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Open Access

10.11609/jott.2024.16.1.24451-24614
www.threatenedtaxa.org

26 January 2024 (Online & Print)
16(1): 24451–24614
ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

Publisher
Wildlife Information Liaison Development Society
www.wild.zooreach.org

Host
Zoo Outreach Organisation
www.zooreach.org

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Cover: Green Sea Turtle *Chelonia mydas* watercolour by Elakshi Mahika Molur.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 January 2024 | 16(1): 24535–24549

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.8084.16.1.24535-24549

#8084 | Received 01 July 2023 | Final received 01 December 2023 | Finally accepted 22 December 2023

OPEN ACCESS

COMMUNICATION

Freshwater fish diversity and IUCN Red List status of glacial-fed (Bheri) and spring-fed (Babai) rivers in the wake of inter-basin water transfer

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Abstract: Freshwater fish are crucial components of aquatic ecosystems that are affected by a range of anthropogenic activities. Freshwater bodies in Nepal are under different threats affecting biodiversity. Inter-basin water transfer (IBWT) involving damming and diversion of water from one river basin to another is considered a major threat to aquatic biodiversity. Impact assessment of such projects include generation of baseline information on different biotic and abiotic variables. The aim of this study was to generate baseline information on fish diversity from the glacial-fed (Bheri) and the spring-fed (Babai) rivers and their selected tributaries from western Nepal in the wake of the first proposed inter-basin water transfer from the former to the latter. A total of 10 sampling sites, five each from Bheri and Babai River systems, were chosen strategically. Electrofishing was conducted encompassing different seasons in 2018 following the standard method. A total of 32 species with catch per unit effort (CPUE) of 47±24 from Bheri and 42 species with CPUE of 63±52 from Babai River were recorded. Cyprinidae, followed by Nemacheilidae, were the most dominant families in both river systems, and *Barilius vagra* and *Schistura beavani* were the most dominant species in both. Species richness and abundance showed a significant difference between rivers, and differences in fish assemblages reflects differences in ecological regimes. Failure to observe migratory species such as *Anguilla bengalensis* suggests that migratory routes may already have been affected. Of the total 52 species recorded, eight are in the threatened categories of the IUCN Red List and need active conservation measures. The findings provide a reference to assess the impacts of water transfers on fish assemblages in these river systems.

Keywords: Abundance, aquatic ecosystems, Babai River, Bheri River, damming, electrofishing, fish assemblages, threats.

Editor: J.A. Johnson, Wildlife Institute of India, Dehradun, India.

Date of publication: 26 January 2024 (online & print)

Citation: Khatri, K., B.R. Jha, S. Gurung & U.R. Khadka (2024). Freshwater fish diversity and IUCN Red List status of glacial-fed (Bheri) and spring-fed (Babai) rivers in the wake of inter-basin water transfer. *Journal of Threatened Taxa* 16(1): 24535–24549. https://doi.org/10.11609/jott.8084.16.1.24535–24549

Funding: This study was supported by the University Grants Commission of Nepal under Faculty Collaborative Research Grant for F.Y. 2072/73 to Bibhuti Ranjan Jha.

Competing interests: The authors declare no competing interests.

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Author contributions: All authors contributed to the study, conception, and design. Material preparation, data collection and analysis were performed by BRJ, SG, URK, and KK. The first draft of the manuscript was written by KK and all authors rigorously worked and revised the manuscript. All authors have read and approved the final manuscript.

Acknowledgements: We thank the University Grants Commission (UGC) Nepal for funding this research. We also acknowledge the Department of National Park and Wildlife Conservation (DNPWC), Nepal for giving us the permission to sample at Mulghat, Bardiya National Park, staff from Bheri-Babai Diversion Multipurpose Project for their cooperation during the field visits. Finally, we thank the students and technicians for helping this work in field and in labs.

INTRODUCTION

Fish are one of the diverse groups of vertebrates, with an estimated 36,484 species globally including 18,495 freshwater fish (Fricke et al. 2023) and also one of the most frequently investigated aquatic organisms (Tornwall et al. 2015), directly related to human well-being (Öztürk et al. 2021) because of their nutritional, socio-economic, and cultural values (Lynch et al. 2016). An estimated 13,000 (belonging to 2,513 genera) freshwater fish species live in lakes and rivers that cover only around 1% of the earth's surface (Levêque et al. 2007) and are thus one of the major components of global biodiversity (Dudgeon et al. 2006; Sedeño-Díaz & López-López 2013).

Freshwater fisheries provide the main source of protein for 200 million people across Asia, Africa, and South America, as well as jobs and livelihoods for 60 million people (WWF 2021). However, over the past few years, decrease in freshwater fish diversity and their population have been reported from their natural habitats, with one in three species being threatened with extinction (WWF 2021) mainly attributed to a range of anthropogenic activities such as overfishing, pollution, use of destructive fishing methods, climate change, and developmental activities (Saund & Shrestha 2007; ADB 2018; Su et al. 2021).

Asia is the home to about 3,553 freshwater fish species with Cypriniformes and Siluriformes as the most dominant orders (Berra 2007; Levêque et al. 2007; Nelson et al. 2016) with high endemicity (De Silva et al. 2007). The exceptional diversity of fish in this region also supports high diversity of fishes in inland waters, which forms the basis of the livelihood; and extremely important for food security particularly for the rural poor people (Thilsted & Wahab 2014; Gurung 2016). However, the knowledge of fish faunal diversity in many parts of Asia, including Nepal, is still in its progressive phase, where survey works are fragmentary and sporadic, with many species yet to be discovered or to be described (Levêque et al. 2007; Eldho & Sajeevan 2022).

Nepal represents both Indo-Malayan and Palearctic realms (Chaturvedi 2012) and coupled with its rich network of rivers and streams (WECS 2011), the country harbours a rich terrestrial as well aquatic biodiversity (GoN 2014). A recent review reported more than 220 freshwater species in the country (Khatri et al. 2020). However, because of its rich network of rivers and streams, the growing demand for electricity, drinking, and irrigation for increasing population, the damming and diversion of these ecosystems have become common (ADB 2018; WWAP 2009). Recently, Nepal was involved in the implementation of inter basin water transfer (IBWT) schemes (GoN 2019) which involve water transfer from donor basins to receiving basins which provide year-round irrigation, generating reliable electricity and also for other multipurpose benefits (Zhu et al. 2018). Such transfers have also been known to cause a range of upstream-downstream ecological, hydrological, and geomorphological changes (Quan et al. 2016; Zhuang 2016). Therefore, such infrastructural developments and their subsequent environmental consequences are often subject to criticism and discussions (Pittock et al. 2009). However, with a growing population and the country's increasing requirement to produce more food and electricity, damming, and diversion of river waters are on the rise, with many more in the pipeline (Khadka & Khanal 2008; WECS 2011; Gurung & Bharati 2012; Suwal et al. 2020).

Damming, diversion, and inter-basin water transfer affect fish fauna in several ways, including loss of species, decreased abundance, and change in behavior; blockade of migratory routes, and interruption in life cycles (Daga et al. 2020; Tien Bui et al. 2020; Bohada-Murillo et al. 2021). These impacts are attributed to changes in migratory fish habitats, discharge regimes, water temperature and water quality, increased exposure to predation, and loss of riverbank forests (Davies et al. 1992; McAllister et al. 2001). In Nepal, migratory species such as *Tor putitora*, *T. tor*, *Bagarius bagarius*, *Clupisoma gaura*, and *Anguilla bengalensis* have already been reported to be affected through the construction of dams in the country (ADB 2018).

The Bheri Babai Diversion Multipurpose Project (BBDMP) is the first inter-basin water transfer designed to transfer 40 m^3/s water from the glacial-fed Bheri to the spring and rain-fed Babai through a 12-km tunnel for hydropower generation and irrigation. The proposed water transfer aims to generate 46 megawatts (MW) of hydroelectricity and irrigate around 51,000 ha of agricultural land in the southwest districts of Banke and Bardiya (GoN/BBDMP 2018). The mandatory environmental impact assessment (EIA) on BBDMP conducted in 2011 has reported only an inventory on fish fauna from the two rivers with 23 and 20 species from the Bheri and the Babai Rivers respectively (EIA 2011). Moreover, the EIA finding is based on only one time sampling. However, a detailed baseline data on fish diversity, including the seasonal variation in fish assemblages and the International Union for

Conservation of Nature (IUCN) categorization of fish species are still lacking which is crucial for developing effective conservation measures. Therefore, the main objective of this study was to prepare baseline data on fish diversity and to identify IUCN category from the selected stretches of the Bheri and the Babai River in the wake of proposed first inter-basin water transfer in western Nepal. Such baseline information are essential components of impact monitoring and thus forms the basis for development of future management strategies. Furthermore, it could also contribute to update the current IUCN Red List on fishes on local scale.

MATERIALS AND METHODS

Study Area

The study was conducted in the selected stretches of the Bheri and the Babai Rivers and their tributaries in western Nepal. Bheri is a glacial-fed perennial river originating from the Mount Dhaulagiri range (Mishra et al. 2018), whereas the Babai River is a perennial spring as well as rain-fed river with a low flow during dry seasons originating from the Siwalik hills (Sharma 1977). The Bheri River is about 264 km long covering a drainage area of about 13,900 km^2 with an elevational range of 200 to 7,746 m. Based on data from 1975 to 2005 observed from seven climatological stations across the drainage, the average annual precipitation in the drainage was 1,202 mm (Mishra et al. 2018). The average annual discharge of the Bheri River at Samaijighat Hydrological station (Station No. 269.5 located at 500 m), upstream of the proposed water diversion is 331.6 m^3/s with minimum and maximum discharge of 74.5 m^3/s and 2150 m^3/s, respectively (GoN/DoHD 2019). The Babai River is about 400 km long and lies in a subtropical region. It has a drainage area of about 3,250 km^2 with an elevational range of 147 to 2,880 m. The average annual rainfall in the basin is reported to be 1,468 mm, based on data from 1975 to 2005 observed at seven climatological stations (Mishra et al. 2021). The average discharge of the Babai River at Chepang Hydrological station (Station No. 289.95 located at 325 m), near the proposed water release is 34.67 m^3/s with minimum and maximum discharge of 5.1 m^3/s and 477 m^3/s, respectively (GoN/DoHD 2019). Upstream, downstream and three tributaries of both the rivers were strategically chosen for sampling. Thus, 10 sites (five each in the Bheri and Babai River systems; Table 1) were sampled based on strategic occurrence and accessibility (Figure 1). The downstream of water release at Babai River was located at Mulghat at Bardiya National Park- a protected area and the mandatory permit for sampling was procured from the Department of National Parks and Wildlife Conservation, Nepal.

