ICHTHYOFAUNAL DIVERSITY OF BABAI RIVER OF DANG DISTRICT, NEPAL

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A thesis submitted in partial fulfillment of the requirement for the award of the Degree of Master of Science in Zoology with special paper Fish Biology and Aquaculture

Submitted To:

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Institute of Science and Technology
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September, 2019

DECLARATION

I hereby declare that the work presented in this thesis entitled " **ICHTHYOFAUNAL DIVERSITY OF BABAI RIVER OF DANG DISTRICT, NEPAL**" has been done by myself and has not been submitted elsewhere for the award any degree. All source of information have been specifically acknowledgement to the author (s) and institution (s).

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RECOMMENDATIONS

This is to recommend that the thesis entitled **"ICHTHYOFAUNAL DIVERSITY OF BABAI RIVER OF DANG DISTRICT, NEPAL"** has been carried out by Ms. Punam G.C. for the partial fulfillment of Master's Degree of Science in Zoology with special paper 'Aquaculture'. This is her original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

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LETTER OF APPROVAL

On the recommendation of supervisor "Assoc. Prof. Dr. Archana Prasad" this thesis submitted by Ms. Punam G.C. entitled **"ICHTHYOFAUNAL DIVERSITY OF BABAI RIVER OF DANG DISTRICT, NEPAL"** is approved for the examination in partial fulfillment of the requirements for Master's Degree of Science in Zoology with special paper Fish Biology and Aquaculture.

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CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Ms. Punam G.C. entitled **"ICHTHYOFAUNAL DIVERSITY OF BABAI RIVER OF DANG DISTRICT, NEPAL"** has been accepted as a partial fulfillment for the requirements of Master's Degree of Science in Zoology with special paper Fish Biology and Aquaculture.

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LIST OF ABBREVIATIONS

Abbreviated form	Details of abbreviation
APHA	American Public Health Association
CO_2	Carbon dioxide
DCA	Detrended Correspondence Analysis
DO	Dissolved Oxygen
EDTA	Ethylene diamine tetra acetic acid
RDA	Redundancy Analysis
W temp	Water temperature

Abstract

Babai River is one of the important River, originated from the eastern end of Dang valley. The present study deals with the study of fish diversity, habitat of fish species and environmental variables for three times in eight months covering three seasons; autumn, winter and spring. Fish sampling was done by using cast net, mosquito net and hook and line with the help of local fisherman from four sampling stations within 7km. Altogether 24 species of fishes belonging to 5 orders, 9 families and 15 genera has been recorded. Cypriniformes was found most dominant with 18 fish species followed by Siluriformes which comprises 3 fish species. The most dominant species of this river was found *Puntius sophore* followed by *Barilius bendelensis, Puntius terio* and *Puntius ticto*. The highest and lowest frequency occurrences were recorded 17.40 and 0.096 of *Puntius sophore* and *Erethistes pussilus* respectively. The highest Shannon Wiener diversity index, Evenness index was found in station III and highest Margalef value was found in station II whereas the lowest value of Shannon Wiener diversity and Margalef Species richness value was observed at station I and lowest value of Evenness index was observed at station II. Similarly, the highest Shannon Wiener diversity index , Margalef Species richness, Evenness index was found in Winter whereas lowest value of Shannon Wiener diversity index , Margalef Species richness, Evenness index was found in spring. The RDA analysis showed that environmental variables like water temperature, pH, free carbon-dioxide, water velocity and dissolved oxygen plays vital role to shape the fish assemblage structure of Babai River.

1. INTRODUCTION

1.1 Background of the study:

Variety of fish species, referred as ichthyofaunal diversity is, basically, the results of influence by physicochemical parameters of the habitat. Over 10,000 fish species live in freshwater (Lundberg et al. 2000). Icthyofaunal diversity is the indicator of wellbeing of the aquatic organisms and thus, represents a well-balanced ecosystem. The distribution and abundance of stream fishes are influenced by many factors operating at multiple scales (Schlosser 1987, Poff 1997). Local-scale habitat variables, such as substratum composition, presence of pools and the amount of available cover, have been shown to correlate strongly with fish assemblage structure (Ibarra and Stewart 1989, Fischer and Paukert 2008, Rowe et al. 2009).

Fish species diversity pattern in rivers is dependent on the complex interaction of the different ecological variables of the river viz., size, surface area of the drainage basin, mean annual river discharge, temperature, depth, flow velocity, channel morphology, substrate, and climate (Welcomme 1985, Hugueny 1989, Oberdorff et al. 1995, 1997, Pusey and Kennard 1996, Guégan et al. 1998, Bunn and Arthington 2002, Arrington and Winemiller 2003, Postel and Richter 2003, Poff and Zimmerman 2010). Stream size, hydrological variability, diversity of habitat, types and availability of in-stream production sources are some key environmental variables that shift along the fluvial gradient from upland headwaters to downstream reaches (Hynes 1970, Horwitz 1978, Vannote et al. 1980). Corresponding with these environmental shifts, the taxonomic structure of stream fish assemblages has been shown to change, and species richness typically increases along with stream size in higher order, lowland streams (Horwitz 1978, Rahel and Hubert, 1991).

Aquatic biodiversity is declining at an increasingly alarming rate, and correspondingly the numbers of imperiled species is increasing (Helfman 2007). Climate change has been identified as one of the major drivers of biodiversity changes in the coming decades (Sala et al. 2000). It is now evident that species from many taxonomic groups have responded to the recent climate modifications by shifting their ranges or becoming extinct locally (Parmesan and Yohe 2003, Root et al. 2003, Hickling et al. 2006). These individual responses may result in substantial changes at the assemblage level (Stralberg et al. 2009, Bertrand et al. 2011). Increasingly, tropical rivers are experiencing anthropogenic alteration related to dam construction, deforestation, pollution, and other impacts that are

expected to reduce food web connectivity and alter the trophic structure of fish assemblages (Dudgeon et al. 2006, Winemiller et al. 2016).

The diverse nature of ichthyofauna in Nepal is confirmed through several researches. Shrestha (2001) recorded 182 indigenous fish species from Nepal. Rajbansi (2005) prepared a checklist from the published literature and reported 187 species, while Saund and (Shrestha 2007) reported 199 species from Nepal. Similarly, (Shrestha 2008) reported 217 indigenous fish species and 15 exotic fish species from Nepal. As of now, a total of 252 fish species have been recorded (Shrestha, 2019), among which 236 species are native. The major river of Western Nepal, Karnali is the habitat of 121 species (Smith et al. 1996). A total of 40 species were recorded in Babai River in Bardiya district (Singh, 2001). Though a lot of studies have been performed in the main river systems, a lot of researches in fish ecology still need to be done in middle sized rivers. So, an attempt has been made to conduct a research in fish diversity of Babai River.

