



Fish species composition, distribution and community structure in the Pathariya River of Kailali, Farwestern, Nepal

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Abstract

This study examined the status of fish resources in the Pathariya River, from September 2017 to August 2018 covering four seasons- Autumn (September, October, and November), Winter (December, January, and February), Spring (March, April, and May) and summer (June, July, and August). We used a cast net of 1.5 cm to 2.5 cm and a Gill net having 2-3 cm mesh size, 30-35 feet long and 3-4 feet width, with the help of a local fisherman. A total of 407 individuals belonging to 4 orders, 8 families, 16 genera, and 25 species were collected from Malbhanga, Thakurwdara, Sonalipur, and Dhunganatol of Pathariya River. The majority of the fishes belonged to the family Cyprinidae (53.56%) followed by Bagridae (17.44%), Mastacembelidae (11.31%), Channidae (8.11%), Cobitidae (5.65%), Claridae (1.72%), Nandidae (1.47%), and Siluridae (0.74%). The most abundant species were *Puntius ticto*, *Puntius sophore*, and *Mystus tengra*. The one-way analysis of variance on Canonical correspondence analysis (CCA) confirmed that dissolved oxygen, free carbon dioxide, and total hardness were the influencing factors ($P < 0.05$) in shaping the fish community structure. The difference in fish assemblage structure and diversity in the Pathariya river are probably related to habitat type, altitude, season, several environmental factors, and anthropogenic activities.

Keywords: Diversity, fish habitat, fish ecology, freshwater, Himalaya

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Introduction

Earth contains an abundance of water which covers 71 % of its surface, out of total water bodies about 97 % remain in the seas, and the remaining 3 % exist as fresh water in Lakes, rivers, streams reservoirs, underground water, and permanent glacier (Wetzel, 1983). However, Nepal is a small mountainous landlocked country comprising of snow-clad Himalayas and has large freshwater bodies which possess 2.27 % of the water resources in the world (DOFD-2013/14) supporting biologically diverse fish fauna and has great potential for hydropower generation and it also contains protein-rich living organisms, which can

be helpful in fishing resources as well as different aquatic flora and fauna (Rai *et al.*, 2008; Gubhaju, 2012). Spatial and temporal variation of fish assemblages in rivers occur at scales from micro-habitat to basin and diel to decadal or longer (Adams *et al.*, 2004). Knowledge of spatial and temporal variation is valuable for identifying sources of assemblage regulation across the river and interpreting time series on fish assemblages (Schlosser, 1990). Fish assemblage variation is a function of many interconnecting factors, including the hydrologic regime, geoclimatic region, species composition, biotic versus abiotic regulation, channel type, disturbance history, and frequency

(Gossmann *et al.*, 1998). Temporal variation is high in warm water streams and in anthropogenically disturbed streams. While, the spatio-temporal variation of fish assemblage structure depends on channel size, and sand bottom streams (Schlosser, 1982). The river systems are used by freshwater fish for feeding, breeding, nursery site, and migration routes. Fish assemblages in rivers and lakes display spatial and temporal variation due to anthropogenic activities and environmental fluctuations (Jackson *et al.*, 2001). Human activities and urban and industrial development throughout the world affect the river ecosystem. Eutrophication, river-lake isolation, and overfishing change the fish assemblage structure and diversity (Volanthen *et al.*, 2012). Thus, fish communities are important as a biological indicator of human-induced change in river and lake ecosystems (Ru, 2013). The present study aimed to study the fish species composition, distribution, and community structure in the Pathariya River of Kailali district.

Materials and Methods

Study area

Pathariya River is located in Kailali district Western, Nepal, having a total length of 45km. But the study was carried out from Malbhanga to Dhunganatol covering a length of about 36km. The Pathariya River originates from Churia hill in the north and finally discharges into Mohana river at Dhunganatol in the south. It lies between 28°22' and 29°05' North latitude and 80°30' to 81°18' East longitude. Altitude ranges 109 m to 1950 m from sea level, the climate varies from tropical to subtropical, the average rainfall is 1840mm, the average annual temperature in Autumn reaches a maximum of 43°C and a minimum of 24°C while in winter maximum temperature is 19°C and minimum temperature is 15°C. Four stations (A, B, C, and D) for the study were selected representing upstream, urban and downstream sites from Malbhanga to Dhunganatol based on accessibility/human disturbances, altitudinal variation, dams, and confluences meeting of other tributaries (Figure 1).