Field Methods

Fish sampling

The sampling was conducted in all major seasons in January (winter), April (spring), June (summer), and November (autumn) in 2018. For fish sampling, electrofishing (Model Honda GXV50) by the wading method was adopted following Jha (2006). Electrofishing is considered a scientific standard method that involves generating an electric field, and the fishes within the field are stunned temporarily. Electrofishing was conducted in two runs of approximately 20 minutes (1200 seconds) each, encompassing approximately 100–500 m (0.1–0.5 km) stretch on each site. The captured fishes were identified up to species level in the field itself following taxonomic literature (Shrestha 1981, 2008), and fishes were photographed. The identified fishes were released back to their natural habitat once the necessary information such as length and weight was collected. Unidentified fish specimens were preserved in 70% ethanol and brought to the Department of Environmental Science and Engineering (DESE), Kathmandu University, for identification following other standard literature (Shrestha 1981; Talwar & Jhingran 1991; Jayaram 2010; Rajbanshi 2012; Fricke et al. 2023) and was further confirmed by fish taxonomists at the Research Laboratory of Fish and Fisheries, Central Department of Zoology, Tribhuvan University. These specimens have been kept for records as voucher specimens at the Central Department of Zoology, Tribhuvan University. Along with fish sampling, selected physico-chemical parameters, viz., temperature, dissolved oxygen (DO), pH, total dissolved solids (TDS), and conductivity were also estimated using portable probes (LUTRON WA-2015). All the samplings were conducted in the morning (0800–1100 h) and afternoon (1300–1600 h).

Data analysis

For fish abundance estimation, the sampled fish species were expressed in catch per unit effort (CPUE) as the number of fishes collected per 10 minutes of electrofishing (Jha 2006). Various species diversity indices such as Shannon index (H') (Spellerberg & Fedor 2003), Simpson's index of diversity (1-D) (Caso & Gil 1988) and Pielou's Evenness (J) (Pielou 1966)

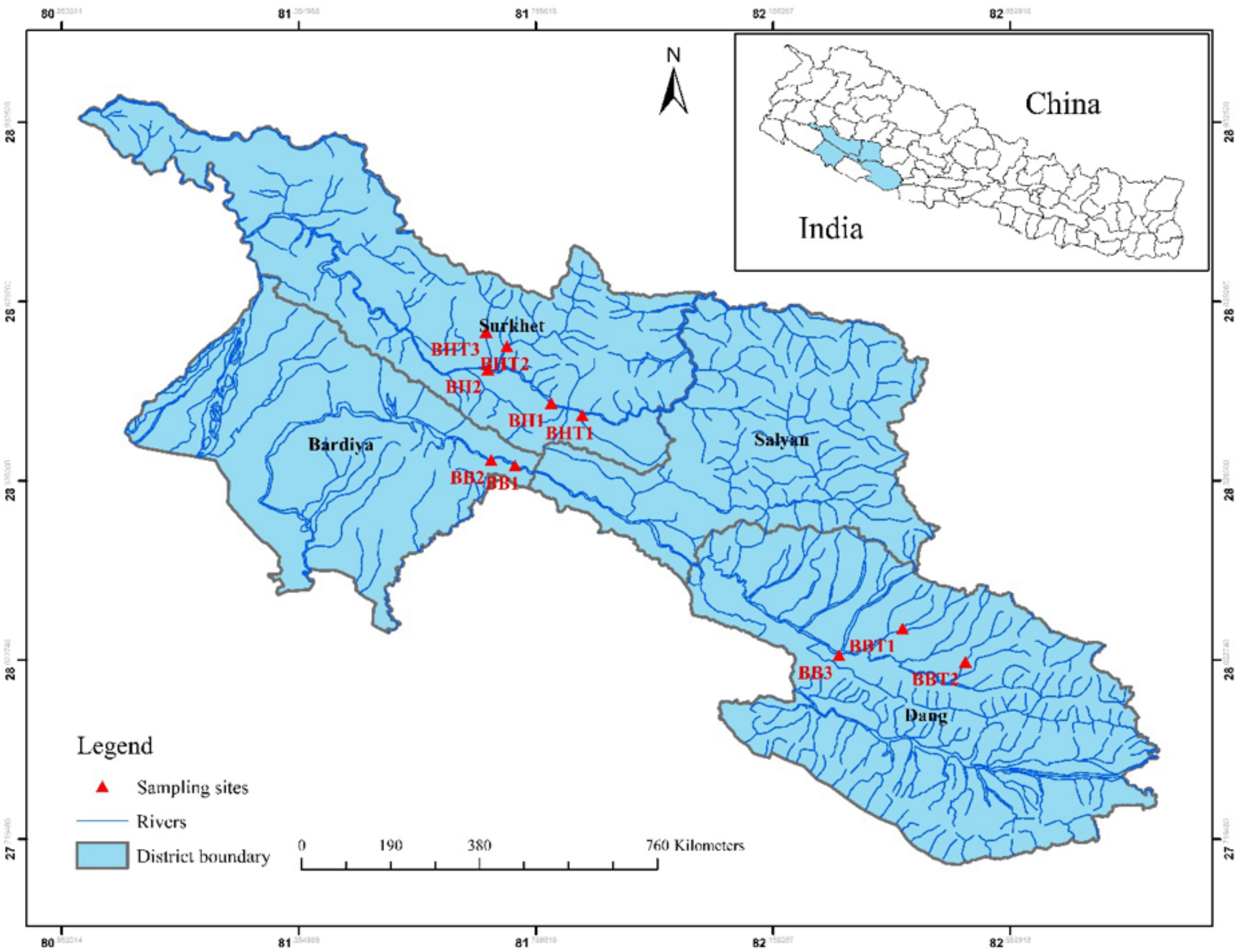

Figure 1. The different sampling sites. Noted legends are sampling sites, major rivers, tributaries and districts boundary.

Table 1. Details of sampling sites with geographical coordinates and elevation.

Site codes	Rivers	Places	Elevation (in m)	Latitude	Longitude	Remarks
BH1	Bheri	Cheepla, Surkhet	436	28.45742°N	081.78235°E	Upstream of water diversion at Bheri
BH2	Bheri	Bhanghari, Surkhet	403	28.51468°N	081.67520°E	Downstream of water diversion at Bheri
BHT1	Goche	Mehelkuna, Surkhet	475	28.43677°N	081.83489°'E	Tributary of Bheri
BHT2	Chingad	Gangate, Surkhet	466	28.55361°N	081.70715°E	Tributary of Bheri
BHT3	Jhupra	Surkhet	497	28.57791°N	081.67207°E	Tributary of Bheri
BB1	Babai	Chepangghat, Surkhet	293	28.35160°N	081.72109°E	Upstream of water release at Babai
B2	Babai	Mulghat, Bardiya	287	28.36127°N	081.68044°E	Downstream of water release at Babai
BB3	Babai	Bel Takura, Dang	561	28.03095°N	082.26972°E	Upstream of Babai
BBT1	Patre	Majhgaun, Dang	594	28.07607°N	082.37733°E	Tributary of Babai
BBT2	Katuwa	Ghorahi, Dang	625	28.01966°N	082.48380°E	Tributary of Babai

were calculated using Past 4 software. Dendrograms were constructed to understand the similarity of fish assemblage structure between the sampling sites. This was done by Hierarchical clustering using group average method with correlation coefficient distance (Jain et al. 1999) using Originpro 2023. Log transformation was done prior to hierarchical clustering to minimize errors. Mann Whitney test was conducted to assess significant variation between the two river systems in species abundance, whereas Kruskall-Wallis test was performed to assess significant variations in species abundance in different seasons. The threat status categorization of the fish species was conducted following IUCN Red List (2023). Moreover, information from a number of members from fish specialist group working closely with the Department of National Parks and Wildlife Conservation, Nepal and IUCN from the region was also taken in preparing the current IUCN Red List threat status (Shrestha 1995; Jha 2006; Allen et al. 2010).

RESULTS

Fish community structure

A total of 8,735 individuals representing 52 fish species belonging to five orders, 12 families, and 35 genera were recorded from Bheri and Babai River systems. Mann-Whitney test revealed significant variation ($p < 0.05$) in the fish assemblages between the two river systems. A total of 32 species belonging to four orders, eight families, and 20 genera were observed in the Bheri river system, whereas 42 fish species belonging to five orders, 12 families, and 31 genera were observed in the Babai River system. In both the river systems, Cypriniformes and Cyprinidae were the dominant order and family, respectively (Table 2; Figure 2). Order Beloniformes with four families, namely Psilorhynchidae, Cobitidae, Bagridae, and Belonidae, were recorded only in the Babai River system.

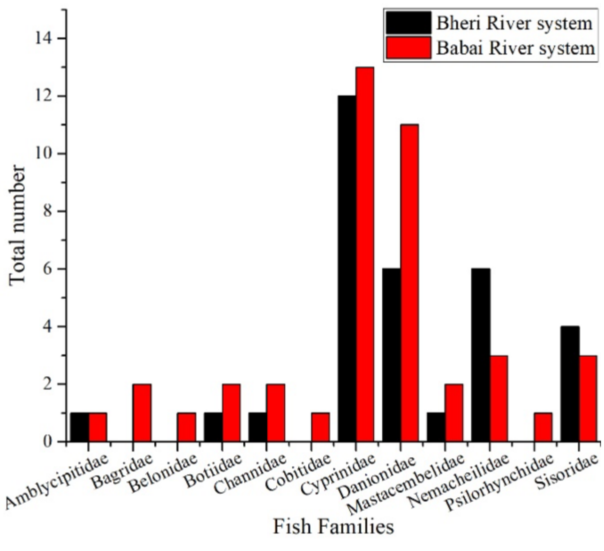

Figure 2. Distribution of fish families recorded in the Bheri and Babai river systems.

