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Research Article

Ichthyofaunal diversity in the Narayani River, Nepal

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Abstract

A stretch of 70 km of Narayani River, from Devghat to Tribenighat was studied during the winter season in 2020-2021 for fish diversity and composition. Altogether 40 fish species belonging to 14 families and 7 orders was recorded. Order Cypriniformes had high taxa dominance (67%) whereas least taxa richness (2%) with single species were recorded from orders Beloniformes, Clupeiformes, Gobiiformes and Osteoglossiformes. Simpson diversity index ranged from 0.1 to 0.8 whereas Shannon diversity and Pielou's evenness ranged from 0.2 to 2.1 and 0.3 to 0.8, respectively reflecting diverse species composition in the river system. Minimum taxa richness and abundance were recorded in river stretches influenced by industrial effluents. High conservation value species such as *Wallago attu, Chitala chitala, Tor tor* and *Neolissochilus hexagonolepis* were documented in the most downstream section, i.e., Tribenighat (112 m asl) of the river. Non-metric multidimensional scaling (NMDS) analysis disentangled three clusters representing sites of upstream river stretches, sites influenced by industrial effluents and sites of downstream river stretches ($p < 0.05$). The outcomes of the study help identify critical river stretches that need high conservation efforts for conserving fish diversity in the Narayani River to support the long-term sustainability of fish populations.

***Keywords**:* Arun Khola, Binaya Khola, fish diversity, river conservation, Lankhu Khola, Rapti River

Introduction

Rivers provide critical habitat for diverse groups of aquatic organisms including fish species. Fish are considered as good bio-indicators of river ecosystem health (Karr, 1981) as their distribution and abundance are associated to habitat characteristics, their diversity and water quality (Huang et al., 2019; Bélanger & Rodriguez, 2002; Deacon & Mize, 1997). The Chitwan National Park situated along the bank of the Narayani River is known for its rich biodiversity, including many endangered species, Royal Bengal Tigers, One Horned Rhino, etc., for which the park is designated as a World Heritage Natural Site in 1984 by UNESCO (United Nations Educational, Scientific, and Cultural Organization). Narayani River System is also rich in fish diversity (Dhakal, 2018; Dhital et al., 2002; Jha & Bhujel, 2014; Shrestha, 2008, 2012; Shrestha & Edds, 2012). However, many of the research have been carried out in the upper stretches, especially in mountains and tributaries while limited research are conducted in the Narayani River though it is one of the highly diverse habitats for fishes (e.g., Dhital et al., 2002; Jha et al., 1989; Jha & Bhujel. 2014).

Many rivers in the country are impacted by habitat alteration, water pollution and overexploitation of aquatic resources including river aggregates (Tachamo Shah & Shah, 2013; Tachamo Shah et al., 2020) and Narayani is not an exception (Dhital et al., 2002). Overfishing, use of destructive fishing methods and habitat destruction due to riverbed extraction, pollution and clearance of riparian vegetation have negatively impacted on fish diversity of the Narayani River system (Dhital & Jha, 2002; Jha & Bhujel, 2014). Many fishermen have also claimed the decline of fish abundance over the years.

Fish species are susceptible to altering temperatures (Walberg, 2011; Bhattacharjya et al., 2017; Jahan, 2018), increase in turbidity (Mishra and Baniya, 2016; Huang et al., 2019), and oxygen availability (Pokharel et al., 2018; Limbu & Gupta, 2020). Many industries have been established along the Narayani River and their effluents are directly discharged into the main river channel. Therefore, any detrimental impact on water quality and habitat alterations in the river would directly affect its fish community composition and diversity. The present study aimed to assess winter fish diversity in different stretches of the Narayani River. This will provide up-to-date status information on the distribution of freshwater fishes in the Narayani River and its selected tributaries. Such information is essential for developing conservation and management strategies to support the conservation of fish populations in Narayani River.

Materials and Methods

Study area and sites

The study was conducted from upstream Devghat, Chitwan that lies at 27.5291° N latitude and 84.3542° E longitude to downstream at Tribenighat, Nawalparasi that

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extends to 27.4531° N latitude and 83.9331° E longitude and has subtropical climate. The Kaligandaki River, which originates in the Tibetan plateau and flows through the Himalaya between Dhaulagiri and Annapurna is the main feeder of Narayani River. The Kaligandaki after joining Trishuli River at Devghat is named as Narayani River, which runs approximately 332 km before it converges onto the Gangetic plains of India.