1.2 Babai River:

Babai River is one of the important and perennial middle sized river that drains the whole of Dang valley. It originates from the eastern end of Dang valley flows to the west up to Bardiya before entering India. A number of small rivers like Sewar khola, Hapur khola, Gwar khola, join the river at different places within Dang valley. The Sharada River, originated from Salyan, is the main tributary of Babai, which confluxes at the place Kalimati Kalche. The Babai river flows from east to west about 40km inside the Bardiya National Park and then turns south crossing the Chure range to emerge into the terai plains, therefore important from biodiversity point of view (Singh 2001).

The Babai River is believed to be inhabited by a large number of aquatic animals, including fishes, Gharials and other macro invertebrates. *Labeo spp.*, *Channa spp.*, *Anguilla spp.*, *Barilius spp.*, *Puntius spp.*, *Tor spp.*, *Neolissocheilus spp*, are the fish species present in Babai (Singh 2001). The exploration of these aquatic animals is very much needed in order to find the existing as well as new species.

1.3 Objectives:

1.3.1 General Objective:

- To explore the ichthyofaunal diversity of Babai River, Dang.

1.3.2 Specific Objectives:

- To investigate the distribution, abundance and frequency of fishes.
- To determine the physicochemical parameters of River.
- To explore the habitat of fish species.

1.4 Significance of the study:

- The findings of the research are very helpful to enrich the fish diversity profile of Nepal.
- The findings show the effect of water quality in aquatic lives.
- This study also provides the information regarding habitat of fish species present in the river.

1.5 Limitation of the study:

Due to the limited lab facilities in the present study area, environmental variables like pH, water temperature, dissolved oxygen, free-carbon dioxide and water velocity were limited for the study.

2. LITERATURE REVIEW

Fish assemblage is an important element in aquatic ecosystem. It provides a good biological indication for the quality of freshwater ecosystems since it is sensitive to a broad range of stressors (Karr 1981, Oberdorff et al. 2002). It has been widely reported that the distribution and abundance of fish species are strongly correlated to environmental variables (Tejerina-Garro et al. 1998, Brown 2000). Local-scale habitat variables, such as substratum composition, presence of pools and the amount of available cover, have been shown to correlate strongly with fish assemblage structure (Ibarra and Stewart 1989, Fischer and Paukert 2008, Rowe et al. 2009). These abiotic parameters have short-term or long-term influences on the structure of fish assemblages (Gasith and Resh 1999). Apart from abiotic factors, biotic factors such as predation and competition could also affect fish assemblages through direct and indirect mechanisms (Jackson et al. 2001).

Fish species diversity pattern in rivers is dependent on the complex interaction of the different ecological variables of the river viz., size, surface area of the drainage basin, mean annual river discharge, temperature, depth, flow velocity, channel morphology, substrate, and climate (Welcomme 1985, Hugueny 1989, Oberdorff et al. 1995, 1997, Pusey and Kennard 1996, Guégan et al. 1998, Bunn and Arthington 2002, Arrington and Winemiller 2003, Postel and Richter 2003, Poff and Zimmerman 2010). Stream size, hydrological variability, diversity of habitat, types and availability of in-stream production sources are some key environmental variables that shift along the fluvial gradient from upland headwaters to downstream reaches (Hynes 1970, Horwitz 1978, Vannote et al. 1980). The above-mentioned environmental variables exhibit significant patterns with the fluvial gradient from upstream to downstream reaches influenced by urbanization with either an increase or decrease in abundance and species richness (Edds et al. 2002; Shrestha et al. 2009; Pease et al. 2012). Other studies such as Edds (1993) and Edds et al. (2002) have analyzed fish assemblage structure and their relationships with environmental variables in Gandaki and Narayani rivers of Nepal.

Stream-size (channel depth and width), discharge and F-CO2 have been mentioned as the most important habitat variables correlated with fish assemblage composition in Red River, USA, and North Tiaoxi River, China (Koel and Peterka 2003, Li et al. 2012). Likewise, Edds (1993) and Dubey et al. (2012) observed that the habitat variables such as conductivity, DO, pH, alkalinity, and salinity were most strongly correlated with the fish community composition of the Kali Gandaki River Basin, Nepal, and the Ganga

River Basin, India. Pokharel, Basnet, Majupuria & Baniya (2018), studied the relationship between fish and environmental variables from Seti Gandaki River Pokhara, Nepal and altogether 30 species of fishes belonging to 5 orders, 9 families and 24 genera were recorded. The redundancy analysis (RDA) revealed significant correlations between fish assemblage and environmental variables they concluded the most important environmental variables structuring the fish assemblage in the Seti Gandaki River Basin were depth, width, conductivity, DO, F-CO_2, SiO_2 and chlorides. Some other variables such as, pH, chlorides and NO_3–N were also important in structuring the fish communities.

Singh (2001) carried out a research in Babai river of Bardiya district, focused mainly on the fish diversity and recorded a total 40 species of fishes belonging to 6 orders, 13 families, and 26 genera. Shrestha (2016) also studied the fish diversity of Triyuga River of Udayapur district and focused only on the fish diversity rather than the environmental variables. Even though, a large number of contributions cited above, a lot of study needs to be done on the ecology and behaviour of fishes and their relationship with the water quality. Thus the present study is carried out to contribute further knowledge about the fish fauna. It is hoped that this study will provide baseline data for further research.

3. MATERIALS AND METHODS

3.1 Study area

The present study area, Babai River is a medium sized perennial river and situated in Dang district of Province no. 5 which originates from the eastern end of Dang valley and flows through Laxmipur, Saudiyar, Duruwa, and Urahari before meeting its tributary Sharada River at Kalimati Kalche and flows through the lowland of Dang, Banke and Bardiya district. The study area is located in the Dang district which starts from Urahari to Motipur at along the Babai River. The Gwar river confluences into Babai within the study area. The four stations were taken at Urahari, Shitalpur, Phulbari and Motipur within the length of 7km.