In the Bheri river system, order Cypriniformes was represented by four families and 25 species followed by Siluriformes (two families with five species); Perciformes and Synbranchiformes (only one family with one species each). The dominant family, Cyprinidae, contributed 37.5% of the total catch and was represented by 12 species followed by Danionidae and Nemacheilidae (18.8% with six species each), Sisoridae (12.5 % with four species), Amblycipitidae, Botiidae, Channidae, and Mastacembelidae (3.1% with only one species each).

In Babai River system, Cypriniformes was represented by six families and 31 species, followed by, Siluriformes (three families with six species); Synbranchiformes and Perciformes (one family with two species each); and Beloniformes was represented by only one family with one species. The dominant family Cyprinidae contributed 31.0 % of the total catch with 13 species followed by Danionidae (26.2% with 11 species); Nemacheilidae and Sisoridae (7.1% with three species each); Botiidae, Channidae, Mastacembelidae, Sisoridae, and Bagridae (4.8% with two species each); Amblycipitidae, Belonidae, Cobitidae, Erethistidae, and Psilorhynchidae were represented by only one species each (2.4%).

Fish richness, abundance, and diversity

Of the 52 species recorded, 10 species were recorded only from the Bheri system and 20 species were recorded only from the Babai River system; while 22 species were common to both the river systems. Eight species—*Barilius barila*, *Barilius vagra*, *Garra gotyla*, *Puntius sophore*, *Tor putitora*, *Paracanthocobitis botia*, *Schistura beavani*, and *Mastacembelus armatus*—were recorded in all seasons in both river systems. *Cabdio morar*, in the Bheri River and *Systomus sarana*, *Rasbora daniconius*, *Tor tor*, and *Xenentodon cancila* in the Babai River were occasional in occurrence with only a single individual being captured during the present study. The highest number of species was recorded from site BB3 (19 species during autumn) and the lowest number (six species) was recorded from sites BH2 and BBT2 during winter and summer (Figure 4b,d). Ornamental fish species such as *Danio rerio*, *Lepidocephalichthys guntea*, and *Macrognathus pancalus* were observed only from the Babai River system.

In Bheri river system, the fish abundance expressed as CPUE ranged from 7.6 to 96.2 with the average value 46.9 whereas, in the Babai River system it ranged from 11.0 to 242.0 with the average value 63.0 (Table 3) indicating moderate average haul. The most abundant fish species was *Barilius vagra*, followed by *Schistura*

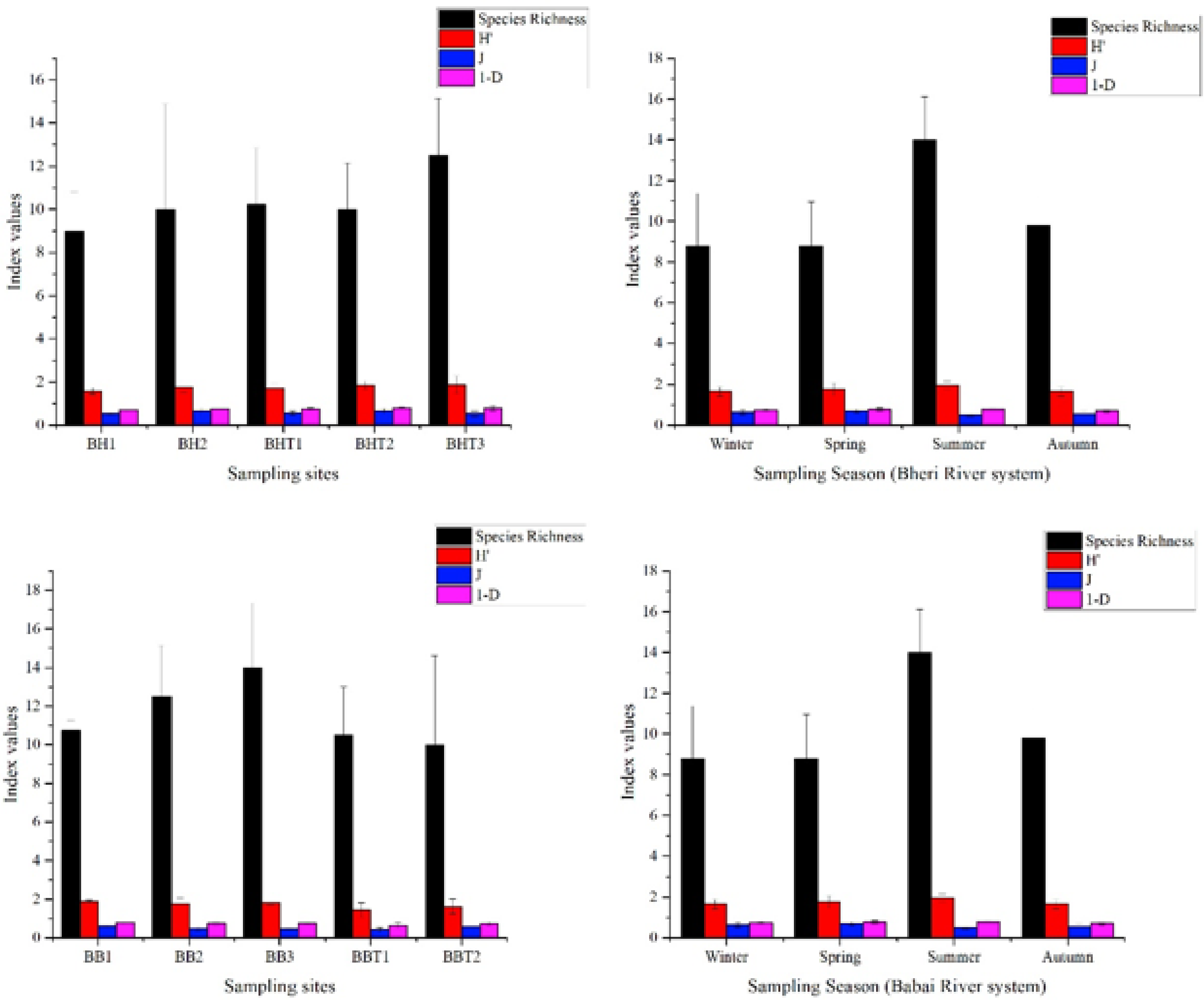

Figure 3. Values of Species Richness, Shannon index (Hˈ), Pielou's evenness (J), and Simpson's index of diversity (1-D) in different sampling sites (3a,c) and seasons (3b,d) in the Bheri and Babai river systems.

beavani in both river systems. The least abundant fish species was *Cabido morar* in Bheri River system (with CPUE of 0.01) whereas, fish species as *Opsarius bendelisis*, *Rasbora daniconius*, *Systomus sarana*, *Tor tor*, and *Xenentodon cancila* (with CPUE of 0.01) were the least abundant in Babai River system.

Seasonal and site-wise ichthyofaunal diversity indices such as Shannon index (Hˈ), Simpson's index of diversity (1-D) and Pielou's Evenness (J) are shown in Figure 3. In Bheri River system, Shannon index (Hˈ) ranged from 1.3 to 2.2 with the mean value 1.7± 0.2 while, Simpson's index of diversity (1-D) ranges from 0.6 to 0.8 with mean value 0.7 ±0.1 and Pielou's evenness (J) ranges from 0.5 to 0.9 with mean value 0.7±0.1. Kruskall Wallis test showed significant variation (H = 7.9, P = 0.04) in Pielou's evenness between seasons in the Bheri system. In the Babai River system, Shannon index (Hˈ) ranged from 0.9 to 2.0 with the mean value 1.7± 0.3 while, Simpson's index of diversity (1-D) ranged from 0.4 to 0.8 with mean value 0.7±0.1 and Pielou's evenness (J) ranged from 0.4 to 0.8 with mean value 0.7±0.1.

Cluster analysis of species composition revealed that fish assemblages of Bheri and Babai River systems had two distinct clusters based on group average method with correlation coefficient distance (Figure 4). The sites BBT1 and BBT2 had more similar faunal assemblages whereas site BH1 does not show any significant similarity with any other site (Figure 4).

IUCN Red List threat status

The threat status category of the observed fish species based on IUCN Red List have been presented in Table 2. Of the 52 species recorded from this study, 43 fish species has been categorized as 'Least

Table 2. Fish taxa recorded from the Bheri and Babai River systems with threat status.