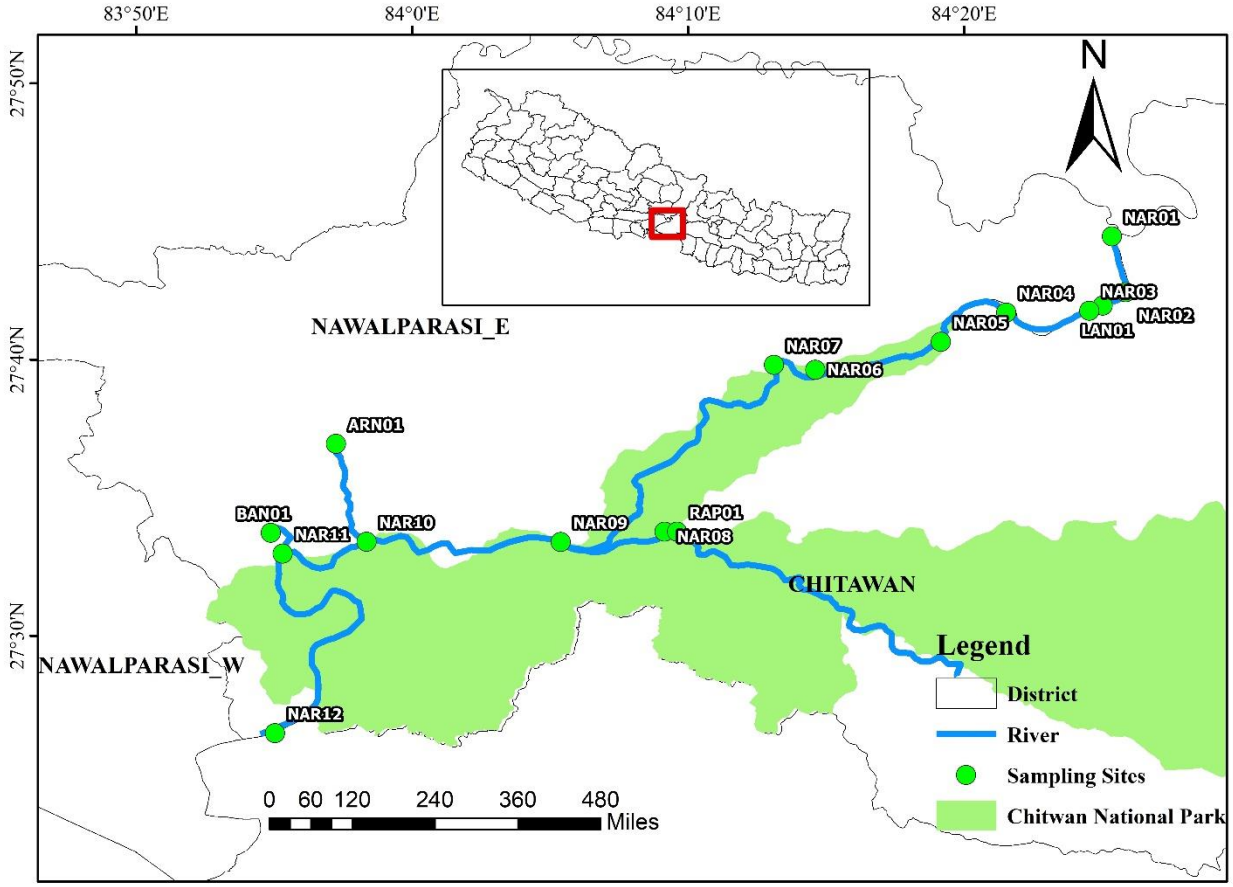

Figure 1 Sampling sites (open circle) distribution along the mainstem river of the Narayani and its tributaries. NAR represents the Narayani River. A total of twelve sites are distributed along the Narayani River with sample codes NAR01 to NAR12 from upstream at Devghat to downstream at Tribenighat. LAN, RHE, RAP, and ARN are the tributaries namely Lankhu Khola, Rheu Khola, Rapti River and Arun Khola, respectively.

Sampling sites: A total of 12 sites in the mainstem of Narayani River from Devghat to Tribenighat and 1 site in each tributary: Lankhu, Rheu, Rapti and Arun River just before the confluence to Narayani River were sampled for fish diversity and composition (Fig.1).

Methods

Fish samples: Fish samples were collected using cast net and seine hauls during winter season (December 2020-January 2021), immediately after lifting of nationwide lockdown imposed by COVID-19 pandemic. Cast nets of mesh size of 2 inch and seine hauls with mesh size of 2 inch were used for capturing fishes.

