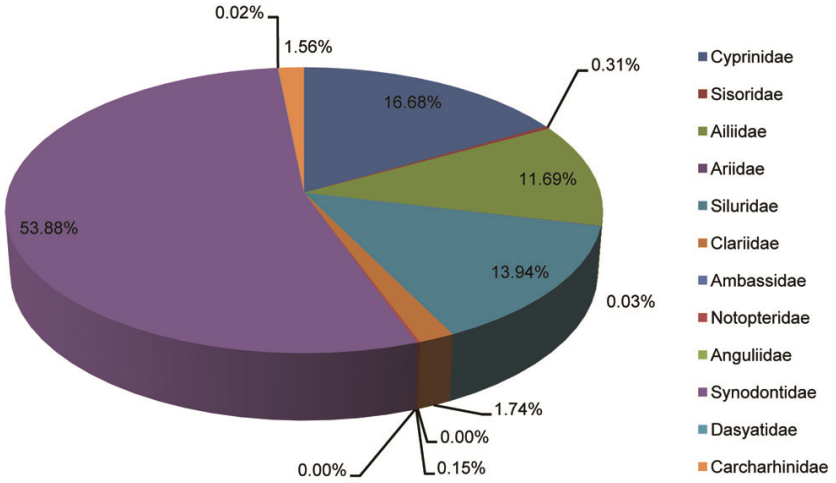

Figure 2. Family-wise threatened fish fauna composition.

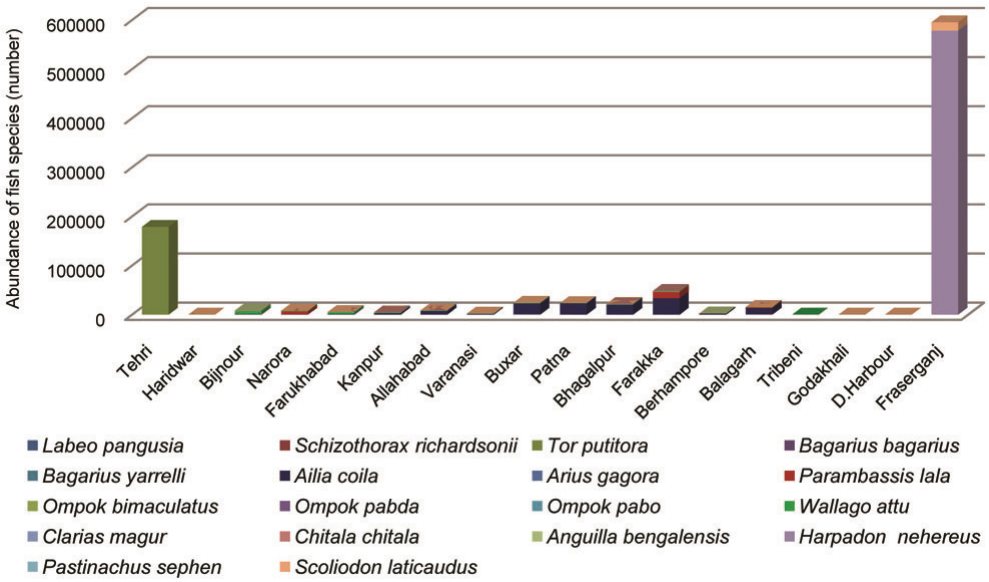

Figure 3. Abundance of threatened fish species in the Ganga river stretch.

and *Nangra nangra*, four other freshwater fish species, viz. *Himantura fluviatis*, *Puntius vittatus*, *Garra lamta* and *Tor mosal* have not been reported in the present study and 25 fish species are under 'Least Concern' in the IUCN Red list. *A. coila*, *A. gagora*, *O. bimaculatus*, *W. attu*, *C. magur*, *P. lala*, *A. bengalensis*, *H. nehereus*, *Pastinachus sephen* and *Scoliodon laticaudus* have been listed under 'threatened' category in this study, though the species were not found under 'threatened' category by Sarker *et al.*[15] According to CAMP (1998), the 18 threatened fish fauna reported in the present study can be categorized as follows: five under endangered list, viz. *Tor putitora*, *O. bimaculatus*, *O. pabda*, *C. chitala* and *A. bengalensis*, four as vulnerable, viz. *S. richardsonii*, *B. bagarius*, *A. coila* and *C. magur* and two, viz. *L. pangusia* and *W. attu* as low risk near threatened. The status of different fish species of River Ganga by different organizations varies from time to time. However, in view of the threats of decreasing trend of fish catch, especially the Red-listed fish species, suitable conservation measures are needed. Changes in hydrological structure due to dam construction, land modification, pollution, industrial effluents, illegal fishing activities, etc. are the major causes for alteration of fish diversity in the Ganga basin, which affect the conservation and management strategies[7,17–20].

River Ganga supports a vast diversity of flora and fauna. Reduction of total fish species as well as the number of fishes under the IUCN Red list may be a major concern for Ganga fish diversity. Efforts for conservation are necessary for the IUCN categorized 18 fish species of River

Ganga, according to the present study. Declaration of fish protected area for *in situ* breeding, construction of fish pass for migratory fishes, river ranching and *ex situ* breeding of fish germplasm of River Ganga should be adopted. Proper study of the ecosystem should be done prior to implementing any hydro-related projects in River Ganga. Restoration of riverine connectivity with associate water bodies like wetlands which allow fish species migration for feeding, breeding as well as rearing should be managed because the linkage is an opportunity for improvement of species community structure.

Conflict of interest: Authors declare no conflict of interest.

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