	Order	Family	Fish species	Bheri River	Babai River	IUCN Red List status
1	Beloniformes	Belonidae	*Xenentodon cancila* (Hamilton, 1822)	×	√	LC
2	Cypriniformes	Botiidae	*Botia almorhae* (Gray, 1831)	√	√	LC
3	Cypriniformes	Botiidae	*Botia dario* (Hamilton, 1822)	×	√	LC
4	Cypriniformes	Cobitidae	*Lepidocephalichthys guntea* (Hamilton, 1822)	×	√	LC
5	Cypriniformes	Cyprinidae	*Bangana dero* (Hamilton, 1822)	√	√	LC
6	Cypriniformes	Cyprinidae	*Chagunius chaunio* (Hamilton, 1822)	×	√	LC
7	Cypriniformes	Cyprinidae	*Tariqilabeo latius* (Hamilton, 1822)	√	√	LC
8	Cypriniformes	Cyprinidae	*Garra annandalei* (Hora, 1921)	√	×	LC
9	Cypriniformes	Cyprinidae	*Garra gotyla* (Gray, 1830)	√	√	LC
10	Cypriniformes	Cyprinidae	*Labeo fimbriatus* (Bloch, 1795)	√	×	LC
11	Cypriniformes	Cyprinidae	*Tariqilabeo macmahoni* (Zugmayer, 1912)	√	×	VU
12	Cypriniformes	Cyprinidae	*Neolissochilus hexagonolepis* (McClelland, 1839)	√	√	NT
13	Cypriniformes	Cyprinidae	*Pethia conchonius* (Hamilton, 1822)	×	√	LC
14	Cypriniformes	Cyprinidae	*Pethia ticto* (Hamilton, 1822)	×	√	LC
15	Cypriniformes	Cyprinidae	*Puntius sophore* (Hamilton, 1822)	√	√	LC
16	Cypriniformes	Cyprinidae	*Puntius terio* (Hamilton, 1822)	√	√	LC
17	Cypriniformes	Cyprinidae	*Schismatorhynchos nukta* (Sykes, 1839)	×	√	EN
18	Cypriniformes	Cyprinidae	*Schizothorax progastus* (McClelland, 1839)	√	×	LC
19	Cypriniformes	Cyprinidae	*Schizothorax richardsonii* (Gray, 1832)	√	×	VU
20	Cypriniformes	Cyprinidae	*Systomus sarana* (Hamilton, 1822)	×	√	LC
21	Cypriniformes	Cyprinidae	*Tor putitora* (Hamilton, 1822)	√	√	EN
22	Cypriniformes	Cyprinidae	*Tor tor* (Hamilton, 1822)	×	√	DD
23	Cypriniformes	Danionidae	*Barilius barila* (Hamilton, 1822)	√	√	LC
24	Cypriniformes	Danionidae	*Opsarius bendelisis* (Hamilton, 1807)	√	√	LC
25	Cypriniformes	Danionidae	*Barilius vagra* (Hamilton, 1822)	√	√	LC
26	Cypriniformes	Danionidae	*Cabdio jaya* (Hamilton, 1822)	√	√	LC
27	Cypriniformes	Danionidae	*Cabdio morar* (Hamilton, 1822)	√	√	LC
28	Cypriniformes	Danionidae	*Danio rerio* (Hamilton, 1822)	×	√	LC
29	Cypriniformes	Danionidae	*Devario devario* (Hamilton, 1822)	×	√	LC
30	Cypriniformes	Danionidae	*Esomus danrica* (Hamilton, 1822)	×	√	LC
31	Cypriniformes	Danionidae	*Laubuka laubuca* (Hamilton, 1822)	×	√	LC
32	Cypriniformes	Danionidae	*Opsarius barna* (Hamilton, 1822)	√	√	LC
33	Cypriniformes	Danionidae	*Rasbora daniconius* (Hamilton, 1822)	×	√	LC
34	Cypriniformes	Nemacheilidae	*Paracanthocobitis botia* (Hamilton, 1822)	√	√	LC
35	Cypriniformes	Nemacheilidae	*Physoschistura elongata* (Sen & Nalbant, 1982)	√	×	VU
36	Cypriniformes	Nemacheilidae	*Schistura beavani* (Günther, 1868)	√	√	LC
37	Cypriniformes	Nemacheilidae	*Schistura prashadi* (Hora, 1921)	√	×	VU
38	Cypriniformes	Nemacheilidae	*Schistura rupecula* (McClelland, 1838)	√	√	LC
39	Cypriniformes	Nemacheilidae	*Schistura savona* (Hamilton, 1822)	√	×	LC
40	Cypriniformes	Psilorhynchidae	*Psilorhynchus pseudecheneis* (Menon & Datta, 1964)	×	√	LC
41	Perciformes	Channidae	*Channa gachua* (Hamilton, 1822)	×	√	LC
42	Perciformes	Channidae	*Channa punctata* (Bloch, 1793)	√	√	LC
43	Siluriformes	Amblycipitidae	*Amblyceps mangois* (Hamilton, 1822)	√	√	LC

	Order	Family	Fish species	Bheri River	Babai River	IUCN Red List status
44	Siluriformes	Bagridae	*Mystus tengara* (Hamilton, 1822)	×	√	LC
45	Siluriformes	Bagridae	*Mystus vittatus* (Bloch, 1794)	×	√	LC
46	Siluriformes	Sisoridae	*Erethistes jerdoni* (Day, 1870)	×	√	LC
47	Siluriformes	Sisoridae	*Glyptothorax kashmirensis* (Hora, 1923)	√	×	CR
48	Siluriformes	Sisoridae	*Glyptothorax telchitta* (Hamilton, 1822)	√	√	LC
49	Siluriformes	Sisoridae	*Glyptothorax trilineatus* (Blyth, 1860)	√	√	LC
50	Siluriformes	Sisoridae	*Pseudecheneis sulcata* (McClelland, 1842)	√	×	LC
51	Synbranchiformes	Mastacembelidae	*Macrognathus pancalus* (Hamilton, 1822)	×	√	LC
52	Synbranchiformes	Mastacembelidae	*Mastacembelus armatus* (Lacepède, 1800)	√	√	LC

Note: IUCN Red list categories of fish taxa observed from the Bheri and Babai River systems following (https://www.iucnredlist.org/).

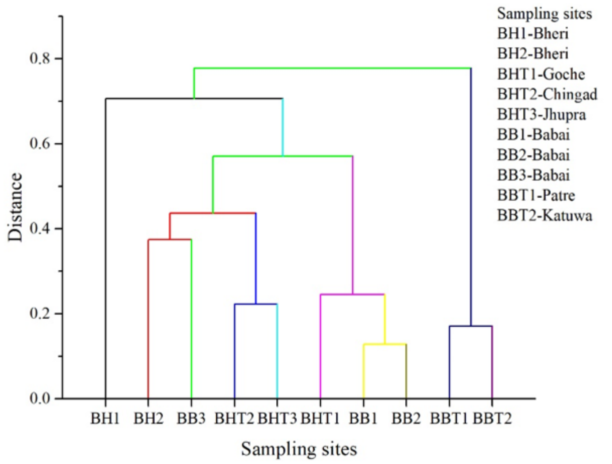

Figure 4. Dendrogram resulting from group average method of fish assemblages from two river systems.

Concerned' and one fish species as 'Data Deficient'. However, two species (*Schismatorhynchos nukta* and *Tor putitora*) have been assigned as 'Endangered', one species (*Neolissochilus hexagonolepis*) as 'Near Threatened', four species (*Tarigilabeo macmahoni*, *Schizothorax richardsonii*, *Physoschistura elongata*, and *Schistura prashadi*) as 'Vulnerable' and one species (*Glyptothorax kashmirensis*) as 'Critically Endangered'.

Physico-chemical parameters

The mean pH, DO, TDS, temperature and conductivity values in the Bheri River system were 8.2 ± 0.5, 9.6 ± 0.9 mgL^{-1}, 159.1 ± 37.0 mgL^{-1}, 21.1 ± 5.2°C, and 295.0 ± 59.7 μScm^{-1}, respectively. In the Babai River system, the mean values of pH, DO, TDS, temperature and conductivity were 8.1 ± 0.4, 8.9 ± 1.6 mgL^{-1}, 198.5 ± 55.3 mgL^{-1},24.5 ± 5.9°C, and 360.7 ± 71.3 μScm^{-1}, respectively. Kruskall Wallis test showed seasonal significant variation in pH, DO and temperature in the Bheri River system ($p < 0.05$); whereas in the Babai River system, significant variation ($p < 0.05$) between seasons was observed only in pH and temperature.

DISCUSSION

Considering more than 220 species reported from Nepalese freshwater ecosystems (Khatri et al. 2020) and presence of 52 (about 23.6%) species in only ten sites indicate a rich fish faunal diversity from the Babai and the Bheri River systems. This is also evident from Pielou's evenness (Figure 3) which ranged from 0.3 (at site BBT1 during winter) to 0.9 (at site BH2 during winter) indicating rich diversity. A previous study by Pandey (2002) reported only 19 species from the Bheri River, whereas the EIA study before the commencement of the dam construction reported 23 species (EIA 2011). Species like *Anguilla bengalensis*, *Labeo angra*, *Bangana dero*, *Psilorhynchus pseudecheneis*, *Bagarius bagairus*, *Clupisoma garua*, *Heteropneustes fossilis*, and *Myersglanis blythii*, reported from Bheri River during EIA (2011) were not observed during our study in Bheri River system. Singh (2002) and G.C & Limbu (2019) reported 39 species and 29 species from the Babai River, respectively, whereas the EIA study conducted in 2011 had reported only 20 fish species from Babai River. Fish species such as *Anguilla bengalensis*, *Amblypharyngodon mola*, *Garra annandalei*, *Bangana dero*, *Labeo dyocheilus*, *Channa striatus*, *Ailia colia*, *Bagarius bagairus*, *Chaca chaca*, and *Wallago attu* reported from Babai River during EIA (2011) were not observed during our study. This difference in the enumeration of the fish species richness could be probably attributed to a range of factors including differences in sampling frequencies, the sampling gears

Table 3. Catch per unit effort values at the Bheri and Babai rivers and their tributaries.