A suitable area of water for cast netting was selected that was free of rocks, plants, woody debris or algae in order to prevent snagging of the cast net. The net was then thrown with a jerk into the water which spread out in a rounded way. After a while, the net was dragged with the help of a central rope and the fish caught were placed in a bucket half-filled with water. The cast net was thrown 40 times per site within a 500 m river stretch in early morning of a day. Seine hauls are inexpensive and comparatively (non-invasive/less disturbance) to fish and are mostly used in turbid water. A suitable flat sampling site free from woody debris, algae, and rocks was selected. The seine net was then deployed perpendicular to the bank between two people placing the foot rope against the substrate. Extended part of the seine was hauled along the desired area of the river. A 'U" shaped was maintained in order to reduce escaping of fish. The seine haul was then slowly

swung towards the shore end. The seine haul was placed 15 times per site.

Upon the collection of fish samples, each fish specimen was tallied and categorized according to their respective species using a taxonomic key in the field (Rayamajhi, 2017). Local knowledge for the identification was valuable as well. The species that couldn't be identified in the field were preserved using 10% formalin and were later identified in the laboratory. The total length (L) and body weight (G) of each fish species were measured using a ruler and a portable weighing balance. Fish species recorded were categorized based on their standard length from small (1-10cm), medium (20-30 cm), and large size (>30).

Water quality parameters: Water quality parameters were measured concurrently with the fish sampling. A total of 15 water quality parameters were measured for each site. Out of 15 parameters measured for each site, parameters such as dissolved oxygen (DO), temperature, pH, and conductivity were measured using Multi-parameter Water Quality Probe (Lutron WA-2015) at site. Turbidity of river water was measured using the Orion AQ 2010- AQUAfast II Turbidity. For remaining parameters (nitrate, phosphate, ammonia and total suspended solids (TSS), water samples were collected and transported to Aquatic Ecology Centre, Kathmandu University for the analysis. The tests were carried out following APHA (2017).

Data analysis

Shannon–Weiner's diversity index (*H*), Simpson diversity index (D), Pielou's evenness index (*J*), were calculated using formulae.

Shannon–Weiner's diversity index (*H*): = $\sum$ Ni/ N ln Ni/N

Where N = sample size, Ni = number of specimens per species, and S = total number of species.

Simpson's Diversity Index (D) = 1 – ($\sum$ n (n-1)) / (N (N-1))

Where n = the total number of organisms of a particular species, N = the total number of organisms of all species.

Pielou's evenness (J) = H/log S

Where, H= Shannon Weiner Index and S= No. of species

To envisage the differences in fish faunal diversity along the sampled river stretches, non-metric multidimensional scaling (NMDS) was performed for abundance data of fish species. NMDS is an indirect gradient analysis that creates an ordination based on a dissimilarity on faunal composition.

Results and Discussion

Species diversity

A total of 40 species representing 14 families and 7 orders were recorded in the study stretches of the Narayani River and its tributaries (Table 1). Overall, the order Cypriniformes was the most diverse group contributing 67% of species richness followed by Siluriforms with 18% and Anabantiforms with 5% (Fig. 2). Orders such as Beloniforms, Clupeiforms, Gobiiformes and Osteoglossiormes were recorded with presence of single species such as *Xenentodon cancila, Gudusia chapra, Glossogobius giuris* and *Chitala chitala*, respectively. *Mastacembelus armatus* recorded in Rapti River during this study, has been reported from Kaligandaki at Ridhi Bazar and Narayani-Amaltari in previous study (Gillette et al., 2016). The species is positively correlated with water quality parameters such as nitrate, phosphate, chlorides, conductivity, etc. (Pokharel et al., 2018). As the species is of economic significance, their natural population has been observed to decrease due to over exploitation and for various ecological imbalances brought on by alteration in its natural habitat (Hossain et al., 2015).

Cyprinidae was the most dominant family among the 14 families recorded in the sites (Fig. 3). Bagridae comes below with 3 species richness followed by Botidae, Nemacheilidae, Sisoridae with 2 species and Badidae, Channidae, Belonidae, Clupeidae, Cobitidae, Gobiidae, Notopteridae, Clariidae and Siluridae with single species.

Earlier studies carried out in the Narayani River system recorded 23 different fish species (Shrestha, 1981) while a longitudinal survey of the Kaligandaki-Narayani River system from 100 m to 3000 m asl documented 111 fish species (Edds, 1986a). In 2002, 69 and 68 fish species were recorded from the Narayani in Chitwan and Rapti River system, respectively (Dhital et al., 2002). Most recent study recorded 21 fish species from Narayani River in Nawalparasi district (Gupta et al., 2022).