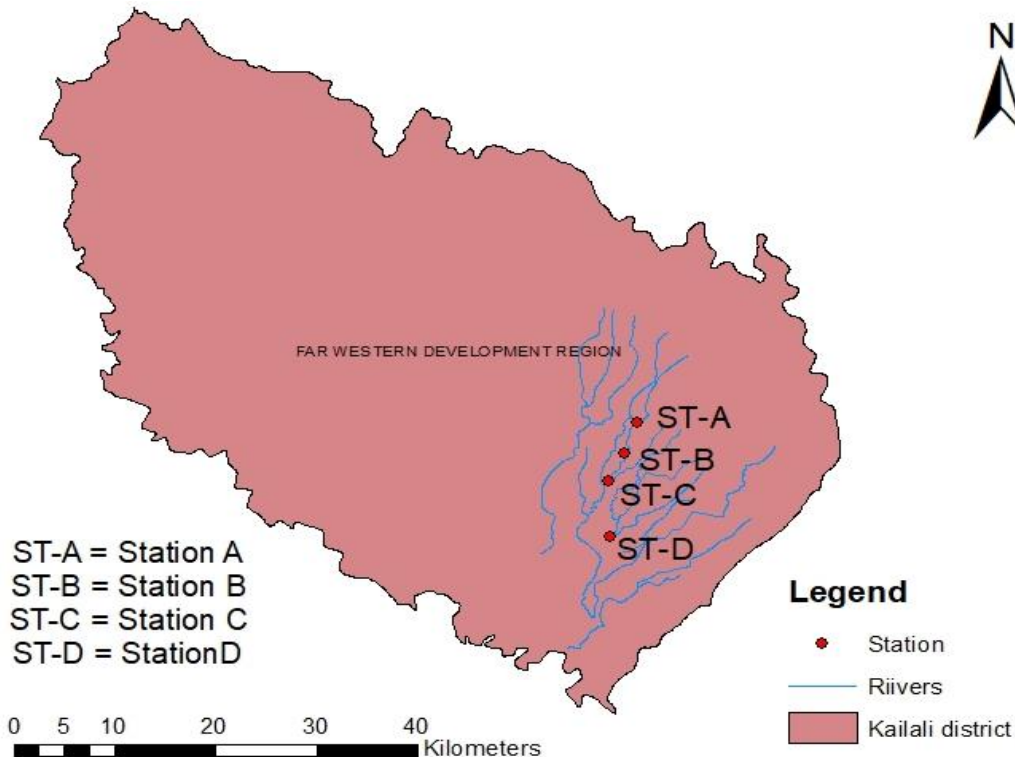


Figure 1. Map of the study area.

Data collection, identification and preservation

For the present investigation the fieldwork was conducted from September 2017 to August 2018 with four seasons- Autumn (September, October, and November), Winter (December, January, and February), Spring (March, April, and May), and summer (June, July, and August). Fishes were sampled at 4 stations using a medium-size cast net of mesh size ranging from 1.5 cm to 2.5 cm and Gill net having 2-3 cm mesh size, 30-35 feet length and 3-4 feet width, with the help of local fisherman. These fishing gears were operated within a 100 m area of each site for 1 hour in each station from 9 am-10 am. A total of 40 throws were made for cast net and 4 hauls for gill net to catch fishes. For estimation of abundance of fishes, two pass removal method (Seber and Le Cren, 1967) was used. Each removal pass includes moving first upstream/river and then downstream/river within a pre-determined length (100m) with an equal effort of 30 minutes for each pass at each station of the river.

The collected fishes were counted, examined, and identified based on their key morphological characters. Fish samples that seemed difficult to identify on spot were preserved in 10% buffered formalin and brought to the Central Department of Zoology, Tribhuvan University for further study. Finally, the identification of fish was carried out following the taxonomic keys of Talwar and Jhingran (1991), Jayram (2010), and Shrestha (2019).