Species	BH1	BH2	BHT1	BHT2	BHT3	Average	BB1	BB2	BB3	BBT1	BBT2	Average	Average total
Xenontodon cancila	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.06	0.00	0.00	**0.01**	0.01
Botia almorhae	0.46	0.00	0.00	0.00	0.00	**0.09**	0.19	0.19	0.00	0.00	0.00	**0.08**	0.08
Botia dario	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.13	0.00	0.00	0.00	**0.03**	0.01
Lepidocephalichthys guntea	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	2.16	25.63	15.88	**8.73**	4.37
Cobdio jaya	0.00	0.00	0.00	0.00	1.25	**0.25**	0.00	0.00	0.00	0.00	0.69	**0.14**	0.19
Bangana dero	0.44	0.56	0.57	0.31	0.00	**0.38**	0.13	1.56	0.13	0.00	0.00	**0.36**	0.37
Barilius barila	1.71	0.38	10.82	1.38	5.75	**4.01**	5.03	8.44	0.19	0.00	0.63	**2.86**	3.43
Opsarius bendelisis	0.00	0.06	0.06	0.00	1.19	**0.26**	0.00	0.00	0.06	0.00	0.00	**0.01**	0.14
Barilius vagra	2.01	1.31	12.09	12.19	16.50	**8.82**	0.69	1.56	4.65	44.13	15.44	**13.29**	11.06
Cabdio morar	0.00	0.06	0.00	0.00	0.00	**0.01**	0.25	0.00	0.00	0.00	0.00	**0.05**	0.03
Chagunius chaunio	0.00	0.00	0.00	0.00	0.00	**0.00**	0.92	0.88	0.00	0.00	0.00	**0.36**	0.18
Tariqilabeo latius	5.29	4.81	0.13	2.25	1.31	**2.76**	0.00	0.19	0.00	0.00	0.00	**0.04**	1.40
Danio rerio	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	1.06	8.00	**1.81**	0.91
Devario devario	0.00	0.00	0.00	0.00	0.00	**0.00**	0.13	0.25	0.00	0.63	0.00	**0.20**	0.10
Esomus danrica	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	1.06	0.00	**0.21**	0.11
Garra annandalei	0.00	0.25	0.00	0.00	0.00	**0.05**	0.00	0.00	0.00	0.00	0.00	**0.00**	0.03
Garra gotyla	1.49	0.56	14.84	3.19	13.50	**6.72**	2.87	11.56	1.49	0.00	0.06	**3.20**	4.96
Labeo fimbriatus	0.00	0.00	0.00	0.00	1.56	**0.31**	0.00	0.00	0.00	0.00	0.00	**0.00**	0.16
Tariqilabeo macmahoni	0.00	0.00	0.00	0.00	0.19	**0.04**	0.00	0.00	0.00	0.00	0.00	**0.00**	0.02
Laubuka laubuca	0.00	0.00	0.00	0.00	0.00	**0.00**	0.19	0.00	0.00	0.00	0.00	**0.04**	0.02
Neolissochilus hexagonolepis	0.00	0.19	0.06	0.13	2.63	**0.60**	0.56	0.00	0.00	0.00	0.00	**0.11**	0.36
Opsarius barna	0.00	0.25	0.00	0.00	0.00	**0.05**	0.06	0.06	0.25	0.00	0.00	**0.08**	0.06
Pethia conchonius	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	1.69	4.69	3.94	**2.06**	1.03
Pethia ticto	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00	0.38	**0.08**	0.04
Puntius sophore	0.19	0.06	3.66	2.13	0.69	**1.34**	1.25	0.75	1.25	30.00	5.38	**7.73**	4.53
Puntius terio	0.00	0.00	0.00	0.41	0.00	**0.08**	0.00	0.00	0.00	0.56	2.50	**0.61**	0.35
Rasbora daniconius	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.06	0.00	0.00	0.00	**0.01**	0.01
Schismatorhynchos nukta	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.13	0.00	0.00	**0.03**	0.01
Schizothorax progastus	0.69	0.19	0.00	0.00	0.00	**0.18**	0.00	0.00	0.00	0.00	0.00	**0.00**	0.09
Schizothorax richardsonii	2.96	0.33	0.00	1.75	0.25	**1.06**	0.00	0.00	0.00	0.00	0.00	**0.00**	0.53
Systomus sarana	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.06	0.00	0.00	**0.01**	0.01
Tor putitora	0.06	0.00	3.37	1.00	0.50	**0.99**	1.03	0.81	0.00	0.00	0.00	**0.37**	0.68
Tor tor	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.06	0.00	0.00	0.00	**0.01**	0.01
Paracanthocobitis botia	0.00	1.81	4.99	8.94	3.25	**3.80**	0.06	0.19	11.27	1.94	1.13	**2.92**	3.36
Physoschistura elongata	0.00	1.00	0.00	0.00	0.69	**0.34**	0.00	0.00	0.00	0.00	0.00	**0.00**	0.17
Schistura beavani	2.95	5.00	2.65	6.75	16.94	**6.86**	2.34	8.50	25.38	15.75	0.19	**10.43**	8.64
Schistura prashadi	0.88	0.00	0.00	0.00	0.00	**0.18**	0.00	0.00	0.00	0.00	0.00	**0.00**	0.09
Schistura rupecula	2.65	3.38	0.00	0.00	1.13	**1.43**	0.13	2.63	1.38	0.00	0.25	**0.88**	1.15
Schistura savona	6.74	0.00	0.00	0.00	0.00	**1.35**	0.00	0.00	0.00	0.00	0.00	**0.00**	0.67

Species	BH1	BH2	BHT1	BHT2	BHT3	Average	BB1	BB2	BB3	BBT1	BBT2	Average	Average total
Psilorhynchus pseudecheneis	0.00	0.00	0.00	0.00	0.00	**0.00**	0.19	0.75	0.19	0.00	0.00	**0.23**	0.11
Channa gachua	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.69	4.00	3.63	**1.66**	0.83
Channa punctata	0.00	0.00	0.44	0.00	0.06	**0.10**	0.25	0.00	0.56	1.56	1.38	**0.75**	0.43
Amblyceps mangois	0.00	0.00	0.93	0.00	0.19	**0.22**	0.00	0.00	6.06	0.38	0.38	**1.36**	0.79
Mystus tengara	0.00	0.00	0.00	0.00	0.00	**0.00**	0.13	0.00	0.06	0.25	0.00	**0.09**	0.04
Mystus vittatus	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	1.19	0.00	0.00	**0.24**	0.12
Erethistes jerdoni	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.06	0.13	0.00	0.00	**0.04**	0.02
Glyptothorax kashmirensis	0.00	0.00	0.00	0.00	0.81	**0.16**	0.00	0.00	0.00	0.00	0.00	**0.00**	0.08
Glyptothorax telchitta	0.69	0.88	0.47	6.00	3.31	**2.27**	0.25	0.44	0.00	0.00	0.00	**0.14**	1.20
Glyptothorax trilineatus	0.65	0.50	0.00	0.00	0.00	**0.23**	0.56	0.94	0.00	0.06	0.00	**0.31**	0.27
Pseudecheneis sulcata	0.95	0.56	0.00	0.69	1.00	**0.64**	0.00	0.00	0.00	0.00	0.00	**0.00**	0.32
Marcognathus pancalus	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	1.06	0.00	0.00	**0.21**	0.11
Mastacembelus armatus	0.00	0.58	3.56	1.00	1.75	**1.38**	0.80	1.69	3.19	0.25	0.44	**1.27**	1.33
Total	**30.81**	**22.72**	**58.62**	**48.09**	**74.44**	**46.94**	**17.97**	**41.69**	**63.27**	**131.94**	**60.25**	**63.02**	54.98

used during surveys. Most fish diversity assessments in Nepal are one-time studies and often rely on locals' knowledge and anecdotes (Khatri et al. 2020). Fish assemblages show seasonal variations too, and thus one-time studies often fail to capture the overall assemblages (Jha et al. 2018; Prasad et al. 2020). Moreover, fish species such as *Anguilla bengalensis*, *Clupisoma garua*, *Bagarius yarrelli*, *Labeo pangusia*, *Wallago attu*, and *Ailia colia* which are listed in the IUCN Red List and reported from both river systems (ADB 2018), were not observed in this study. However, these species in Babai River were reported earlier by Shrestha (1999) and EIA (2011) in Bheri River. Species like *Anguilla bengalensis* is a noted catadromous fish (Arai & Chino 2012; Baumgartner & Wibowo 2018) requiring movements from freshwater regimes to oceanic waters for spawning. *Tor putitora* is another migratory species (Pinder et al. 2019) that often takes refuge in upstream river reaches and tributaries. In contrast, species like *Bangana dero*, *Barilius vagra*, *Neolissochilus hexagonolepis*, *Schizothorax progastus*, *S. richardsonii*, *Labeo fimbriatus*, and *Tariqilabeo macmahoni* observed in the Bheri River system are short migratory fishes. Many studies in Nepal and elsewhere have revealed that migratory fish are especially affected when longitudinal connections in rivers are disrupted due to dam construction (Bhatt et al. 2017; ADB 2018; Reid et al. 2019; Barbarossa et al. 2020; Yadav et al. 2020). The Babai Dam Weir cum Bridge at Parewa Odar - located about 40 km downstream of the proposed water release Bardiya National Park, was constructed in 1993 (ADB 2018; GoN/BIP 2001) to supply water for irrigation. The construction and operation of this dam may have disrupted the subsequent migration of these species in upstream reaches of the river.

Our finding regarding Cyprinidae being the most dominant fish family is in accordance with many previous studies from a large number of freshwaters from Nepal (Sharma 2008; Shrestha 2008; Rajbanshi 2012; Khatri et al. 2020). Cyprinidae is considered a rich taxon and is known to contain as many as 1,270 species; and it is one of the most abundant freshwater fish taxa in Asia (Berra 2007; Levêque et al. 2007).

Although several fish species were common to both the river systems, some taxa were exclusively found either in the glacial-fed Bheri River or the rain-fed Babai River system. Taxa like *Schizothorax progastus* and *S. richardsonii* were observed only in Bheri River, whereas taxa like *Xenentodon cancila*, *Danio rerio*, and *Lepidocephalichthys guntea* were observed only in Babai River system. Pathak et al. (2014) and Rajbanshi (2002) have also reported these taxa in glacial-fed and rain-fed rivers of Nepal. *Schizothorax* spp. live typically in cold and fast flowing waters in the Himalayan and sub-Himalayan regions of the Indian subcontinent and are distributed from Afghanistan to Myanmar, including Nepal; central Asia, Kazakhstan and China (Petr & Swar

2002; Sarkar et al. 2012; Khan et al. 2020). In contrast, species like *Barilius* spp., *Puntius* spp., *Tor* spp., *Labeo* spp., *Neolissochilus hexagonolepis*, and *Clarias* spp. are common in cool to warm water regimes (Bhagat 2002; Sharma 2008; Gurung et al. 2016). *Garra gotyla* - a common cyprinid fish has been frequently reported in the lower basin of South Asian rivers (Rayamajhi & Jha 2010), was also observed in both the river systems. *Barilius vagra* is also a common species, particularly in the pools (Singh & Agarwal 2013), and it showed higher abundance in the Babai River.

Ornamental fish species such as *Danio rerio*, *Lepidocephalichthys guntea*, and *Macrognathus pancalus* were observed only in sites BB3, BBT1 and BBT2 characterized by slow and shallow water of the Babai River system. These species are known to be found in a range of habitats such as slow and shallow water of rivers, floodplains, ponds, swamps, ditches, typically in open locations with relatively clear water and abundant vegetation at the margins as well as estuaries (Spence et al. 2006; Suresh et al. 2006; Havird & Page 2010; Gupta 2016). Interestingly, cluster analysis of present study indicated presence of similar fish assemblages in sites BBT1 and BBT2. However, this was expected because these sites were located in the Dang Valley with similar ecological regimes. Similar ecological regimes have been known to support similar biological assemblages too (Granados-Dieseldorff et al. 2012). In contrast, sites BB1 and BB2 from the main Babai River were located in Surkhet Valley and these sites were characterized by higher discharge and rocky substrates. In contrast, sites BH1, BH2, and BHT2 from Bheri River system were characterized by higher discharge, higher depth with a cooler temperature and the dominant substrates in these sites were rock and boulder. These sites form a separate cluster from BBT2 and BBT2.