Conservation status of fish

Among the 40 species documented in this study, majority of species are listed in IUCN's categories (2009, 2010, 2012) as least concern, however, *Neolissochilus hexagonolepis* (2009) as Near Threatened, *Tor tor* as Data Deficit, *Chitala chitala* as Near Threatened and *Wallago attu* as Vulnerable are listed in the IUCN's red list category (Table 1). Three species *Erethistoids cavatura, Rasbora daniconius* and *Labeo gonius* were recorded only in tributaries: Rapti and Binaya Khola. The species *Erethistoids cavatura* was found in the gravel bed of the river and is endemic to Nepal (Ng & Edds, 2005).

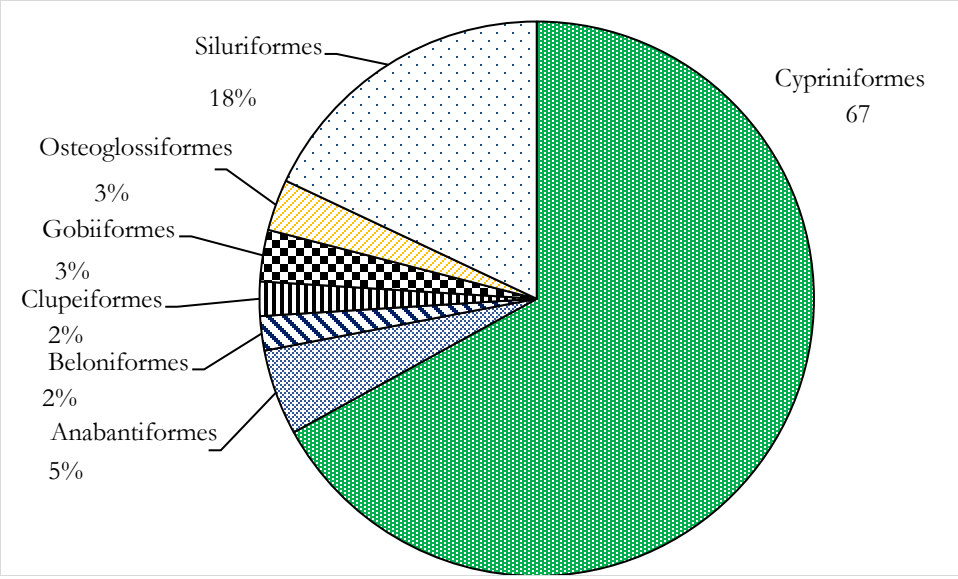

Figure 2 Relative proportion of fish composition in the study stretches of the Narayani River and its tributaries

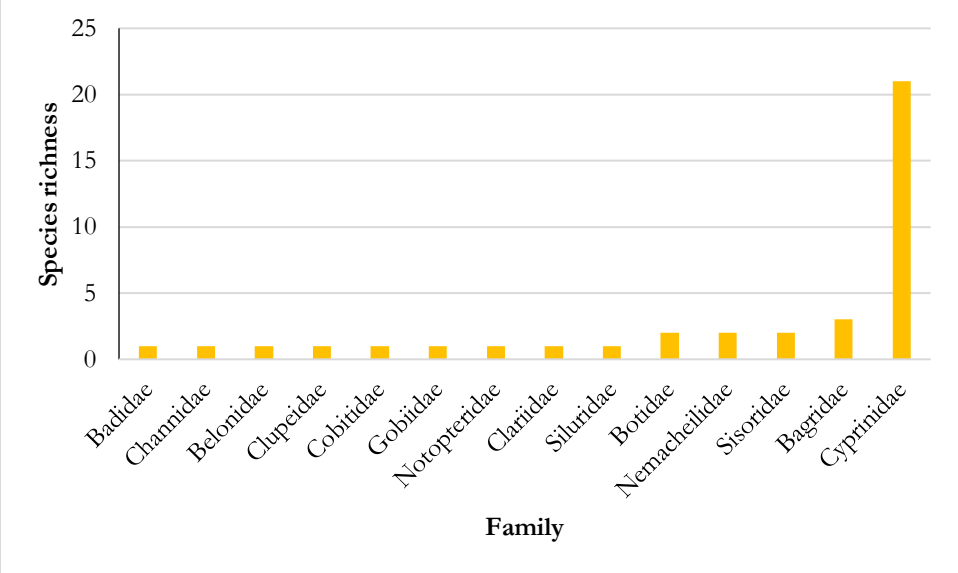

Figure 3 Fish species richness in study river stretches in the Narayani River and its tributaries

In our study, fishes with high conservation values such as *Brachydanio rario*, *Neolissochilus hexgonolepis*, and *Tor tor* were recorded in the upstream and downstream of the Narayani Bridge. The Narayani Bridge is located in an urban area, Narayanghat where a wide range of human activities including the operation of stemmers for a few years now. The downstream of the bridge had once been a highly polluted river stretch due to the continuous discharge of effluents from the operation of Bhrikurti Paper Mills (but permanently closed in 2011). These species have been sighted in the river stretches after several years with relatively improved water quality and river habitat status may be due to a year-long nationwide lockdown imposed by COVID-19. The results are encouraging and indicate that upon habitat improvement these species can recolonize the river stretches slowly (Reice et al., 1990).