Water samples were collected and both physical and chemical properties were analyzed following the standard methods of Adoni (1985), Trivedy and Goel (1984), and the American Public Health Association (APHA,1998). Water temperature was measured using a digital thermometer by submerging it to the depth of one foot for 2-3 minutes. DO meter (Model: DO5509, Lutron) and pH meter (HI 98107, HANNA instruments) were used to measure DO and pH respectively. The float method was carried out to measure the velocity of the water. Transparency and turbidity were measured by the Sechii disc method, by dipping a metallic plate consisting of alternative black and white quadrants on the surface and a hook tied up

with string. Free CO₂ was measured by titration method, while EDTA complexometric titration was carried out to analyze water hardness.

Data analysis

The diversity of the fish assemblage was quantified in the first step of data processing, and then a statistical comparison was performed. Detrended correspondence analysis (DCA) (Hill and Gouch, 1983) was used to investigate the relationship between fish community structure and environmental variables. The eigenvalue (0.53) and axis length (3.17) obtained from DCA suggested that the linear model associated with CCA was more applicable. Therefore, a direct multivariate ordination method (Legendre and Legendrem, 1998) based on a linear response of species to environmental gradients was applied.

Results and discussion***Fish species composition***

A total of 407 individuals representing 25 species belonging to 4 orders, 8 families, and 16 genera were recorded (Table 1). Among four orders, Cypriniformes was found to be dominating order followed by Siluriformes, Symbranchiformes, and Perciformes (Figure 2). Of 8 families, Cyprinidae was found to be having a higher number of fish species followed by Bagridae, Mastacembelidae, Channidae, Claridae, Nandidae, and the smallest family was Siluridae which comprised the least number of fish species (Figure 3). This result is in line with the findings of several previous research works (Limbu *et al.*, 2018; Limbu *et al.*, 2019; Limbu and Gupta, 2019; Limbu and Prasad, 2020, Limbu *et al.*, 2021a; Tumbahangfe *et al.*, 2021; Shrestha *et al.*, 2021), who have stated that the majority of freshwater fishes fall under the order Cypriniformes and family Cyprinidae. Among 25 fish species, *Puntius ticto* was recorded in the largest number and followed by *Puntius sophore* and *Mystus tengra* while *Labeo caeruleus* was recorded in the smallest number and followed by *Labeo rohita*, *Ompok bimaculatus*, and *Cynophyrngodon idelius*.

Table 1: Fishes of Pathariya River.

Order	Family	Code	Species
Cypriniformes	Cyprinidae	C1	<i>Puntius sophore</i> Hamilton-Buchanan, 1822
	Cyprinidae	C2	<i>Puntius terio</i> Hamilton-Buchanan, 1822
	Cyprinidae	C3	<i>Puntius ticto</i> Hamilton, 1822
	Cyprinidae	C4	<i>Labeo rohita</i> Hamilton, 1822
	Cyprinidae	C5	<i>Labeo calbasu</i> Hamilton, 1822
	Cyprinidae	C6	<i>Labeo caeruleus</i> Day, 1877
	Cyprinidae	C7	<i>Cirrhinus mrigala</i> Hamilton, 1822
	Cyprinidae	C8	<i>Cirrhinus reba</i> Hamilton, 1822
	Cyprinidae	C9	<i>Barilius barila</i> Hamilton, 1822
	Cyprinidae	C10	<i>Aspidoparia morar</i> Day, 1878
	Cyprinidae	C11	<i>Esomus danricus</i> Hamilton, 1822
	Cyprinidae	C12	<i>Cytnopharyngodon idellus</i> Valenciennes, 1844
	Cobitidae	C13	<i>Acanthocobotis botia</i> Hamilton, 1822
	Cobitidae	C14	<i>Lepidocephalus guntea</i> Hamilton-Buchanan, 1822
	Cobitidae	C15	<i>Lepidocephalus menoni</i> Pillai and Yazdani, 1976
Siluriformes	Bagridae	C16	<i>Mystus tengra</i> Misra, 1976
	Bagridae	C17	<i>Mystus bleekeri</i> Day, 1877
	Bagridae	C18	<i>Mystus vittatus</i> Bloch, 1797
	Bagridae	C19	<i>Aporichthys seenhala</i> Sykes, 1839
	Claridae	C20	<i>Clarius batrachus</i> Linnaeus, 1758
	Siluridae	C21	<i>Ompok bimaculatus</i> Bloch, 1794
Perciformes	Channidae	C22	<i>Channa punctatus</i> Bloch, 1793
	Nandidae	C23	<i>Nandus nandus</i> Hamilton, 1822
Synbranchiforms	Mastacembelidae	C24	<i>Macrognathus aral</i> Bloch and Schneider, 1801
	Mastacembelidae	C25	<i>Mastacembelus armatus</i> Lacepede, 1800