Fish abundance varied between different seasons in the Bheri and the Babai River systems. The highest fish abundance in the Bheri River system was observed during summer, whereas in the Babai River system, the highest abundance was observed during autumn. Many studies in Nepal (Jha et al. 2007, 2018) and elsewhere (Galib et al. 2016; Park et al. 2020) have reported seasonal variation in fish assemblages in different rivers. Seasons induce change in different environmental regimes of the lotic systems such as discharge, temperature, dissolved oxygen, and availability of food (Dowling & Wiley 1986; Winemiller & Jepsen 1998). The Babai River and its tributaries being rain-fed are characterized by relatively higher temperature (24.5±5.9°C) low flow particularly during winter and spring, whereas during the autumn, the flow and discharge are increased. In contrast, Bheri River being a glacial-fed river is characterized by a low temperature (21.1±5.2°C). Differences in temperature regimes along with differences in flow and food availability during different seasons probably explain the differences in fish abundance in different seasons in the Bheri and the Babai River systems.

Presence of single occurrence of some species like *Cabdio morar*, *Systomus sarana*, *Tor tor*, and *Xenentodon cancila* but their abundant occurrence in earlier studies (Shrestha 1999) suggest that their natural populations are declining mainly attributed to anthropogenically induced stressors (Hossain et al. 2009; Islam & Dutta 2018; Pinder et al. 2019; Barman et al. 2021). Relatively lower CPUE values of 46.9 ± 24.1 and 63.0 ± 51.8 in the Bheri and the Babai River systems respectively also suggests moderate average haul indicating decline in natural fish populations compared to higher CPUE values reported by Jha et al. (2006) in several rivers in Nepal. For instance, CPUE values 71.9, 96.1 and 110.2 were observed in Aandhikhola, Arungkhola, and Karrakhola (Jha et al. 2006).

Tor tor though considered to have a wide distribution (Lal et al. 2013) is being reported to be affected by dams (Sharma 2003). In central India, the species is now restricted in certain pockets of protected areas in Narmada, Tapti, Betwa, and Chambal rivers (Johnson et al. 2012). In this study also, this species was observed only from BB2 which is located inside a protected area—Bardiya National Park.

Although majority of the fish species (43 species out of 52) observed in the study belong to Least Concern category of IUCN Red List, some species belong to Vulnerable and Endangered categories (Table 2) which need active conservation measures. *Tor putitora* (Golden Mahseer) listed as an Endangered species is a large sized migratory fish is an inexpensive but high-quality protein source (WHO 2003; Tacon & Metian 2013; Johnson et al. 2021). This species is also a popular game fish for anglers across India, Pakistan, Bangladesh and Nepal. *Tor tor* (*Tor* mahseer) which was categorized as Data Deficient also needs some attention because studies have showed their decline over the years (Sharma 2003). *Schizothorax richardsonii* Snow Trout categorized as Vulnerable is also one of the highly valued freshwater fish from the Himalayan and trans-Himalayan rivers of India, Bhutan, Nepal, Pakistan, and Afghanistan and constitutes as a principal subsistence food fishery in the different parts of Nepal particularly in the mountainous regions (Peter

& Swar 2002). This study has highlighted the population decline of many species due to various forms of human impacts such as high fishing pressure, loss of habitats resulting from river damming which affect breeding cycle, migration of fish species; natural disasters, pollutions, which requires the need of monitoring and conservation.

CONCLUSION

This study assessed the fish diversity, distribution and selected physico-chemical parameters of Bheri and Babai River systems and in different seasons. A total of 52 species were recorded from the two river systems indicating a rich fish diversity. Moreover, the glacial-fed Bheri River system was found to harbor cold-water taxa, whereas the rain-fed warmer Babai River had warm water taxa only. The difference in the fish community structure and abundance between the two river systems reflects differences in different ecological regimes associated with environmental variables. The average CPUE values in both the river systems reflects a moderate average haul and is indicative of some disturbances in these rivers and their tributaries. Some widely distributed species such as *Barilius vagra, Schistura beavani, Garra gotyla, Puntius sophore, Barilius barila,* and *Paracanthocobitis botia* are abundant corresponding to the previous studies. Observation of some species such as *Opsarius barna, Tor* spp, *Schistura prashadi, Hara jerdoni,* and *Glyptothorax kashmirensis* in small numbers and the fact that out of 52 species observed, eight species belong to IUCN Near Threatened, Vulnerable and Endangered categories indicate the need of an active measure of conservation. Failure to capture long migratory species like *Anguilla bengalensis*, reported in earlier studies, suggest that the migratory route of such species may already have been affected. There is an urgent need for robust surveys on the abundance, distribution and ecological requirements over the natural range of this species. The findings of this research provide baseline information on the fish diversity of the Bheri and Babai River systems. The data obtained could contribute to Fish Specialist Groups to evaluate IUCN Red List, as well as could help in assessing the overall impacts of water transfer in the Bheri and Babai Rivers.

REFERENCES

ADB (2018). *Impact of Dams on Fish in the Rivers of Nepal*. 6 ADB Avenue, Mandaluyong City, 1550 Metro Manila, Philippines, x+94pp. https://doi.org/10.22617/TCS189802

Allen, D.J., S. Molur & B.A. Daniel (2010). *The Status and Distribution of Freshwater Biodiversity in the Eastern Himalaya*. IUCN, Cambridge, UK and Zoo Outreach Organization, Coimbatore, India, vii+88 pp.

Arai, T. & N. Chino (2012). Diverse migration strategy between freshwater and seawater habitats in the freshwater eel genus Anguilla. *Journal of Fish Biology* 81(2): 442–455. https://doi.org/10.1111/j.1095-8649.2012.03353.x

Barbarossa, V., R.J. Schmitt, M.A.J. Huijbregts, C. Zarfl, H. King & A.M. Schipper (2020). Impacts of current and future large dams on the geographic range connectivity of freshwater fish worldwide. *Proceedings of the National Academy of Sciences USA* 117(7): 3648–3655. https://doi.org/10.1073/pnas.1912776117

Barman, S.K., M. Kunda, S.K. Mazumder, M. Nahiduzzaman, P.P. Barman & S.K. Das (2021). Fish-diversity in the Kura River of Bangladesh: Patterns and threats. *Malaysian Applied Biology* 50(3): 1–14. https://doi.org/10.55230/mabjournal.v50i3.2208

Baumgartner, L.J. & A. Wibowo (2018). Addressing fish-passage issues at hydropower and irrigation infrastructure projects in Indonesia. *Marine and Freshwater Research* 69(12): 1805–1813. https://doi.org/10.1071/MF18088

Berra, T.M. (2007). *Freshwater Fish Distribution*. The University of Chicago Press, USA, 606 pp.

Bhagat, R.P. (2002). A check-list of Fishes of Nepal. *Medha* 2(102–113): 102.

Bhatt, J.P., S. Tiwari & M.K. Pandit (2017). Environmental impact assessment of river valley projects in upper Teesta basin of Eastern Himalaya with special reference to fish conservation: a review. *Impact Assessment and Project Appraisal* 35(4): 340–350. https://doi.org/10.1080/14615517.2017.1354642

Bohada-Murillo, M., G.J. Castaño-Villa & F.E. Fontúrbel (2021). Effects of dams on vertebrate diversity: a global analysis. *Diversity* 13(11): 528. https://doi.org/10.3390/d13110528

Caso, C. & M.A. Gil (1988). The Gini-Simpson index of diversity: estimation in the stratified sampling. *Communications in Statistics-Theory and Methods* 17(9): 2981–2995. https://doi.org/10.1080/03610928808829784

Chaturvedi, M.C. (2012). *Ganga-Brahmaputra-Meghna waters: advances in development and management*. CRC Press, Boca Raton, London, New York, 407 pp.

Daga, V.S., V.M. Azevedo-Santos, F.M. Pelicice, P.M. Fearnside, G. Perbiche-Neves,L.R. Paschoal, D.C. Cavallari, J. Erickson, A. Ruocco & I. Oliveira (2020). Water diversion in Brazil threatens biodiversity. *Ambio* 49(1): 165–172. https://doi.org/10.1080/03610928808829784

Davies, B.R., M. Thoms & M. Meador (1992). An assessment of the ecological impacts of inter-basin water transfers, and their threats to river basin integrity and conservation. *Aquatic Conservation: Marine and Freshwater Ecosystems* 2(4): 325–349. https://doi.org/10.1002/aqc.3270020404

De Silva, S.S., N.W. Abery & T.T. Nguyen (2007). Endemic freshwater finfish of Asia: distribution and conservation status. *Diversity and Distributions* 13(2): 172–184. https://doi.org/10.1111/j.1472-4642.2006.00311.x

Dowling, D.C. & M.J. Wiley (1986). The effects of dissolved oxygen, temperature, and low stream flow on fishes: a literature review. Ilinois Natural History Survey Technical Reports. Aquatic Biology Section, 66 pp.

Dudgeon, D., A.H. Arthington, M.O. Gessner, Z.I. Kawabata, D.J. Knowler, C. Lévêque,R.J. Naiman, A.H. Prieur-Richard, D. Soto & M.L. Stiassny (2006). Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological reviews* 81(2): 163–182. https://doi.org/10.1017/S1464793105006950

EIA (2011). Environmental Impact Assessment (EIA) study of Bheri Babai Diversion Multipurpose Project Component 'B' Hydropower, 361 pp.

Eldho, P.S. & M.K. Sajeevan (2022). Freshwater fishes of the Chimmony Wildlife Sanctuary, Western Ghats, India. *Journal of Threatened Taxa* 14(6): 21190–21198. https://doi.org/10.11609/jott.7687.14.6.21190-21198

Fricke, R., W.N. Eschmeyer & R. Van der Laan (eds)(2023). Catalog of fishes: Genera, Species, References. California Academy of Sciences, San Francisco, CA, USA. Available online at http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp. Accessed on 4 May 2023.