Table 1 Fish species recorded in mainstem Narayani and its tributaries. Letters: M and T represent "mainstem" and "tributary", respectively

SN	Order	Family	Genus species	Rivers		IUCN Status
				M	T	
1	Anabantiformes	Badidae	*Badis Badis*	☐		Least Concern (2010)
2	Anabantiformes	Channidae	*Channa punctata*	☐		Least Concern (2019)
3	Beloniformes	Belonidae	*Xenentodon cancila*	☐		Least Concern (2019)
4	Clupeiformes	Clupeidae	*Gudusia chapra*	☐		Least Concern (2019)
5	Cypriniformes	Botiidae	*Botia histrionica*	☐		Least Concern (2010)
6	Cypriniformes	Botiidae	*Botia lohachata*	☐		Not evaluated
7	Cypriniformes	Cobitidae	*lepidocephalichthys guntea*	☐	☐	Least Concern (2012)
8	Cypriniformes	Cyprinidae	*Bangana dero*	☐		Least Concern (2010)
9	Cypriniformes	Cyprinidae	*Cirrhinus mrigala*	☐		Least Concern (2010)
10	Cypriniformes	Cyprinidae	*Garra annandalei*	☐		Least Concern (2009)
11	Cypriniformes	Cyprinidae	*Labeo angra*	☐		Least Concern (2007)
12	Cypriniformes	Cyprinidae	*Labeo boga*	☐		Least Concern (2010)
13	Cypriniformes	Cyprinidae	*Labeo dyocheilus*	☐		Least Concern (2010)
14	Cypriniformes	Cyprinidae	*Labeo fimbriatus*	☐		Least Concern (2011)
15	Cypriniformes	Cyprinidae	*Labeo gonius*		☐	Least Concern (2010)
16	Cypriniformes	Cyprinidae	*Puntius sophore*	☐	☐	Least Concern (2010)
17	Cypriniformes	Cyprinidae	*Puntius terio*	☐	☐	Least Concern (2010)
18	Cypriniformes	Cyprinidae	*Puntius ticto*	☐		Least Concern (2010)
19	Cypriniformes	Cyprinidae	*Tor mosal*	☐	☐	Data Deficient (2018)
20	Cypriniformes	Cyprinidae	*Barilius bendelisis*	☐		Least Concern (2010)
21	Cypriniformes	Cyprinidae	*Barilius barila*	☐	☐	Least Concern (2010)
22	Cypriniformes	Cyprinidae	*Barilius vagra*	☐		Least Concern (2010)
23	Cypriniformes	Cyprinidae	*Brachydanio rerio*	☐		Least Concern (2009)
24	Cypriniformes	Cyprinidae	*Cabdio morar*	☐		Least Concern (2009)
25	Cypriniformes	Cyprinidae	*Esomus danricus*	☐		Least Concern (2007)
26	Cypriniformes	Cyprinidae	*Rasbora daniconius*		☐	Least Concern (2011)

27	Cypriniformes	Cyprinidae	*Neolissocheilus hexagonolepis*			Near Threatened (2009)
28	Cypriniformes	Cyprinidae	*Tor tor*			Data deficit (2018)
29	Cypriniformes	Cyprinidae	*Salmostoma acinaces*			Least Concern (2011)
30	Cypriniformes	Nemacheilidae	*Acanthocobitis botia*			Least Concern (2007)
31	Cypriniforme	Nemacheilidae	*Schistura sikaiensis*			Least Concern (2010)
32	Gobiiformes	Gobiidae	*Glossogobius giuris*			Least Concern (2019)
33	Osteoglossiformes	Notopteridae	*Chitala chitala*			Near Threatened (2010)
34	Siluriformes	Bagridae	*Rita rita*			Least Concern (2010)
35	Siluriformes	Bagridae	*Sperata aor*			Least Concern (2011)
36	Siluriformes	Bagridae	*Mystus bleekeri*			Least Concern (2009)
37	Siluriformes	Clariidae	*Clarias magur*			Endangered (2010)
38	Siluriformes	Siluridae	*Wallago attu*			Vulnerable (2019)
39	Siluriformes	Sisoridae	*Glyptothorax alaknandi*			Least Concern (2009)
40	Siluriformes	Sisoridae	*Erethistoides cavatura*			Data deficient (2009)