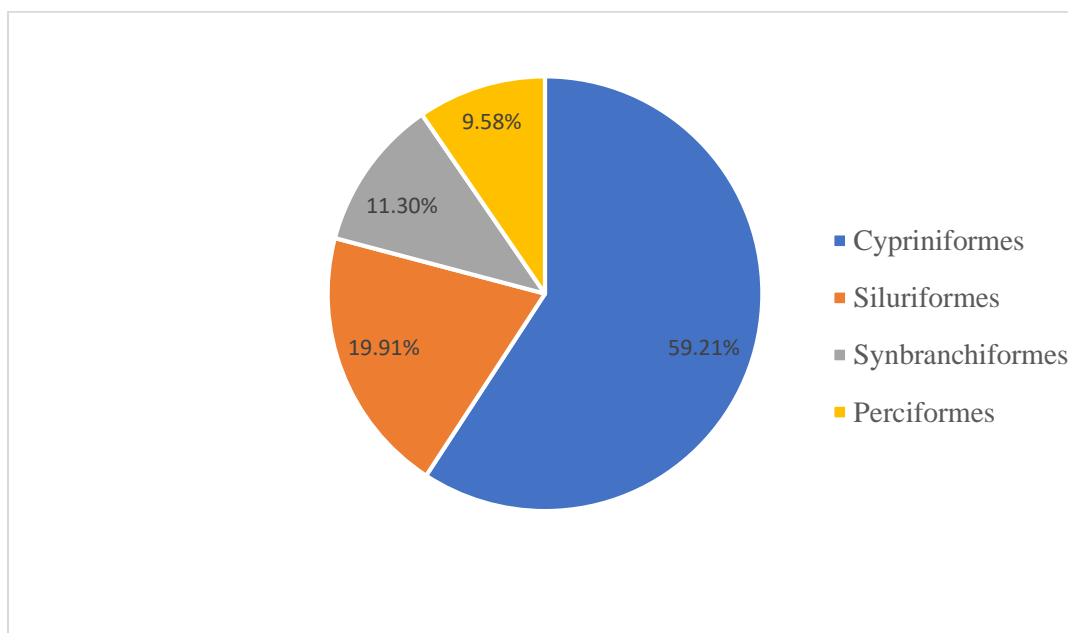


Figure 2: Order-wise percentage composition of fishes of Pathariya River.

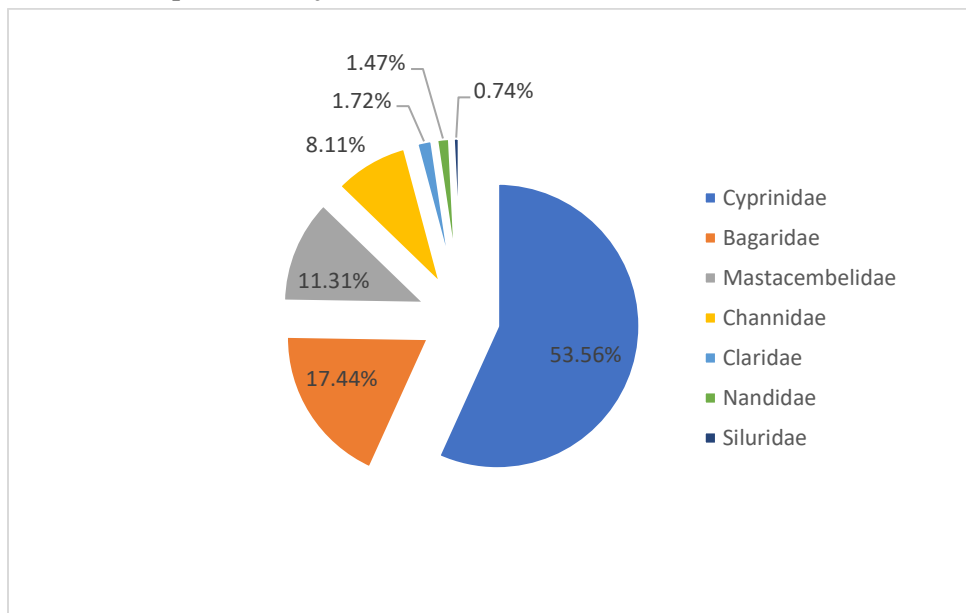


Figure 3. Family-wise percentage composition of fishes of Pathariya River.