Galib, S.M., M.A. Rashid, N. Chaki, A. Mohsin & M.A.R Joadder (2016). Seasonal variation and community structure of fishes in the Mahananda River with special reference to conservation issues. *Journal of Fisheries* 4(1): 325–334. https://doi.org/10.17017/jfish.v4i1.2016.139

G.C, P. & J.H. Limbu (2019). Spatio-temporal variation of fish assemblages in Babai River of Dang district, Province No. 5, Nepal. *Our Nature* 17(1): 19–30. https://doi.org/10.3126/on.v17i1.33988

GoN (2014). *Nepal fifth national report to Convention on Biological Diversity*. Government of Nepal Ministry of Forests and Soil Conservation Singha Durbar, Kathmandu, Nepal, 66 pp.

GoN (2019). *Irrigation Master Plan 2019*. Government of Nepal, Department of Water Resources and Irrigation Ministry of Energy, Water Resources, and Irrigation Singha Durbar, Kathmandu, Nepal, 106 pp.

GoN/BBDMP (2018). Government of Nepal. Babai Bheri Diversion Multipurpose Project. http://www.bbdmp.gov.np. Accessed on 22 January 2018.

GoN/BIP (2001). Government of Nepal. Babai Irrigation Project. http://www.babaiip.gov.np. Accessed on 22 April 2021.

Granados-Dieseldorff, P., M.F. Christensen & P.H. Kihn-Pineda (2012). Fishes from Lachuá lake, upper Usumacinta basin, guatemala. *Check List* 8(1): 095–101. https://doi.org/10.15560/8.1.095

Gupta, S. (2016). Feeding and reproductive biology of *Macrognathus pancalus* (Hamilton, 1822), an indigenous fish species of Indian subcontinent: A Review. *International Journal of Research in Fisheries and Aquaculture* 6(1): 8–12.

Gurung, P. & L. Bharati (2012). Downstream impacts of the Melamchi Inter-Basin Water Transfer Plan (MIWTP) under current and future climate change projections. *Hydro Nepal: Journal of Water, Energy and Environment* Special issue 23–29. https://doi.org/10.3126/hn.v11i1.7199

Gurung, T.B. (2016). Role of inland fishery and aquaculture for food and nutrition security in Nepal. *Agriculture & Food Security* 5(1): 1–9. https://doi.org/10.1186/s40066-016-0063-7

Gurung, T.B., A. Gurung & T.M. Doody (2016). Connecting flows, fish diversity and ecology in the Koshi Basin. In T. Doody, S. Cuddy, & L. Bhatta (Eds.), *Connecting flow and ecology in Nepal: current state of knowledge for the Koshi Basin*. Sustainable Development Investment Portfolio (SDIP) project. CSIRO, Australia, 174 pp.

Havird, J.C. & L.M. Page (2010). A revision of *Lepidocephalichthys* (Teleostei: Cobitidae) with descriptions of two new species from Thailand, Laos, Vietnam, and Myanmar. *Copeia* 2010(1): 137–159. https://doi.org/10.1643/CI-08-240

Hossain, M.Y., J. Ohtomi & Z.F. Ahmed (2009). Morphometric, meristic characteristics and conservation of the threatened fish, *Puntius sarana* (Hamilton, 1822)(Cyprinidae) in the Ganges River, northwestern Bangladesh. *Turkish Journal of Fisheries and Aquatic Sciences* 9(2): 223–225. https://doi.org/10.4194/trjfas.2009.0215

WWF (2021). *The World's Forgotten Fishes*. WWF International, Gland, Switzerland, 48 pp.

Islam, M.S. & P. Dutta (2018). Food, feeding habit and reproductive biology of freshwater garfish (*Xenentodon cancila*) from south-western Bangladesh: Implications to fishery management. *Journal of Fisheries and Life Sciences* 3(2): 26–33.

Jain, A.K., M.N. Murty & P.J. Flynn (1999). Data clustering: a review. *Association for computing Machinery* 31(3): 264–323. https://doi.org/10.1145/331499.331504

Jayaram, K.C. (2010). *The Freshwater Fishes of the Indian Region*. Second Edition.Narendra Publishing House, Delhi, 616 pp.

Jha, B.R. (2006). Fish ecological studies and its application in assessing ecological integrity of rivers in Nepal. PhD Thesis. Department of Biological Sciences and Environmental Science Kathmandu University Dhulikhel, Nepal, 301 pp.

Jha, B.R., H. Waidbacher, S. Sharma & S. Michael (2006). Fish species composition, number and abundance in different rivers and seasons in Nepal and the reevaluation of their threat category for effective conservation and management. *Ecology Environment & Conservation* 12(1): 25–36.

Jha, B.R., H. Waidbacher, S. Sharma & M. Straif (2007). Fish base study of the impacts of dams in different rivers of Nepal and its seasonal variations. *Ultra Science* 18(1): 27–44.

Jha, B.R., S. Gurung, K. Khatri, A. Gurung, A. Thapa, K. Mamta, B. Gurung & S. Acharya (2018). Patterns of diversity and conservation status of freshwater fishes in the glacial fed and rain fed rivers of Eastern Nepal. *Environmental Biology of Fishes* 101(8): 1295–1305. https://doi.org/10.1007/s10641-018-0776-5

Johnson, J., R. Parmar, K. Ramesh, S. Sen & R.S. Murthy (2012). Fish diversity and assemblage structure in Ken River of Panna landscape, central India. *Journal of Threatened Taxa* 3161–3172. https://doi.org/10.11609/JoTT.o3024.3161-72

Johnson, J.A., B. Dhawan & S. Kuppusamy (2021). Study on ecology and migratory patterns of golden mahseer (*Tor putitora*) in river Ganga using Radio telemetry techniques. Wildlife Institute of India, 47 pp.

Khadka, R.B. & A.B. Khanal (2008). Environmental management plan (EMP) for Melamchi water supply project, Nepal. *Environmental Monitoring and Assessment* 146: 225–234. https://doi.org/10.1007/s10661-007-0074-8

Khan, M.R., B.A. Rakha & M.S. Ansari (2020). Diversity and Distribution of Genera Schizothorax and Schizothorichthyes in River Swat, Pakistan. *Pakistan Journal of Zoology* 52(6): 2419–2421. https://doi.org/10.17582/journal.pjz/20180904060941

Khatri, K., B.R. Jha, S. Gurung & U.R. Khadka (2020). Freshwater fish diversity and its conservation status in different water bodies of Nepal. *Nepal Journal of Environmental Science* 8: 39–52. https://doi.org/10.3126/njes.v8i1.34442

Lal, K., R. Singh, A. Pandey, B. Gupta, V. Mohindra, P. Punia, S. Dhawan, J. Verma, L. Tyagi & P. Khare (2013). Distributional records of *Tor mahseer*, *Tor tor* (Hamilton, 1822) from Southern India. *Journal of Applied Ichthyology* 29(5): 1086–1090. https://doi.org/10.1111/jai.12017

Levêque, C., T. Oberdorff, D. Paugy, M. Stiassny & P.A. Tedesco (2007). Global diversity of fish (Pisces) in freshwater. In: Balian, E.V., C. Lévêque, H. Segers & K. Martens (Eds.), *Freshwater Animal Diversity Assessment*. Developments in Hydrobiology 198: 545-567. https://doi.org/10.1007/978-1-4020-8259-7_53

Lynch, A.J., S.J. Cooke, A.M. Deines, S.D. Bower, D.B. Bunnell, I.G. Cowx, V.M. Nguyen, J. Nohner, K. Phouthavong & B. Riley (2016). The social, economic, and environmental importance of inland fish and fisheries. *Environmental Reviews* 24(2): 115–121. https://doi.org/10.1139/er-2015-0064

McAllister, D.E., J.F. Craig, N. Davidson, S. Delany & M. Seddon (2001). Biodiversity impacts of large dams. IUCN / UNEP / WCD, 68 pp.

Mishra, Y., T. Nakamura, M.S. Babel, S. Ninsawat & S. Ochi (2018). Impact of Climate Change on Water Resources of the Bheri River Basin, Nepal. *Water* 10(2): 220. https://doi.org/10.3390/w10020220

Mishra, Y., Babel, M. S., Nakamura, T., & Mishra, B. (2021). Impacts of Climate Change on Irrigation Water Management in the Babai River Basin, Nepal. *Hydrology* 8(2): 85. https://doi.org/10.3390/hydrology8020085

Nelson, J.S., T.C. Grande & M.V. Wilson (2016). *Fishes of the World*.

John Wiley & Sons, Inc., Hoboken, New Jersey, 707 pp.

Öztürk, M., V. Altay & R. Efe (2021). *Biodiversity, conservation and sustainability in Asia: Prospects and challenges in West Asia and Caucasu*. Springer Cham, 655 pp.

Pandey, C.B. (2002). A study on the effect of Physico-chemical parameters on the Fish Fauna in the Bheri River. MSc Thesis. Department of Zoology, Tribhuvan University, Nepal, viii+98 pp.

Park, J.M., R. Riedel, H.H. Ju & H.C. Choi (2020). Fish Assemblage Structure Comparison between Freshwater and Estuarine Habitats in the Lower Nakdong River, South Korea. *Journal of Marine Science and Engineering* 8(7): 496. https://doi.org/10.3390/jmse8070496

Pathak, A.K., U.K. Sarkar & S.P. Singh (2014). Spatial gradients in freshwater fish diversity, abundance and current pattern in the Himalayan region of Upper Ganges Basin, India. *Biodiversitas Journal of Biological Diversity* 15(2): 186–194. https://doi.org/10.13057/biodiv/d150210

Petr, T. & D.B. Swar (2002). *Cold Water Fisheries in the Trans-Himalayan Countries*. Food & Agriculture Organisation of the United Nations Rome, 352 pp.