Table 2 Diversity indices from mainstream and tributaries of Narayani River. Rich-"Richness", Abun-"Abundance", H - "Shannon–Weiner's diversity index", D- "Simpson's Diversity Index", J - "Pielou's evenness, Bou-"Boulder", Cob-"Cobble", Sto-"Stones", San-"Sand", Peb-" Pebbles"

Mainstem	Sites	Rich	Abun	D	H	J	Major Substrates	Stressors
	NAR01	6	10	0.76	1.61	0.83	Bou & Cob	Littering, Bank cutting & Boating
	NAR02	10	40	0.79	1.86	0.64	Cob	Fishing & Boating
	NAR03	7	34	0.65	1.42	0.59	Sto & San	Boating, Bathing, Littering, Fishing & Stemmer
	NAR06	5	15	0.44	0.95	0.52	Sto	Littering & Cremation
	NAR07	2	12	0.15	0.29	0.67	Sto	Wastewater discharge & Bank cutting
	NAR08	4	32	0.51	0.94	0.64	Cob	Cremation
	NAR09	7	38	0.77	1.64	0.73	Cob & Sto	Cremation
	NAR10	9	27	0.86	2.06	0.88	San	Bathing & Fishing
	NAR11	10	27	0.84	2.01	0.75	Sto & San	Fishing
	NAR12	11	44	0.58	1.45	0.39	San	-
Tributaries	RHE01	4	36	0.25	0.55	0.43	San	Fishing & Riverbed erosion
	RAP01	4	17	0.64	1.15	0.79	San	Swimming, Boating & Fishing
	ARN01	5	20	0.73	1.42	0.82	Sto	Littering, Fishing
	BAN01	7	140	0.72	1.43	0.59	Peb & Cob	Cremation

Fish species composition

Barilius spp., *Puntius* spp. and *Acanthocobitis botia* were recorded in almost all study sites of the mainstream river (Table 2) and were also documented in earlier studies (Shrestha, 1981, 1990, 1994, 2004, 2008, 2012; Jha et al., 1989, 2014; Dhakal, 2018; Dhital et al., 2002; Rajbanshi, 2002, 2012; Edds, 1986a, 1986b, 1993; Ng, 2003; Shrestha & Edds, 2012). Single species of *Chitala chitala, Rita rita, Sperato aor, Mystus bleekeri* and *Wallago attu* were recorded only in Tribenighat site near the barrage where maximum number of species was documented.

Minimum richness (2) and abundance (12) of fish were recorded in the site (NAR 07) where water quality was recorded poor due to the wastewater discharged from industries situated along the Narayani Riverbank. Diversity and abundance of fish species increased gradually as the river entered Chitwan National Park (NAR 08-NAR 11). This suggests the detrimental impact of wastewater discharge from industries situated along the banks between the sites downstream of NAR 03 and NAR 07 to the fish diversity in the river. Similar results of low species abundance were documented by other research scholars in Narayani River (Sah et al., 2002). Only two species *Puntius terio* and *Esomus danrica* were recorded for NAR 07. *Esomus* spp is regarded as a tolerant species and has been recorded in an area with heavy metal contamination (Neeratanaphan et al., 2017). Furthermore, relatively low diversity of fish species was documented for the sites: NAR01, NAR 03 and NAR 06, with increased external stressor such as bank cutting, boating, waste dumping and littering (Table 2). The maximum number of species richness and abundance were recorded in the most downstream section of the Narayan River at Tribenighat in our study. Trebenighat is located upstream of Gandak Barrage. The barrage's gate opens during high water volume each year, in particular monsoon season (July and August, communication with locals during field visits) and other months remain closed creating standing waterbodies of over 2 m deep. This also leads to deposition of sand and silt dunes further hindering spawning grounds for fishes (Jha, 2018). The operations of barrage early throughout the year halt upstream and downstream migration of fishes which might reduce the fish population in upstream sections of Narayani River. Jha (2018) reported a decreasing catch of fishes at Tribenighat over the time.

Fish length and weight

Standard length (SL) of individual fish species ranged from 3.1 cm to 70.2 cm, similarly individual body weight (BW) ranged from less than 1 g to 3950 g. Species such as *Chitala chitala, Cirrhinus mrigala mrigala* and *Labeo* spp measured SL up to 70.2 cm, while BW recorded up to 3950 g in Tribenighat, while the average SL ranged from 4 cm to 10 cm whereas BW ranged from 1 g to 44 g in the study river stretches (Table 3).

