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Status of fish diversity and their Habitat Ecology in the upper Ganga Basin, Uttarakhand

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ABSTRACT

Ganges is the largest riverine ecosystem of India and supports diverse aquatic community compared to others aquatic ecosystem. The aim of the present study was carried out to assess the fish diversity status in relation to major physico-chemical parameters on spatiotemporal scales. Fish species were collected along with physicochemical parameters from selected eight sampling zones of the upper Ganga basin from September 2017 to August 2018. Aquatic diversity status was analysed with the help of PAST (version 3.0) software. The result of present experimental study clearly indicated that upper Ganga river basin provides the natural habitat of 27 fish species as *Tor putitora (8.54%), Tor tor* (10.68%), *Schizothorax richardsonii* (11.50%) and *S. plagiostomus* (10.95%) are major dominant species. Water temperature, water velocity and dissolved oxygen contributed as major influential ecological factors for fish species richness and their distribution in the upper Ganga river ecosystem.

Key words : *Fish diversity, Habitat ecology, Upper Ganga basin, Temporal, Spatial abundance.*

Introduction

The Ganges river system along with its tributaries forms the single largest riverine system in India. Mainly river Ganga originates from the Gangotri to the Bay of Bengal and is divided into three major stretches i.e. the upper Ganga river stretch from Gangotri to Haridwar, middle Ganga river stretch from Haridwar to Varanasi and the lower Ganga river stretch from Varanasi to Bay of Bengal (Malik *et al*., 2003) not only due to the difference in geomorphology, ecology and rheology but also in term of socio cultural heritage. Upper Ganga segment lies in Garhwal region (Latitude $29^0$26′ to $31^0$28′N) and (Longitude $77^0$49′ to $86^0$06′E) of the central Himalayas with the total geographical area of 39,090 sq. Km. (Nautiyal *et al*., 1993). The upper segment flows on the steep and narrow bed, commonly the substrate is in form of boulders, cobbles and rocks which carried cold water are less subjected to anthropogenic pollution. The lotic ecosystem of Bhagirathi river is characterized by cold water, high water velocity, low productivity and distinct aquatic biodiversity with abundant rapids, runs, riffles and few deep pools. Upper Ganga basin supports the survival of million with an average density of about 1,000 inhabitants per square kilometre. Mainly the river water is being utilized for many purposes, i.e., fishing, irrigation, transportation and domestic usage. Ganga and its tributaries are controlled by barrages diverting flow for various purposes, i.e. for agricultural purposes, for drinking etc as a result fish catch have been declined, and thereafter, loss of species diversity. Fish diversity is par-

tially dependent upon certain environmental variable which always effect the competing population. Various studies regarding fish fauna of the river Ganges and its tributaries have been made by various authors (Sarkar *et al.,* 2010; Sharma *et al.,* 2019). However, considering the reason mentioned above the present study aimed to investigate the status of fish species in relation to the habitat ecology.

Materials and Methods

Study Area

The study area was divided into four sampling zones and every zone has further three stations for the collection of hydrological parameters and fish species. Upper Bhagirathi river (Z1), Lower Bhagirathi river (Z2), Upper Ganga river (Z3) and Lower Ganga river (Z4), was selected to along upper Ganga basin to analyse the physicochemical characteristics and fish species richness. Fish samples were collected with the help of local fish anglers, local landing canters and from the previously contacted fisherman. For laboratory research work few samples from the total catch was collected from each sampling zone and frozen them in the ice box. Further, fish species sample were sorted and identified to species level. The water temperature was determined with the help of digital thermometer (Testo 1113-TMH) pH by using a pen-type meter (HANNA = HI98107) TDS and Conductivity by using a pen type meter (HANNA = HI98301). A Secchi disc (20 cm diameter) was used to measure the water transparency.