Fish community vs Physico-chemical parameters

The CCA biplot indicated the relationship between species and environmental variables (Figure 4). The fish species of C16, C8, C20, C23, C21, C4, C15, C12, C6, C18, and C5 are positively related to water temperature, water velocity, and total hardness but negatively related to pH, transparency, and free carbon dioxide. Similarly, the fish species of C1, C3, and C17 are highly associated with pH, transparency, and free carbon dioxide. Furthermore, dissolved oxygen is positively related to species of C24, C9, C13, and C14. Meanwhile, species of C2, C7, C25, C10, C19, and C22 are not related to any selected environmental variables. One-way analysis of variance on Canonical correspondence analysis (CCA) vindicated that among the selected parameters, dissolved oxygen, free carbon dioxide, and total hardness were the influencing factors ($P < 0.05$) to shape the fish community structure. Limbu *et al.* (2021b) and Shrestha *et al.* (2021) observed that the environmental variables such as conductivity, DO, pH, alkalinity, and salinity were most intensely correlated with the fish community composition of the Betani River and Lohore River, Nepal. Moreover, the diversity and distribution pattern of fish has been widely related to the environmental factors like dissolved oxygen (DO), free carbon dioxide (CO₂), pH, alkalinity, and more critically

with the temperature (Yan *et al.*, 2010; GC and Limbu, 2019; Chaudhary *et al.*, 2020; Limbu *et al.*, 2020; Limbu and Prasad, 2020; Prasad *et al.*, 2020; Rajbanshi *et al.*, 2021a; 2021b; Chaudhary and Limbu, 2021). The fish abundance lower in winter and higher in summer were found in the present study (Appendix I). Likewise, Pokharel (2011) from Seti Gandaki River, Jaramilla-Villa *et al.* (2011) from central Andes Columbia, Jaun *et al.* (2015) from northern Andes Columbia reported higher fish abundance in summer and lower in winter. This is due to changes in environmental variables and these variables are mostly influenced by altitude and seasons. Some species are seasonal like *Puntius*, *Mystus* and *Channa* are highly abundant in Pathariya River in the summer season, and their abundance decrease in the winter season. A similar type of results was found by Oli *et al.* (2013) from Rampur Ghol, and Rizal (2015) from Tinau River. This may be due to the availability of food resources, habitat area, environmental factors, and refuge from predators. Different environmental variables influence fish health as well as the diversity and distribution of fishes in water bodies. In the present study, the highest temperature and transparency were observed in spring, lowest temperature and transparency were observed in winter and summer seasons (Appendix II) respectively.