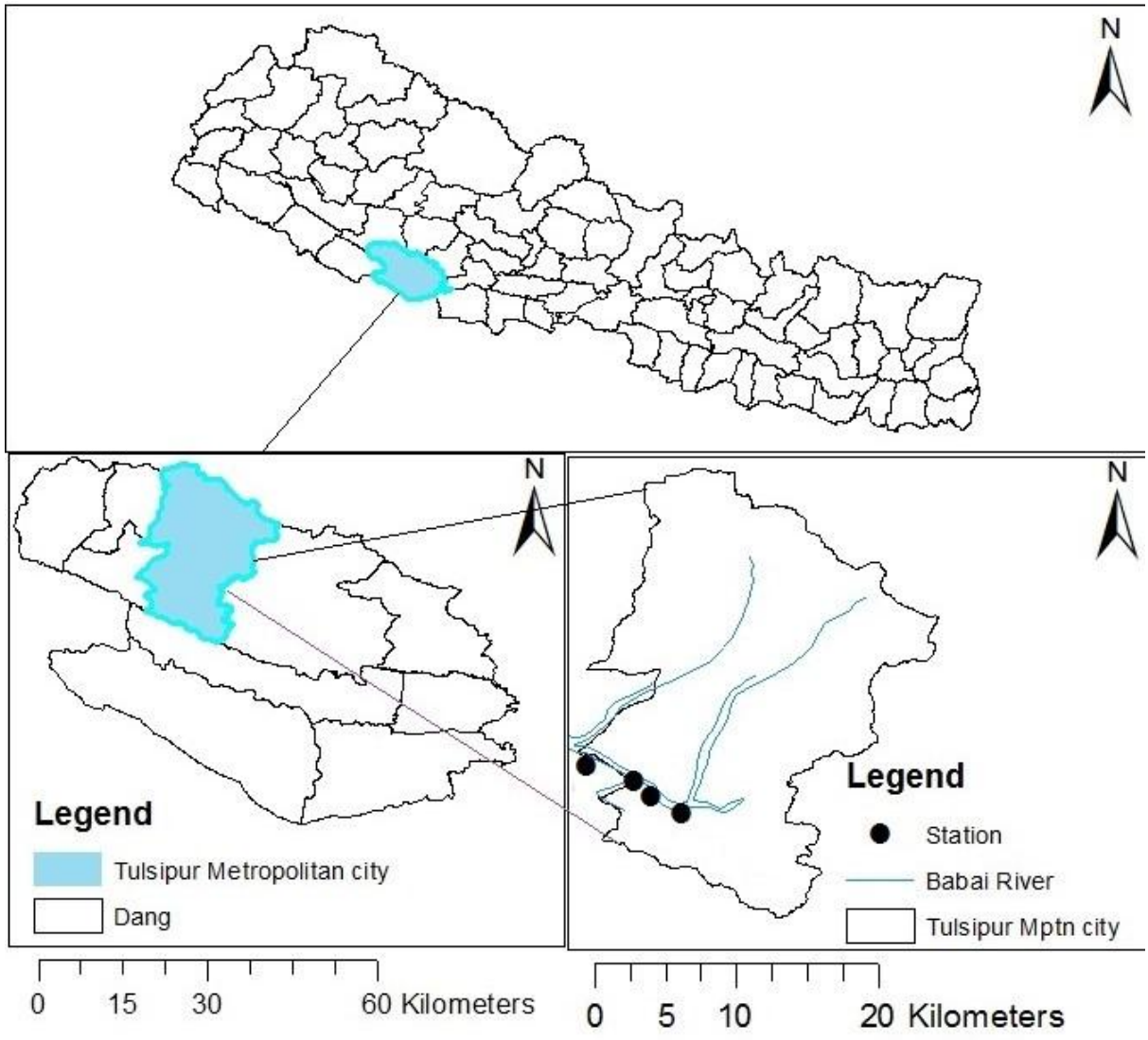

Fig 1: Map of the study area of Babai River

3.2 Sampling stations:

A preliminary survey was done prior to the selection of sampling sites and altogether four sampling sites I, II, III, and IV were taken along the river side. Sampling sites were selected on the basis of human settlement area, confluence point of river and near the Tulsipur- Amelia Highway (fig.1).

Sampling station I

The sampling site I (28°01'54.2″N 82°16'19.3″E) was selected at the conflux point of Sewa khola and Babai, in Urahari. This area is also near the human settlement area and using this for their household purpose like washing, bathing themselves as well as cattle.

Sampling station II

The sampling site II (28°02'28.7″N 82°15'10.8″E) was chosen near the bridge of Tulsipur-Amelia Highway in Shitalpur. This station is near the area of temple which is also used as picnic spot. The river bed consists of cobble, pebble and sand.

Sampling station III

The third sampling site (28°02'52.2″N 82°14'15.03″E) was selected at Phulbari which is the broader part of the river. The river bed consists of cobble, pebble and sand.

Sampling station IV

The sampling site (28°03'38.1″N 82°13'8.6″E) was selected at Motipur near Forest area. This site is the area after the conflux point of Tui Khola.

3.3 Sampling time period:

The field work was conducted three times in the month of October (autumn), January (winter) and May (spring) from October 2018 to May 2019.

3.4 Fish sampling, preservation techniques and identification:

For the present study, the fishes were collected from each stations with the help of local fishermen by using locally available fishing gear like cast net, mosquito net, hook and line. 6 mm × 6 mm mesh size of cast net was used for the collection of fishes is during morning time at 8- 11 am of autumn, winter and spring. Sampling was done near the periphery of 400- 500m in each station. Cast net was thrown 25 to 30 times in each station. Fish sampling was done near the runs, marshy places, edges of the river. The data collection was done from October 2018 to May 2019. The collected fishes were photographed at the spot with Samsung Galaxy J-5 Mobile camera and the identification was done at CDZ lab, as well as at the spot. The fishes were freed after identification in the river. The unidentified fishes were kept in 40% of formaldehyde for 7-8 hours, then preserved in 10% formalin for further study in CDZ lab. For the identification of fish

species, standard method of Talwar and Jhingran (1991), Jayram (1999), Shrestha (2019) were used. Habitat documentation of different fish species was done by direct observation.