Table 3 Major fish composition along the sampled site of mainstem and tributaries along with aggregate standard length (SL), total length (TL) and weight

	Sites	Length (cm) (Mean ± SD)		Weight (g) (Mean ± SD)	Major fish Species
		SL	TL		
Mainstem	**NAR01**	5.76 ±1.63	7.09 ± 1.89	3.4 ± 2.27	*Barilius* spp., *Puntius* spp.
	NAR02	4.52 ±1.24	5.68 ± 1.27	2.54 ± 1.59	*Barilius* spp., *Escomus danrica, Tor mosal, Puntius* spp.
	NAR03	5.99 ± 1.98	7.22 ± 2.05	3.82 ± 2.38	*Barilius barilla, Acanthocobitis botia, Puntius terio, Tor tor*
	NAR06	3.18 ± 0.62	4.15 ± 0.85	1.54 ± 0.58	*Escomus danricus, Puntius terio*
	NAR07	3.69 ± 1.22	4.7 ± 1.52	2.67 ±3.15	*Acanthocobitis botia, Channa punctata, Puntius* spp.,
	NAR08	6.77 ± 1.18	8.20 ± 1.37	2.09 ± 0.53	*Barilius* spp., *Labeo boga*
	NAR09	9.20 ± 8.82	11.45 ± 10.97	64.5 ± 97.12	*Labeo dyocheilus, Esomus danricus, Acanthocobitis botia, Puntius terio*
	NAR10	4.35 ± 1.01	5.43 ± 1.11	3.07 ± 1.57	*Botia histrionica, Garra annandalei, Gudusia chapra, Puntius* spp.
	NAR11	4.44 ± 1.47	5.56 ± 1.54	2.85 ±2.49	*Puntius* spp, *barilius* spp,
	NAR12	10.56 ± 15.47	11.89 ± 17.32	44.02 ± 152.94	*Salmostoma acinaces, Cabdio morar, Chitala, chitala, Labeo dyocheilus, Wallago attu, Rita, rita*
Tributaries	**RHE01**	4.63 ± 0.59	5.77 ± 0.66	1.63 ± 1.19	*Barilius barilla, Acanthocobitis botia, Erethistoides cavatura*
	RAP01	6.05 ± 1.79	7.69 ± 2.05	4.88 ± 2.99	*Barilius barila, Labeo gonius, Acanthocobitis botia*

ARN01	4.46 ± 1.17	5.55 ± 1.43	3.5 ± 2.93	*lepidocephalichthys guntea, Puntius terio, Barilius barilla Acanthocobitis botia*
BAN01	3.65 ± 0.84	4.60 ± 1.04	1.93 ± 1.22	*Puntius* spp., *Acanthocobitis botia, Salmostoma acinaces, Tor mosal*

Identification of critical river stretch for winter season

Non-metric multidimensional scaling (NMDS) was performed based on fish abundance, which resulted in three clusters of sites (stress value 0.16, Fig. 4). Sites with moderate and high species richness and abundance were assembled in cluster 1 and cluster 2, respectively, whereas the site with low species richness and abundance was singled out in another cluster 3.

Fish size and weight were also different across the clusters in particular for small sized fish (Table 4; $p < 0.001$). While medium sized fish did not differ between the clusters 1 and 2. Large sized fish was recorded only in cluster 2. Most of the sites in cluster 2 are located along the Chitwan National Park where fishing and other human activities are prohibited, therefore, the sites are minimally disturbed and allowed to colonize high diversity and large sized fish species.

Water quality parameters across the three clusters

Water quality parameters: nitrate, DO, chloride, CO_2, temperature and TSS among the three clusters showed variations as well. High concentration of TSS with minimum DO was measured in cluster 3 (Table 5). NAR 07 was the only site present in cluster 3, which was highly influenced by wastewater discharge from the industries situated along the Narayani River. Discharge of untreated wastewater reduces dissolved oxygen due to increased microbial activities (Tachamo-Shah & Shah, 2013). Sites specially located in urban and industrial areas in Nepal exhibited lower DO while high nutrient concentrations (Sah et al., 2000; Tachamo-Shah & Shah, 2012). Poor water quality has been documented as a major problem declining fish population in the country (Khatri et al., 2020).