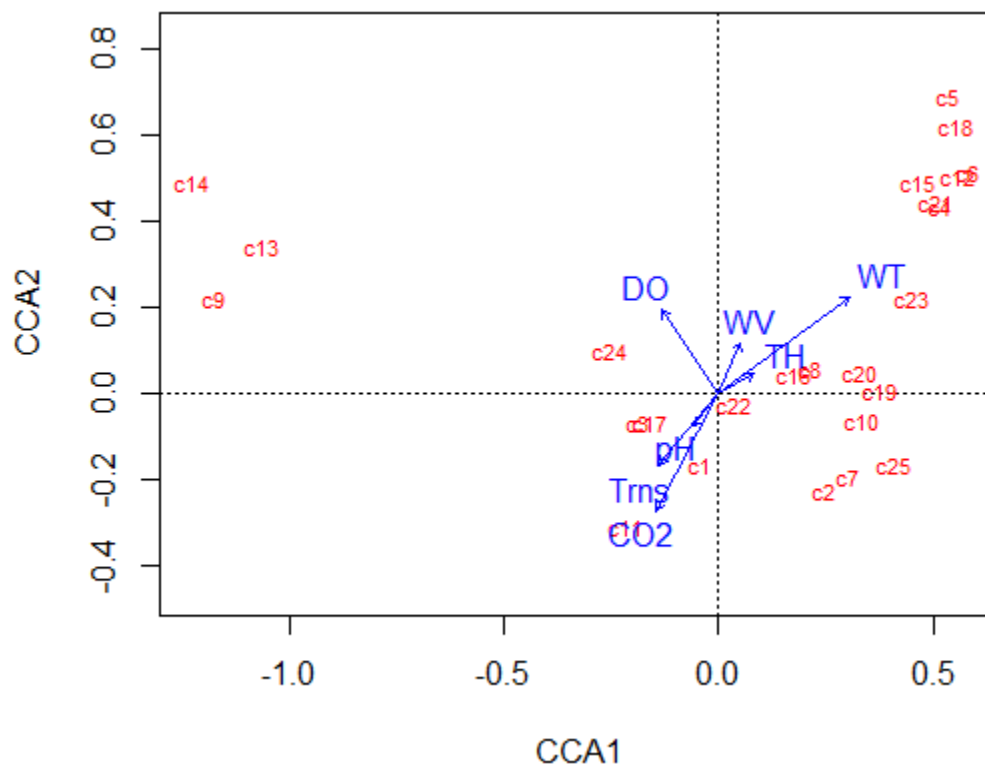


Figure 4. Ordination bi-plot of the fish species assemblages and environmental variables obtained by Canonical correspondence analysis (CCA) (WV = water velocity, WT = water temperature, TH = total hardness, CO₂ = free carbon dioxide, Trns = transparency); (for species code see table 1).

Yadav (2017) also found lower temperatures during winter in the Bagmati river. The variation in temperature could be due to seasons and altitude. The fish abundance and species richness are positively correlated with water temperature is an important factor that affect on growth and development of fishes. Santosh and Singh (2007) suggested that transparency between 30cm to 40cm is suitable for the high productivity of fish ponds. The different factors like dispersion of plankton, suspended clay particles, organic matter, pigment as well as human activities also affect on transparency of the river water. Generally, the velocity of water decreases downstream but in the present study velocity of water was found to be increased downstream (station D). It could be due to the impacts of tributary or mainstream. The chemical parameter of water such as (pH) greatly influence the survival of fish in both lotic as well as

lentic water systems. In the present study, the water of the Pathariya river was slightly alkaline. Rijal (2015) from the Tinau river and Yadav (2017) from the Bagmati river also reported slightly alkaline water. According to Santosh and Singh (2007), the suitable value of pH for freshwater fish species ranges from 7 to 8.5 above and below which is stress full for fish. The value of pH is greatly influenced by the concentration of CO₂ gas. Both high and low levels of DO are fatal to the fish species. DO is an important factor that affects the distribution, growth, survival, physiological, and behavior of fishes. In the study period, the highest value of DO in summer and the lowest value of DO in winter were recorded. The amount of required dissolved oxygen is different for different fish species and it depends on seasons and weather. Bhatnagar *et al.* (2004) reported suitable amount of oxygen level is greater than 5mg/l for fish while

according to Santosh and Singh (2007) catfish and other air-breathing fishes can survive in low concentration of oxygen less than 4mg/l. The solubility of oxygen in water decreases due to an increase in salinity, temperature, low atmospheric pressure, high amount of plankton, and submerged plants in water. Free carbon dioxide is highly soluble in water and the main sources of CO₂ in water from atmospheric CO₂ and the respiration of aquatic animals. The high concentration of CO₂ causes a reduction in the concentration of pH. In the present study, the highest amount of CO₂ in winter and the lowest amounts of CO₂ in spring (March) seasons were recorded. According to Boyd and Lichtkoppler (1998) fish avoid free CO₂ levels as low as 5 mg/l but most species can survive in water containing up to 60 mg/l in running water. However, according to Santosh and Singh (2007) the CO₂ in water less than 5 mg/l support good fish production in the pond. Hardness is the measure of alkaline earth metals such as calcium and magnesium which are essential to fish for bone and scale formation.