3.5 Sampling of Environmental variables

The following Environmental variables were analyzed during each field visit:

3.5.1 Water temperature

Temperature is a measure of the degree of hotness or coldness of the body. Temperature measures how much the molecules of a substance are moving. When the substance is hotter, the molecules move more and vice-versa. Water temperature was recorded by using a standard mercury thermometer by dipping directly into water for two minutes. The result was expressed in degree Celsius (^oC).

3.5.2 Hydrogen ion concentration (pH)

The pH of water is a measurement of the concentration of hydrogen ion. It also indicates how acidic or basic a substance is. The pH was measured by using a calibrated pH meter (HI 98107, HANNA Instrument).

3.5.3 Free- carbon dioxide (CO_2)

To determine the free CO_2, 100 ml of sample was taken in a conical flask and few drops of phenolphthalein was added. Then the sample was titrated against 0.05N of NaOH until the slight pink end point was recorded. Calculation was done by using the following equation;

$$\text{Free } (CO_2) = \frac{(ml * Normality \ \ of \ NaOH * 1000 * 44)}{V}$$

Where, V = Volume of water sample taken

3.5.4 Water velocity

Water velocity was measured by the float method with the help of a stop watch, measuring tape and a floating plastic ball. A floating plastic ball was thrown in the flowing river then the distance travelled by the ball was measured by measuring tape and time taken was recorded with the help of stopwatch.

3.5.5 Dissolved Oxygen (DO)

DO (mg/l) was measured by the Winkler titra-metric method. Water from each sampling site was collected in 300ml BOD bottle without bubbling. Then, 2ml of $MnSO_4$ and 2ml of KI was poured gently from the side of the bottle, then this mixture was shaken well so

as to complete the reaction and the sample was left half an hour for the settlement of the precipitates (ppts.). Then, 2ml of conc. H_2SO_4 was added in the solution to dissolve the brown ppt. settled on the bottom. After this 0.025N sodium thiosulphate was taken in the burette rinsed by the solution for titration. About 50ml of the mixture was taken on the conical flask and one or two drops of starch solution was added as indicator. Then, the sample was titrated against the sodium thiosulphate solution, till the solution become colourless.

The value obtained was calculated by using following formula:

$$Dissoved\ oxygen\ \left(in\frac{mg}{ml}\right) = \frac{ml \times N\ of\ \ Na_2S_2O_3\ used\ during\ titration \times 8 \times 1000}{V_2\ (\frac{V_1 - V}{V_1})}$$

Where, V= Volume of $MnSO_4$ and KI
V1= Volume of BOD bottle
V2= Volume of part of titrant

3.6 Data analysis (RDA analysis)

Season and site-wise Shannon-Weiner index, were calculated by using R software. Mean values of environmental variables, standard deviation and species-species correlation were also calculated by using R software. Redundancy analysis (RDA), a direct multivariate ordination method (Ter Braak, 1988a; Ter Braak and Prentice 1988b) based on a linear response of species to environmental gradients (Gauch, 1982; Ter Braak 1986; Palmer, 1996) was applied by using vegan library in "R" (Oksanen *et al.*, 2015) to determine whether redundancy analysis (RDA), or canonical correspondence analysis (CCA) would be the most appropriate model to describe the association between species abundance, sites, seasons and environmental variables. The values of axis length and eigen values obtained from DCA suggested that the linear model associated with RDA was more applicable.

3.6.1 Season wise and Station wise Shannon- Weiner index (H′):

The diversity of species was calculated by using Shannon- Weiner diversity index (Shannon and Weaver, 1949). It is an information index and is the most commonly used diversity index in ecology. Technically, the Shannon- Weiner Index (when applied to ecology) quantifies the uncertainty associated with predicting or identifying new taxa, given number of taxa and evenness in abundance of individuals within each taxa.

Shannon Weiner diversity index is designated as H′ which is calculated as,

$H' = -\sum (ni\ N \times \ln ni\ N$

Where, ni = number of individuals of amount (biomass) of each of the species.

N=Total number of individuals in the sample.

Ln= Logarithm of base e.

The value of Shannon- Weiner Index was calculated by applying the data in R program in the following ways.

> library (vegan)

> diversity (diversity)

> diversity (diversity, index= "Shannon") and run

3.6.2 Species richness index (d):

The species richness is calculated by using Margalef species richness (Margalefs1968) which is designated by d, and calculated mathematically as,

Margalef species richness (d) =S-l/logN

Where,

S= Total no. of species

N=Total no. of individuals in the sample

3.6.3 Evenness Index (E):

To calculate whether species are distributed evenly across seasons and across landscapes elements, evenness index was determined by the following equations (Pieleu, 1966).

E= H/log S

H=Shannon Weiner s diversity index.

S= Total no. lf species in the sample.

4. RESULTS

4.1 Fish Diversity in Babai River, Dang:

The Babai River is the slow moving river that supports the diverse fish fauna. During the present study, different fish species were reported which includes 24 species 5 orders 9 families and 15 genera.

4.1.1 Distribution and frequency of fish species:

The distribution, and frequency of fish species in Babai River varied according to the seasons, station (Table 1).

Table 1: Fish distribution and frequency in Babai River, Dang

S. N.	Name of species	Autumn				Winter				Spring				Total	Frequency
		I	II	III	IV	I	II	III	IV	I	II	III	IV		
1.	*L. fimbriatus*	-	-	1	1	-	2	3	2	-	-	-	-	9	0.87
2.	*G. gotyla*	-	1	2	-	-	1	1	2	2	-	1	1	11	1.06
3.	*G. rupecula*	-	1	-	-	2	1	1	-	-	-	1	-	6	0.58
4.	*P. sophore*	12	39	16	20	11	4	8	12	-	11	14	33	180	17.40
5.	*P. terio*	10	17	14	19	5	-	7	9	-	4	15	18	118	11.41
6.	*P. chola*	5	9	7	13	1	4	11	-	9	-	8	5	72	6.96
7.	*P. ticto*	2	15	-	15	2	7	-	16	10	11	21	9	108	10.44
8.	*P. conchonius*	-	10	5	6	3	-	5	-	-	4	15	7	55	5.31
9.	*T. putitora*	1	-	-	-	-	-	-	1	-	-	-	-	2	0.19
10.	*B. bendelensis*	1	2	19	15	13	20	9	26	14	19	8	11	157	15.18
11.	*B. barila*	-	10	9	8	12	3	9	6	-	-	2	-	59	5.70
12.	*B. shacra*	-	-	-	-	5	8	15	9	-	-	-	-	37	3.57
13.	*B. modestus*	-	12	1	-	-	5	9	13	-	1	2	-	43	4.15
14	*B. barna*	-	2	-	-	-	3	1	-	-	-	1	-	7	0.67
15.	*D. devario*	-	-	6	7	-	-	15	8	-	1	3	4	44	4.25
16.	*P. balitora*	-	-	2	-	1	-	1	3	2	-	-	1	10	0.96
17.	*A. botia*	1	1	12	6	2	2	3	10	3	6	3	5	54	5.22
18.	*S. savona*	-	-	-	1	1	-	-	-	-	2	-	-	4	0.38
19.	*M. bleekeri*	10	1	2	-	2	7	11	-	1	4	-	-	38	3.67
20.	*E. pussilus*	-	1	-	-	-	-	-	-	-	-	-	-	1	0.096
21.	*H. fossilis*	-	-	-	-	-	-	1	-	-	-	1	-	2	0.19
22.	*X. cancila*	-	2	-	-	-	1	-	3	1	-	1	-	8	0.77
23.	*M. armatus*	-	1	-	4	-	-	-	-	-	-	1	1	7	0.67
24.	*C. punctata*	-	-	-	-	-	-	-	-	-	-	-	2	2	0.19
	Total													1034	