Pielou, E.C. (1966). The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology* 13: 131–144. https://doi.org/10.1016/0022-5193(66)90013-0

Pinder, A.C., J.R. Britton, A.J. Harrison, P. Nautiyal, S.D. Bower, S.J. Cooke, S. Lockett, M. Everard, U. Katwate & K. Ranjeet (2019). Mahseer (*Tor* spp.) fishes of the world: status, challenges and opportunities for conservation. *Reviews in Fish Biology and Fisheries* 29(2): 417–452. https://doi.org/10.1007/s11160-019-09566-y

Pittock, J., J.H. Meng & A.K. Chapagain (2009). *Interbasin Water Transfers and Water Scarcity in a Changing World: a solution or a pipedream?* World Wildlife Fund, Germany, 61 pp.

Prasad, A., A. Shrestha, J.H. Limbu & D. Swar (2020). Spatial and temporal variation of fish assemblages in Seti Gandaki River, Tanahu, Nepal. *Borneo Journal of Resource Science and Technology* 10(2): 93–104. https://doi.org/10.33736/bjrst.2048.2020

Quan, Y., C. Wang, Y. Yan, G. Wu & H. Zhang (2016). Impact of inter-basin water transfer projects on regional ecological security from a telecoupling perspective. *Sustainability* 8(2): 162. https://doi.org/10.3390/su8020162

Rajbanshi, K.G. (2002). Zoo-geographical distribution and the status of coldwater fish of Nepal. In T.D. Peter & D.B. Swar (Eds.), *Cold water fishes of Trans-Himalayan countries. F.A.O. Fisheries Technical Paper*. No.431 (pp. 221–246).

Rajbanshi, K.G. (2012). *Biodiversity and distribution of freshwater fishes of Central/Nepal Himalayan Region*. Nepal Fisheries Society (NEFIS), Balaju, Machhapokhari, Kathmandu, Nepal, 136 pp.

Rayamajhi, A. & B.R. Jha (2010). Garra gotyla (errata version published in 2018). The IUCN Red List of Threatened Species, 2010, e.T166526A135871930. https://doi.org/10.2305/IUCN.UK.2010-4.RLTS.T166526A6228736.en

Reid, A.J., A.K. Carlson, I.F. Creed, E.J. Eliason, P.A. Gell, P.T.J. Johnson, K.A. Kidd, T.J. MacCormack, J.D. Olden, S.J. Ormerod, J.P. Smol, W.W. Taylor, K. Tockner, J.C. Vermaire, D. Dudgeon & S.J. Cooke (2019). Emerging threats and persistent conservation challenges for freshwater biodiversity. *Biological Reviews Cambridge Philosophical Society* 94(3): 849–873. https://doi.org/10.1111/brv.12480

Sarkar, U.K., A.K. Pathak, R.K. Sinha, K. Sivakumar, A.K. Pandian, A. Pandey, V.K. Dubey & W.S. Lakra (2012). Freshwater fish biodiversity in the River Ganga (India): changing pattern, threats and conservation perspectives. *Reviews in Fish Biology and Fisheries* 22(1): 251–272. https://doi.org/10.1007/s11160-011-9218-6

Saund, T.B. & J. Shrestha (2007). Fish and Benthic Fauna in Kulekhani Reservoir, Makwanpur. *Nepal Journal of Science and Technology* 8: 63–68.

Sedeño-Díaz, J.E. & E. López-López (2013). Fresh water fish as sentinel organism: from the molecular to the population level, a Review, pp. 151–173. In: Türker, H. (ed.). *New Advances and Contributions to Fish Biology* IntechOpen. https://doi.org/10.5772/54825

Sharma, C.K. (1977). *River systems of Nepal.* Sharma. S, 23/281 Bishalnagar, Kathmandu, Nepal, 211 pp.

Sharma, C.M. (2008). Freshwater fishes, fisheries, and habitat prospects of Nepal. *Aquatic Ecosystem Health & Management* 11(3): 289–297. https://doi.org/10.1080/14634980802317329

Sharma, R.C. (2003). *Protection of an endangered fish Tor tor and Tor putitora population impacted by transportation network in the area of Tehri dam project, Garhwal Himalaya, India* pp. 83-90. 2003 International Conference on Ecology and Transportation (ICOET 2003), Lake Placid New York, United States, 688 pp. http://www.icoet.net/downloads/03FishPassage.pdf

Shrestha, B.C. (1999). Baseline Report of Bheri–Babai Hydroelectric Project. *Environment Impact Assessment Stage–I, New Era/Nippon Koei/JICA Kathmandu, Nepal*, 51 pp.

Shrestha, J. (1981). *Fishes of Nepal*. Curriculum Development Centre, Tribhuvan University, Kathmandu, Nepal, 318 pp.

Shrestha, J. (1995). Enumeration of the Fishes of Nepal. Biodiversity Profiles Project Publication No. 10. Department of National Parks and Wildlife Conservation, Ministry of Forests and Soil Conservation, His Majesty's Government of Nepal, Kathmandu, 4 pp.

Shrestha, J. (1999). Coldwater fish and fisheries in Nepal, pp. 13–40. In: Petr, T. (ed.). *Fish and Fisheries at Higher Altitudes. Asia. Food and Agriculture Organization Fisheries Technical Paper No.* 385, Food and Agriculture Organization of the United Nations, Rome, 304 pp.

Shrestha, T.K. (2008). *Ichthyology of Nepal: a study of fishes of the Himalayan waters*. Himalayan Ecosphere, Kathmandu, Nepal, 388 pp.

Singh, G. & N. Agarwal (2013). Fish diversity of Laster stream, a major tributary of river Mandakini in Central Himalaya (India) with regard to altitude and habitat specificity of fishes. *Journal of Applied and Natural Science* 5(2): 369–374. https://doi.org/10.31018/jans.v5i2.334

Singh, R. (2002). Fish biodiversity and fishery resources of Babai River, Nepal. MSc Thesis. Department of Zoology, Tribhuvan University, Nepal, vii+78 pp.

Spellerberg, I.F. & P.J. Fedor (2003). A tribute to Claude Shannon (1916–2001) and a plea for more rigorous use of species richness, species diversity and the 'Shannon–Wiener' Index. *Global Ecology and Biogeography* 12(3): 177–179. https://doi.org/10.1046/j.1466-822X.2003.00015.x

Spence, R., M. Fatema, M. Reichard, K. Huq, M. Wahab, Z. Ahmed & C. Smith (2006). The distribution and habitat preferences of the zebrafish in Bangladesh. *Journal of Fish Biology* 69(5): 1435–1448. https://doi.org/10.1111/j.1095-8649.2006.01206.x

Su, G., M. Logez, J. Xu, S. Tao, S. Villéger & S. Brosse (2021). Human impacts on global freshwater fish biodiversity. *Science* 371(6531): 835–838. https://doi.org/10.1126/science.abd3369

Suresh, V., B. Biswas, G. Vinci, K. Mitra & A. Mukherjee (2006). Biology and fishery of barred spiny eel, Macrognathus pancalus Hamilton. *Acta Ichthyologica et Piscatoria* 36(1): 31–37. https://doi.org/10.3750/AIP2006.36.1.05

Suwal, N., A. Kuriqi, X. Huang, J. Delgado, D. Młyński & A. Walega (2020). Environmental Flows Assessment in Nepal: The Case of Kaligandaki River. *Sustainability* 12(21): 8766. https://doi.org/10.3390/su12218766

Tacon, A.G. & M. Metian (2013). Fish matters: importance of aquatic foods in human nutrition and global food supply. *Reviews in fisheries Science* 21(1): 22–38. https://doi.org/10.1080/10641262.2012.753405

Talwar, P. & G. Jhingran (1991). *Inland fisheries of India and adjacent countries.* (Vol. 2). Oxford and IBH Publishing Company Pvt. Limited, New Delhi, 1158 pp.

Thilsted, S. & M. Wahab (2014). Production and conservation of nutrient-rich small fish (SIS) in ponds and wetlands for nutrition security and livelihoods in South Asia. Dhaka, Bangladesh, 47 pp.

Tien Bui, D., D. Talebpour Asl, E. Ghanavati, N. Al-Ansari, S. Khezri, K. Chapi, A. Amini & B. Thai Pham (2020). Effects of inter-basin water transfer on water flow condition of destination basin. *Sustainability* 12(1): 338. https://doi.org/10.3390/su12010338

Tornwall, B., E. Sokol, J. Skelton & B.L. Brown (2015). Trends in stream biodiversity research since the river continuum concept. *Diversity* 7(1): 16–35. https://doi.org/10.3390/d7010016

WECS (2011). *Water resources of Nepal in the context of Climate Change*. Water and Energy Commission Secretariat, Government of Nepal, Kathmandu, 67 pp.

WHO (2003). Diet, nutrition, and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation (Vol. 916). World Health Organization. Geneva, Switzerland, 149 pp.

Winemiller, K.O. & D.B. Jepsen (1998). Effects of seasonality and fish movement on tropical river food webs. *Journal of Fish Biology* 53: 267–296. https://doi.org/10.1111/j.1095-8649.1998.tb01032.x

WWAP (2009). United Nations World Water Development Report 3: Water in a changing World. Paris: UNESCO, and London: Earthscan, 318 pp.

Yadav, P., A. Kumar, S.A. Hussain & S.K. Gupta (2020). Evaluation of the effect of longitudinal connectivity in population genetic structure of endangered golden mahseer, *Tor putitora* (Cyprinidae), in Himalayan rivers: Implications for its conservation. *PLoS One* 15(6): e0234377. https://doi.org/10.1371/journal.pone.0234377

Zhu, X., J. Wu, H. Nie, F. Guo, J. Wu, K. Chen, P. Liao, H. Xu & X. Zeng (2018). Quantitative assessment of the impact of an inter-

Journal of Threatened Taxa is indexed/abstracted in Bibliography of Systematic Mycology, Biological Abstracts, BIOSIS Previews, CAB Abstracts, EBSCO, Google Scholar, Index Copernicus, Index Fungorum, JournalSeek, National Academy of Agricultural Sciences, NewJour, OCLC WorldCat, SCOPUS, Stanford University Libraries, Virtual Library of Biology, Zoological Records.

NAAS rating (India) 5.64

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ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

January 2024 | Vol. 16 | No. 1 | Pages: 24451–24614
Date of Publication: 26 January 2024 (Online & Print)
DOI: 10.11609/jott.2024.16.1.24451-24614

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