Conclusion

A total of 407 individuals representing 25 species from 4 orders, 8 families, and 16 genera were recorded. Among the 25 fish species, *Puntius ticto* had the most records, followed by *Puntius sophore* and *Mystus tengra*, while *Labeo caeruleus* had the fewest, followed by *Labeo rohita*, *Ompok bimaculatus*, and *Cytnophyrngodon idelius*. The one-way analysis of variance on Canonical correspondence analysis (CCA) confirmed that dissolved oxygen, free carbon dioxide, and total hardness were the influencing factors ($P < 0.05$) in shaping the fish community structure.

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Appendix -I

Station	Season	c1	c2	c3	c4	c5	c6	c7	c8	c9	c10	c11	c12	c13	c14	c15	c16	c17	c18	c19	c20	c21	c22	c23	c24	c25
A	Autumn	5	0	7	0	0	0	0	0	6	0	3	0	5	4	0	0	4	0	0	0	0	4	0	5	0
A	Winter	2	0	4	0	0	0	0	0	2	0	0	0	1	0	0	0	2	0	0	0	0	0	0	1	0
A	Spring	0	0	3	0	0	0	0	0	2	0	2	0	0	3	0	0	0	0	0	0	0	2	0	3	0
A	Summer	3	0	0	0	0	0	0	0	3	0	3	0	0	0	0	0	5	0	0	0	0	1	0	3	0
B	Autumn	4	3	5	0	0	0	2	0	0	5	2	0	0	0	0	0	3	0	2	0	0	2	0	4	0
B	Winter	2	0	4	0	0	0	0	0	0	2	2	0	0	0	0	0	2	0	3	0	0	1	0	0	0
B	Spring	0	3	1	0	0	0	2	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0
B	Summer	6	2	0	0	0	0	2	0	0	3	1	0	0	0	0	0	1	0	1	0	0	3	0	0	0
C	Autumn	4	2	5	2	0	0	3	0	0	3	4	0	0	0	0	0	4	0	5	3	2	3	2	2	3
C	Winter	1	0	2	0	0	0	1	0	0	2	3	0	0	0	0	0	0	0	2	0	0	2	0	0	1
C	Spring	0	1	1	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	1	0	1	0	1	0
C	Summer	2	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	1	0	1	1
D	Autumn	6	3	3	2	2	1	2	3	0	4	2	3	0	0	5	2	7	3	6	2	3	5	4	9	4
D	Winter	3	0	2	0	0	0	1	2	0	2	2	0	0	0	1	1	1	0	0	1	0	2	0	2	1
D	Spring	1	2	3	0	0	1	1	1	0	3	1	2	0	0	2	0	3	1	2	0	0	3	0	1	0
D	Summer	2	1	1	2	1	0	4	0	0	5	1	0	0	0	2	0	0	1	1	2	2	3	0	2	1
	Total	41	17	43	6	3	2	20	6	13	31	31	5	6	7	10	3	35	5	22	9	7	33	6	35	11

Appendix-II

Station	Season	Water temperature (°C)	Transparency (cm)	Water velocity (m/s)	pH	Dissolved oxygen (mg/l)	CO ₂ (mg/l)	Total hardness (mg/l)
A	Autumn	23	25	0.83	7.8	8.52	7.82	155
A	Winter	19	60	0.83	8	8.21	9.53	153
A	Spring	25	70	0.66	7.7	9.67	7.35	150
A	Summer	25	15	1.5	7.9	10.66	7.35	156
B	Autumn	26	20	0.66	7.6	7.25	7.32	157
B	Winter	17	57	0.05	8.2	6.84	10.73	159
B	Spring	28	68	0.25	7.8	7.05	6.72	155
B	Summer	27	10	1.83	7.6	8.33	6.83	161
C	Autumn	27	22	0.66	7.6	7.11	7.25	160
C	Winter	17	57	0.03	8.2	6.56	11.85	152
C	Spring	29	55	0.28	7.8	6.98	6.53	160
C	Summer	28	8	1.83	7.7	8.54	6.67	160
D	Autumn	27	18	0.83	7.6	7.83	7.25	165
D	Winter	15	75	0.66	8.4	6.74	10.73	157
D	Spring	29	77	0.58	7.5	7.51	6.32	163
D	Summer	28	7	2.16	7.5	10.66	6.68	170