4.1.2 Systematic position of the fish:

Table 2. Systematic position of the fish

S. N.	Order	Sub-order	Family	Sub-family	Genus	Species
1.	Cypriniformes PL: I-VII		Cyprinidae	Cyprininae	*Labeo*	*L. frimbitus*
					Garra	*G. gotyla*
						G. rupecula
					Puntius	*P. sophore*
						P. terio
						P. chola
						P. ticto
						P. conchonius
					Tor	*T. putitora*
				Danioninae	*Barilius*	*B. bendelensis*
						B. barila
						B. shacra
						B. modestus
						B. barna
					Danio	*D. devario*
			Psilorhynchidae		*Psilorhynchus*	*P. balitora*
			Nemacheilidae		*Acanthocobotis*	*A. botia*
					Schistura	*S. savona*
2.	Siluriformes PL: VIII		Bagridae	Bagrinae	*Mystus*	*M. bleekeri*
			Sisoridae	Sisorinae	*Erethistes*	*E. pussilus*
			Heteropneustidae		*Heteropneustes*	*H. fossilis*
3.	Beloniformes PL: IX		Belonidae		*Xenentodon*	*X. cancila*
4.	Synbranchiformes PL: IX		Mastacembelidae		*Mastacembelus*	*M. armatus*
5.	Anabantiformes PL: IX	Channoidei	Channidae		*Channa*	*C. punctata*

4.1.3 Order wise fish composition:

During the present study, different fish species of 5 orders were recorded. Out of 1034 fish catch 976 belong to order Cypriniformes which is about 94.39% of total fish catch, 41 fishes belong to order Siluriformes which is 3.96%, 8 fishes belong to order Beloniformes which is 0.77%, 7 fishes belong to order Synbrachiformes which is 0.67% of total catch whereas Anabantiformes have the lowest no. of fish catch which is only 0.19%. So, the Babai River is dominated by order Cpriniformes (Fig.2).

Table 3.Order wise fish composition

S.N.	Order	No. of fish species	Frequency	No. of fish catch	Frequency
1.	Cypriniformes	18	75	976	94.39
2.	Siluriformes	3	12.5	41	3.96
3.	Beloniformes	1	4.16	8	0.77
4.	Synbrachiformes	1	4.16	7	0.67
5.	Anabantiformes	1	4.16	2	0.19
Total		24		1034	

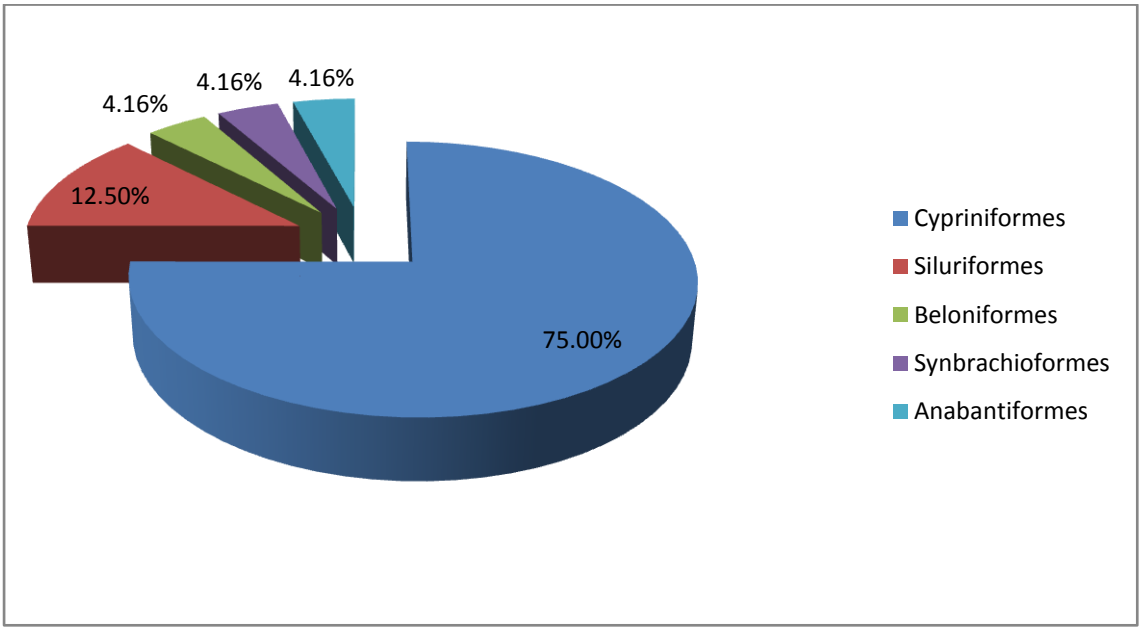

Fig 2: Order wise fish distribution in Babai River

4.1.3 Family wise fish composition:

During the study, fishes of 9 families were recorded. Out of 1034 total catch family Cyprinidae consists of 87.81% of total catch followed by family Nemacheilidae 5.60%, Bagridae 3.67%, Psilorhynchidae 0.96%, Belonidae 0.77%, Mastacembelidae 0.67%, Channidae and Heteropneustidae 0.19% followed by Sisoridae 0.096% . So the fishes of Cyprinidae family were dominant species in Babai River (Fig. 3).