Results and Discussion

Distinct hydro-graphic conditions of different zones during different months. Maximum water temperature was recorded 21.2 ^{0}C at Zone 4 during July where the minimum water temperature was found 10.9 ^{o}C at Zone 1 during January, it can be due to direct relationship between bright sunshine, its duration and air temperature. Maximum average water temperature 16.4 ^{0}C recorded at zone 4 and minimum average water temperature 14.9 ^{0}C was recorded at zone 3. No significant difference was found in temperature among the stations. Water temperature was recorded minimum at Zone 1 and maximum at Zone 4 due to seasonal and altitudinal variation. Kumar *et al.,* (2018) also reported a variation in water temperature during seasonal changes. Khanna *et al.,* (2013) observed seasonal variation of water temperature ranged between 8.0 to 18.0 °C in the Bhagirathi river. Water pH values vary between 7.2 (July in Zone 2 and June, July in zone 1) to 8.2 during February in Zone 1). Mean water pH found in highest value 7.63 at zone 1 & zone 3 where lowest value 7.57 at Zone 4. Because the availability of many types of carbonates and bicarbonates in water enhance dissolve carbon dioxide level by dissociation and acts as a raw material for photosynthesis. Similarity observation was reported by (Ayoade *et al.,* 2009). TDS ranges from 235.4 mg/L (recorded during September at zone 4) to 63.7 mg/L (recorded during June at zone 1and Zone 2). Turbidity ranges from 535 NTU (recorded during October at zone 4) to 52 NTU (recorded during January at zone 1). The water was exceedingly turbid (539.2 NTU) during October, while it was clear (53.0 NTU) in January at Zone 1. Overall turbidity was highest during the monsoon months (July- August) due to highest precipitation in the catchment basin. Similarly, observation has been made by (Pathak *et al.,* 2015) while working on the determination of water quality index river Bhagirathi in Uttarkashi, Uttarakhand. Dissolve Oxygen (DO) ranges from 9.3 mg/L (recorded during February at zone 2) to 7.1 mg/L (recorded during June at zone 4) with a maximum mean 8.15 mg/L at zone 2 and minimum mean 7.96 mg/L at Zone 4. The reduction of DO might be due to organic load through the municipal, domestic sewage and nutrients. Dissolved Oxygen ranges between 7.1 and 9.3 mg/L and the almost same value is also reported by (Malik *et al.,* 2018) in the river Bhagirathi river. Srivastava *et al.,* (2016) recorded DO concentration of Ganga river which ranged from 5.4–8.2 mg/L. COD ranges from 6.6 mg/L (recorded during January at zone 4) to 5.1 mg/L (recorded during June at zone 1and in March at Zone 4). BOD ranges from 2.6 mg/L (recorded during June at zone 1 and July at Zone 4) to 1.0 mg/L (recorded during February at zone 1). Maximum mean 2.0 mg/L at zone 4 and minimum mean 1.94 mg/L at Zone 1due to high temperature favour microbial activity.

Fish species diversity (Species abundance and distribution)

Total of 1825 individuals were enumerated which comprises 27 fish species (Table 1). Maximum number of major fish species was counted for

Schizothorax richardsonii (210 individuals), *Schizothorax plagiostomus* (200 individuals), *Tor tor* (195 individuals) and minimum for *Namachelius montanus* (19 individuals), in which *Schizothorax richardsonii* are maximum (11.50 %) and *Namachelius montanus* are (1.04 %) of total individuals respectively. The highest number of 520 individuals was counted in zone 4 throughout the study period whereas lowest number of individuals (391) was found in zone 3 due to relatively low human interference and optimum environmental condition and on the other hand, the lowest number of individuals observed at zone 3 due to an extreme environmental condition. Monthly abundance (individuals) variation was significant in all sampling zones. Highest number (249) of individuals was recorded in January. The monthly abundance for each sampling zone sharply reduced from June to September. The occurrence of fish species and their relative abundance is related with the number of factors viz. velocity, nature of substratum, water temperature, and water depth, availability of food, physicochemical properties and stream length (Kumar *et al.,* 2019). Sharma *et al.,* (2018) reported about 20 species collected by different types of the net from

Table 1. Temporal and spatial species abundance and distribution of fish species at selected sampling zones during 2016-2017