High DO was recorded in clusters 1 and 2 with low concentration of nitrate and TSS (Table 5). Usually, high concentration of DO and low nutrient concentrations indicate good water quality status providing suitable environment for aquatic species (Venkataraman et al., 2007; Tachamo Shah & Shah, 2013; Cheng, 2019).

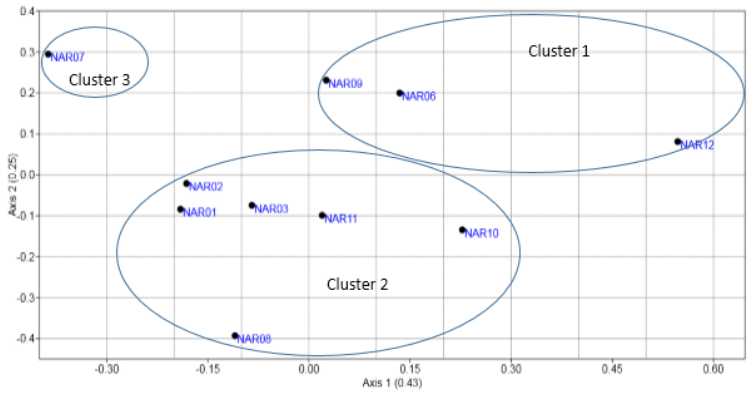

Figure 4 Ordinations of sample sites by nonmetric multidimensional scaling (NMDS) based on the Bray- Curtis similarity matrix using fish species abundance

Figure 4 Fish faunal composition (richness and abundance) among the clusters.

Table 4 Fish length and weight across the NMDS clusters for different fish size categories

Clusters		Cluster 1	Cluster 2	Cluster 3
Small Size Fish	Standard length (cm)	5.09 ± 1.55	3.96 ± 2.03	3.18 ± 0.62
	Total Length (cm)	6.29 ± 1.73	4.71 ± 2.54	4.15 ± 0.85
	Weight (g)	2.83 ± 1.93	2.39 ± 3.34	1.54 ± 0.58
Medium Size Fish	Standard length (cm)	22.2 ± 9.62	21.34 ± 2.28	
	Total Length (cm)	23.85 ± 10.11	25.91 ± 2.94	

	Weight (g)	119 ± 151.32	191.37 ± 85.99
Large Size Fish	Standard length (cm)		55.33 ± 14.29
	Total Length (cm)		62.44 ± 12.47
	Weight (g)		1983 ± 139.97

Table 5 Physiochemical parameters of the three NMDS clusters

S.N	Physio-Chemical Parameters	Cluster 1	Cluster 2	Cluster 3
1	pH	8.42 ± 0.39	8.33 ± 0.28	8.80
2	Temperature (°C)	19.34 ± 2.59	18.08 ± 1.10	22.50
3	Dissolved Oxygen (D.O) (mg/L)	7.23 ± 1.69	9 ± 2.01	3.60
4	Total Suspended Solids (TSS) (mg/L)	9.93 ± 5.89	7.2 ± 5.70	40.00
5	Turbidity	11.09 ± 5.93	17.04 ± 9.49	34.60
6	Free CO_2 (ppm)	19.17 ± 5.85	25 ± 50	30.00
7	Alkalinity (ppm)	47.5 ± 9.35	50 ± 50	55.00
8	Hardness (ppm)	77.67 ± 7.50	77.67 ± 1.53	75.00
10	Ammonia (ppm)	0.65 ± 0.15	0.99 ± 0.83	0.69
11	Nitrate (ppm)	5.14 ± 5.00	2.82 ± 2.31	8.41
12	Orthophosphate (ppm)	0.09 ± 0.08	0.11 ± 0.03	0.08
13	Total Phosphorus (ppm)	0.16 ± 0.06	0.24 ± 0.10	0.25
15	Sulphate (ppm)	4.08 ± 1.66	3.29 ± 0.74	2.26
16	Chloride (ppm)	51.23 ± 24.88	52.48 ± 35.26	67.48
17	Total Organic Nitrogen (ppm)	1.99 ± 1.09	1.61 ± 0.66	1.39

Conclusions

Narayani River is home to an array of diverse fish species including key species such as *Tor tor, Neolissochilus hexagonolepis* and *Brachydanio rario*. The IUCN red list *species Chitala chitala* and *Wallago attu* recorded recently, was not long been reported in the river system. Cypriniformes is the most common as well as abundant order in this river. The downstream sections of the Narayani River were highly diverse, especially in the river along the Chitwan National Park compared to upstream river stretches providing critical habitats and spawning grounds for many fish species. The maintenance of river ecosystem through conservation of riparian habitats and prohibiting anthropogenic activities is key for fish conservation in the Narayani River.

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