Table 4: Family wise fish composition in Babai River

S.N.	Family	No. of fish species	Frequency	No. of fish catch	Frequency
1.	Cyprinidae	15	62.50	908	87.81
2.	Psilorhynchidae	1	4.16	10	0.96
3.	Nemacheilidae	2	8.33	58	5.60
4.	Bagridae	1	4.16	38	3.67
5.	Sisoridae	1	4.16	1	0.096
6.	Heteropneustidae	1	4.16	2	0.19
7.	Belonidae	1	4.16	8	0.77
8.	Mastacembelidae	1	4.16	7	0.67
9.	Channidae	1	4.16	2	0.19
	Total	24		1034	

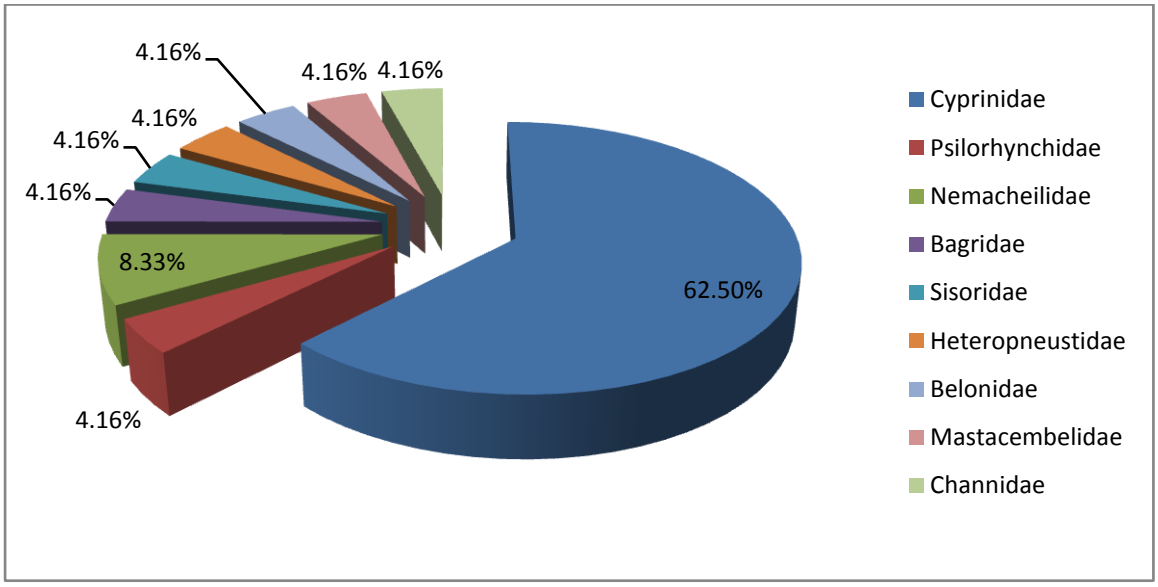

Fig 3: Family wise fish distribution in Babai River

Photo plate-I
Order: Cypriniformes

Labeo fimbriatus Bloch, 1795

Garra gotyla gotyla Gray, 1830

Garra rupecula McClelland, 1839

Photo plate-II

Puntius terio Hamilton- Buchanan, 1822

Puntius chola Hamilton- Buchanan, 1822

Photo plate-III

Puntius sophore Hamilton- Buchanan, 1822

Puntius ticto Hamilton- Buchanan, 1822

Photo plate-IV

Puntius conchonius Hamilton- Buchanan, 1822

Tor putitora Hamilton- Buchanan, 1822

Barilius bendelensis Day, 1878

Photo Plate V

Barilius modestus Day, 1872

Barilius barila Hamilton- Buchanan, 1822

Barilius shacra Hamilton- Buchanan, 1822

Photo Plate VI

Barilius barna Day, 1878

Danio devario Hamilton- Buchanan, 1822

Photo Plate VII

Psilorhynchus balitora Day,1877

Acanthocobotis botia Hamilton- Buchanan, 1822

Schistura savona Hamilton- Buchanan, 1822

Photo Plate VIII
Order: Siluriformes

Mystus bleekeri Day, 1877

Erethistes pussilus Muller and Troschel,

Heteropnestus fossilis Bloch, 1794

Photo Plate IX
Order: Beloniformes

Xenentododon cancila Hamilton- Buchanan, 1822

Order: Synbranchioformes

Mastacembelus armatus Hora, 1921

Order: Anabantiformes

Channa punctata Bloch, 1793

4.2 Physical Analysis of Water

4.2.1 Water temperature:

The temperature plays very important role in distribution of fish fauna in the river. The water temperature was recorded to be the lowest as 18˚C in February at station I. The highest water temperature recorded was 25˚C in May at station III and IV (Fig. 4).

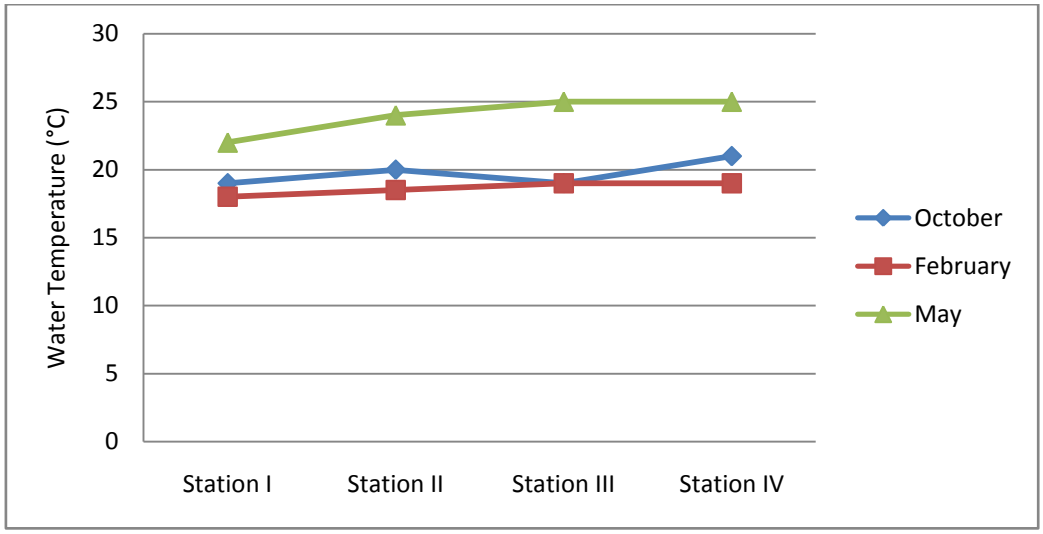

Fig 4: Variation in temperature at different station and season.