Code	Species	No.	%	Z_1	Z_2	Z_3	Z_4	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug
F1	*Schizothorax richardsonii*	210	11.507	89	40	43	38	10	19	25	32	27	20	18	12	16	10	13	8
F2	*S. plagiostomus*	200	10.959	90	32	35	43	10	17	22	33	21	16	17	12	16	13	11	12
F3	*Tor tor*	195	10.685	40	65	58	32	6	7	16	15	18	28	15	16	24	16	25	9
F4	*T. putitora*	**156**	8.548	33	50	45	28	10	12	14	12	16	13	21	15	11	13	10	9
F5	*Crossocheilus latius*	6 7	3.671	14	20	24	9	3	4	6	5	8	9	8	4	4	8	5	3
F6	*Garra gotyla gotyla*	55	3.014	12	10	12	21	1	1	3	2	7	8	5	4	8	9	4	3
F7	*G. lamta*	56	3.068	16	10	11	19	2	1	3	2	7	5	4	3	7	14	4	4
F8	*Barilius bendelisis*	98	5.370	22	14	24	38	3	6	9	14	16	9	7	5	15	10	3	1
F9	*Cirrhinus mrigala*	68	3.726	15	21	10	22	12	5	9	8	13	6	8	3	4	0	0	0
F10	*Catla catla*	50	2.740	9	14	14	13	2	0	5	0	12	7	5	4	5	4	3	3
F11	*Labeo rohita*	62	3.397	16	19	11	16	0	4	7	5	14	9	4	2	0	10	6	1
F12	*Danio devario*	46	2.521	7	11	12	16	4	3	7	4	9	2	6	4	3	0	1	3
F13	*Rasbora daniconius*	62	3.397	12	10	12	28	0	0	7	7	13	5	6	4	3	5	8	4
F14	*Namachelius rupicola*	26	1.425	4	5	6	11	0	1	0	0	10	3	1	4	5	2	0	0
F15	*N. beavani*	29	1.589	8	5	4	12	2	2	1	0	0	1	2	8	6	4	3	0
F16	*N. zonatus*	22	1.205	6	3	4	9	0	0	0	0	1	1	0	7	5	3	4	1
F17	*N. montanus*	19	1.041	4	3	2	10	1	0	2	1	0	2	1	3	5	2	1	1
F18	*Glyptothorax madraspatnam*	28	1.534	7	3	4	14	2	1	0	0	3	1	0	8	4	5	3	1
F19	*G. pectinopeterus*	29	1.589	8	5	3	13	1	1	0	0	0	2	0	3	9	6	4	3
F20	*G. cavia*	23	1.260	6	7	5	5	3	2	1	2	3	0	0	5	3	2	2	0
F21	*Bagarius bagarius*	41	2.247	10	2	1	28	4	4	3	3	5	4	7	4	2	2	1	2
F22	*Pseudechenies sulcatus*	56	3.068	19	10	12	15	5	4	5	3	12	5	4	2	1	4	5	6
F23	*Clupisoma garua*	58	3.178	18	11	13	16	5	6	7	4	10	6	5	3	0	4	6	2
F24	*Botia Dario*	36	1.973	10	8	5	13	2	0	1	2	3	0	5	10	6	4	3	0
F25	*Botia almorhae*	28	1.534	7	8	5	8	2	3	1	2	2	1	0	4	6	5	2	0
F26	*Mastacembelus armatus*	65	3.562	17	10	13	25	3	2	5	7	12	6	5	3	1	11	7	3
F27	*Oncorhynchus mykiss*	40	2.192	14	5	3	18	6	2	3	1	7	1	8	5	2	2	0	3
	Total	1825	100.00	513	401	391	520	99	107	162	164	249	170	162	157	171	168	134	82

Bhagirathi river, where Khanna *et al.*,(2013) observed 53 fish species from the Ganga river. The reasons for the reduction in species diversity are long-term change in hydrological and meteorological parameters. A large amount of fresh water discharge from dam and reservoir brings sediment and causes siltation and makes water turbid which ultimately effects on species number. The highest number of individuals was observed at Zone 4 and this is due to relatively low human interference and optimum environmental condition and on the other hand lowest number of individuals observed at Zone 3 due to extreme environmental interference. Five major dominant species was observed in the upper Ganga basin which is similar to several studies which reported the dominance of the resident species in the river (Sharma *et al.*, 2018; Agarwal *et al.*, 2011).