4.2.2 Water Velocity:

The water velocity also plays very important role in distribution of fish fauna in the river. The water velocity was recorded to be the lowest as 0.39m/s in May at station I. The highest water velocity recorded was 0.82 in October at station III (Fig.5).

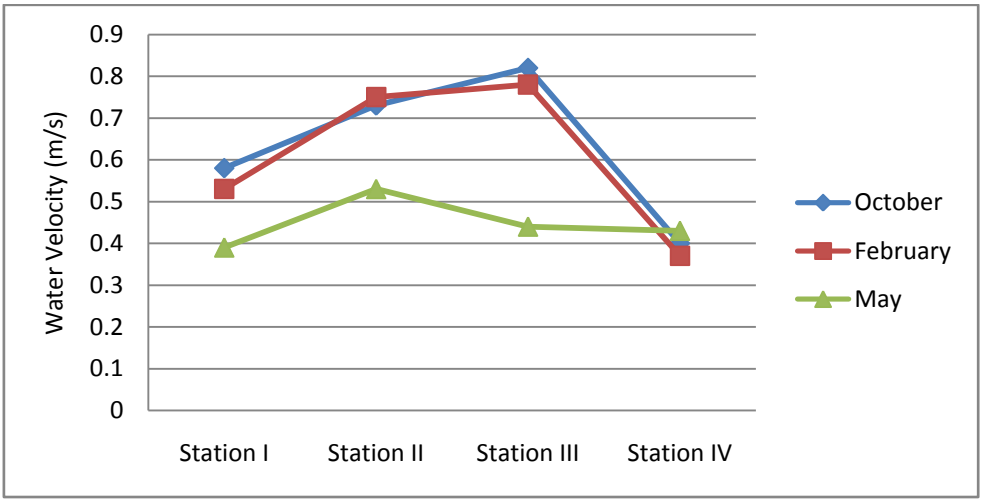

Fig 5: Variation in velocities at different stations and seasons.

4.3 CHEMICAL ANALYSES OF WATER

The following chemical parameters were analyzed during the present study.

4.3.1 Hydrogen Ion Concentration (pH):

The highest value of pH was recorded 8.4 at station II in February while the lowest pH value was recorded 7.8 in May at station I (fig.6).

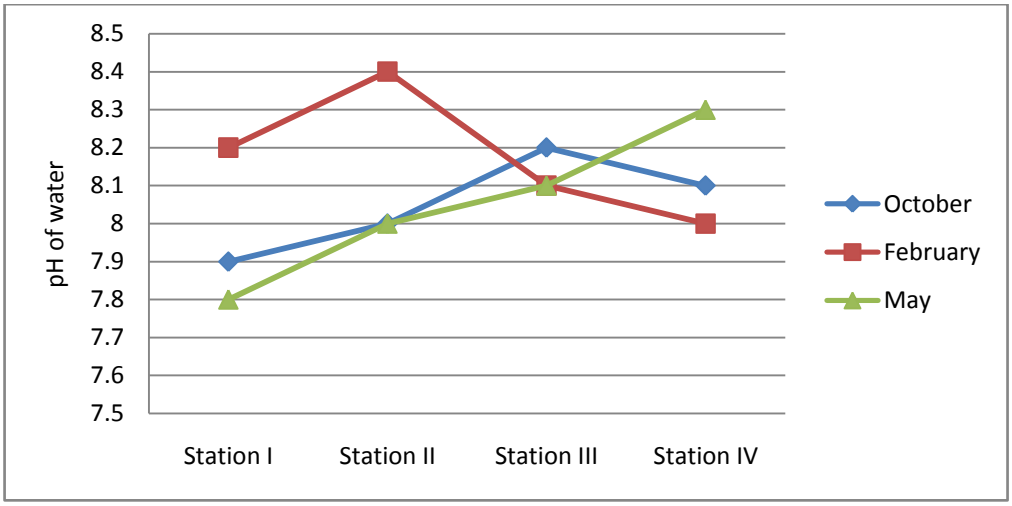

Fig 6: Variation in pH value at different stations and seasons.

4.3.2 Dissolved Oxygen (DO):

The dissolved oxygen at different stations and seasons of the Babai River were recorded. Highest dissolved oxygen value recorded was 8.5 mg/l at station I in February. Similarly the lowest dissolved oxygen value recorded was 7.3 mg/l at station IV in May (fig.7).

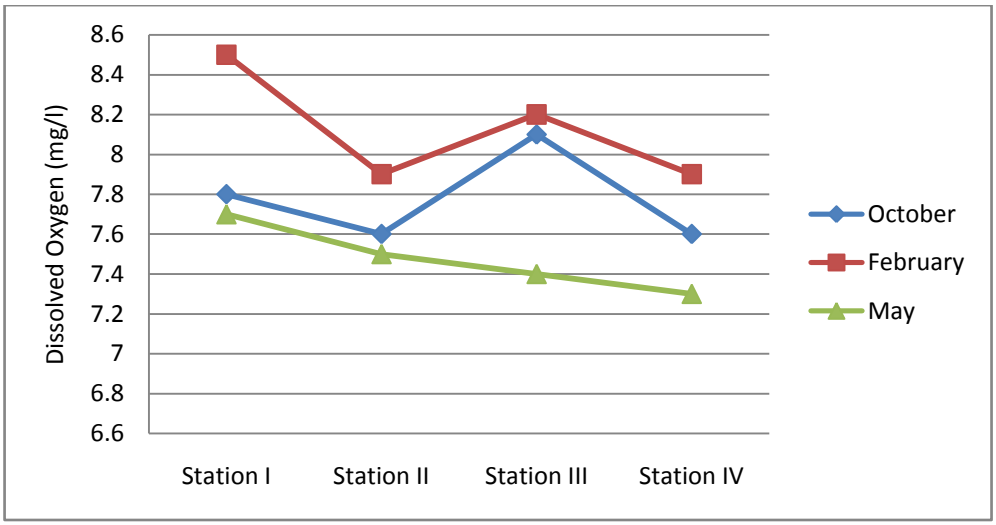

Fig 7: Variation in DO at different stations and seasons.