Diversity Status

Highest Simpson index (1-D) (0.9532) was found at Zone 4 and lowest (0.9155) was found at zone 1. Higher Simpson index (1-D) values were found in April (0.9468) where low during December (0.8899). Highest Shannon index (H) (3.17) was found at Zone 4 and lowest (2.874) was found at zone 1. Higher Shannon index (H) values were found in April (3.11) where low during December (2.549). Highest evenness value (0.8819) was found at Zone 4 and lowest (0.6557) was found at zone 1. Highest evenness value was found 0.8303 in April and lowest value observed 0.6096 in December. The main causes of the differences occurring in the biodiversity indexes are seasonal variations of nutrients at the seagrass beds affecting the coexistence of many shspecies (Huh and Kitting, 1985).

CCA analysis of species abundance and water parameters

The results obtained from first two axes were plotted in (Fig. 1). The vector length of a given variable indicates the importance of the variable in CCA analysis and the longest vector of pH at four showed significant correlation with zone Z1. Vector length of dissolved oxygen showed significant with zone Z2 and Z3 where water temperature showed significant relation with zone Z4. High values of pH are associated with *Pseudechenius sulcatus*and *Clupisoma garua.* High values of DO are associated with *Schizothorax plagiostomus*and *Tor tor.* High values of water velocity are associated with *Oncorhynchus mykiss* (Fig. 1).

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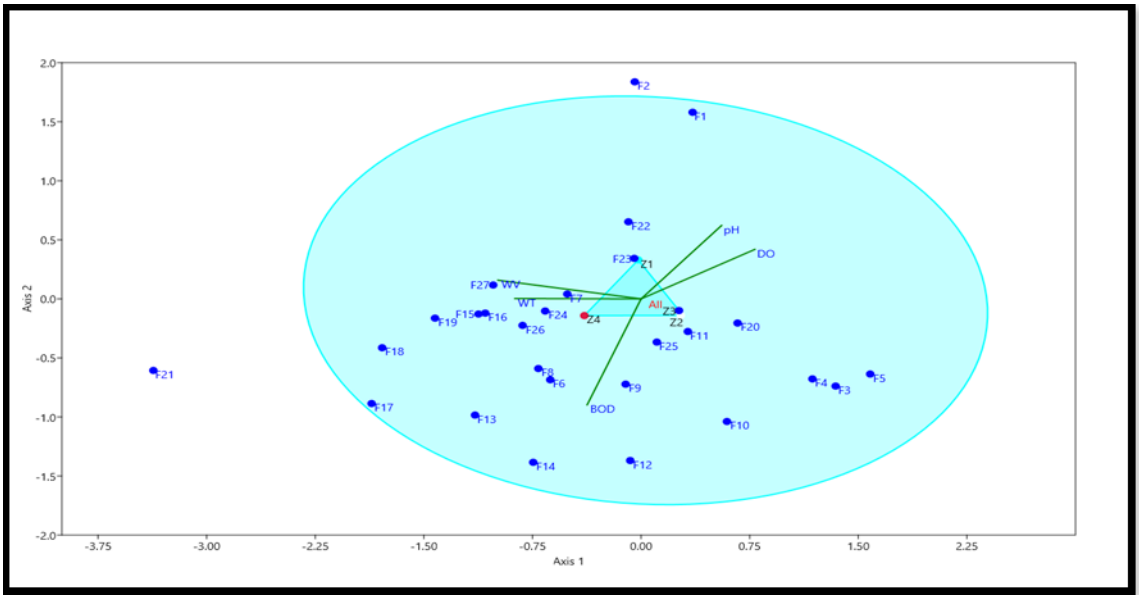

Fig. 1. CCA analysis of fish species abundance and water parameters.

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