4.3.3 Free Carbon dioxide (CO_2):

The highest value of free carbon dioxide observed was 12.01 mg/l in May at stations IV. The lowest value was 8.24 mg/l in February at station I (fig 8).

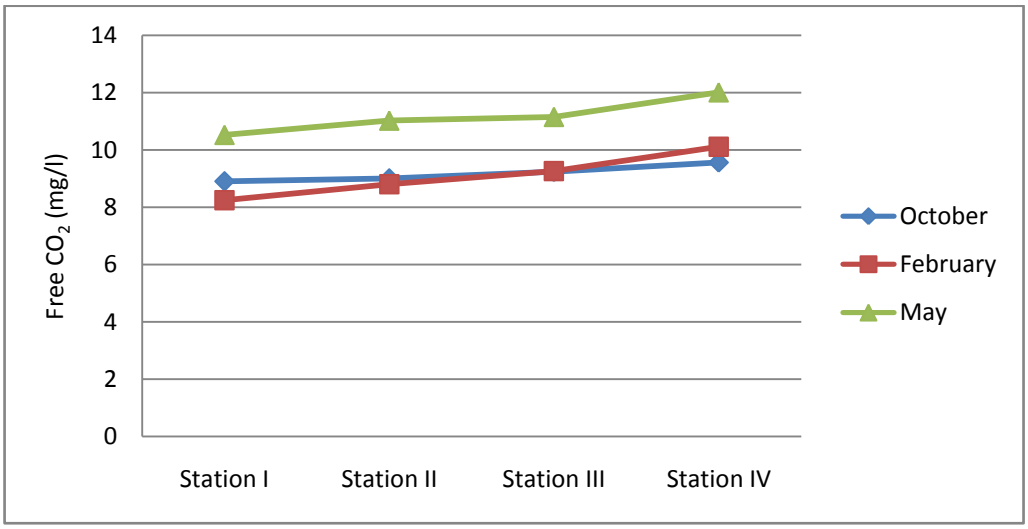

Fig 8: Variation in free CO_2 at different stations and seasons.

Table 5: Physico-chemical parameters in different stations

S. N.	Parameters	Autumn				Winter				Spring			
		I	II	III	IV	I	II	III	IV	I	II	III	IV
1.	Water temp.	19	20	19	21	18	18.5	19	19	22	24	25	25
2.	DO(mg/L)	7.8	7.6	8.1	7.6	8.5	7.9	8.2	7.9	7.7	7.5	7.2	7.3
3.	Free CO2(mg/L)	8.9	9.0	9.23	9.56	8.24	8.80	9.26	10.11	10.52	11.02	11.15	12.01
4.	pH	7.9	8	8.2	8.1	8.2	8.4	8.1	8.0	7.8	8.0	8.1	8.3
5.	Velocity	0.58	0.73	0.82	0.40	0.53	0.75	0.78	0.37	0.39	0.53	0.44	0.43

4.4 General habitat of fishes of Babai River:

Habitat documentation of the different fish species was done by direct observation method .Habitat of different fish species present in the Babai River were observed during field visit and recorded (Table 6).

Table 6: General habitat of fishes of Babai River.

S. N.	**Scientific name of the species**	**Common Name**	**Habitat type**
1	*L. fimbriatus*	Gardi	Bottom of the river, near aquatic vegetation.
2	*G.gotyla gotyla*	Buduna	Rapid parts of river, wave washed rocky bottom.
3	*G. rupecula*	Buduna	Running water, near bottom which consists small stones, gravels
4	*P. sophore*	Pothe, Pothi	Close to the bottom, near or within the areas of dense pant growth.
5	*P. terio*	Pothe, Pothi	Close to the bottom, areas with aquatic vegetation, edges of river.
6	*P. chola*	Pothe, Pothi	Close to the bottom, near or within the areas of dense pant growth, ditches
7	*P. ticto*	Pothe, Pothi	Stagnant water, Close to the bottom, areas with aquatic vegetation, swampy areas.
8	*P. conchonius*	Pothe, Pothi	Close to the bottom, near or within the areas of dense pant growth.
9	*T. putitora*	Sahar	Rapid part of river, pools
10	*B. bendelensis*	Faketa	Pebbly and rocky bottom, clear running water
11	*B. barila*	Faketa	Riffles, Pebbly and rocky bottom, clear running water
12	*B. shacra*	Faketa	Pools, Pebbly and rocky bottom, clear running water
13	*B. modestus*	Faketa, Fageta	Pebbly and rocky bottom, clear running water
14	*B. barna*	Tilauri	Pebbly and rocky bottom, clear running water
15	*D. devario*	Pateri	Stagnant water, near bottom of moderately floating water
16	*P. balitora*	Gadelo	Running water, riffles and water with substrates
17	*A. botia*	Guita, Garel	Sandy bottom, running water and edges of river.
18	*S. savona*	Gadela, Gadelo	Running water, riffles and water with substrates
19	*M. bleekeri*	Tyangna	Canals, stagnant water as well as flowing water.
20	*E. pussilus*	Datari	Flowing water, edges of river.
21	*H. fossilis*	Singi	Edge of the river, puddle, paddy fields, marshy areas.
22	*X. cancila*	Sui- machha	Ditches, pools, inundated field.
23	*M. armatus*	Bam- machha	Bottom of the river, below the rocks, stones.
24	*C. punctata*	Charingo, Bhoti	Edge of the river, puddle, paddy fields, marshy areas.

4.5 Diversity Status

The value of Shannon Wiener diversity index (H′), Species richness (d) and Evenness (E) were calculated according to each station and season. The highest Shannon Wiener diversity index was found in station III (2.62) and lowest value was found in station I (2.36). The Margalef Species richness value was observed maximum at station II (7.89) whereas lowest value was observed (6.94) at station I. Evenness index was found to be highest at station III (2.01) and lowest at station II (1.88) (Fig.4).

Similarly, the highest Shannon Wiener diversity index was found in winter (2.62) followed by autumn (2.40) and lowest value was found in spring (2.28). The Margalef Species richness value was observed maximum in winter (7.83) followed by autumn (7.76) whereas lowest value was observed (7.67) in spring. Evenness index was also found to be highest in winter (1.98), (1.81) in autumn and lowest in spring (1.74) (Fig.5).

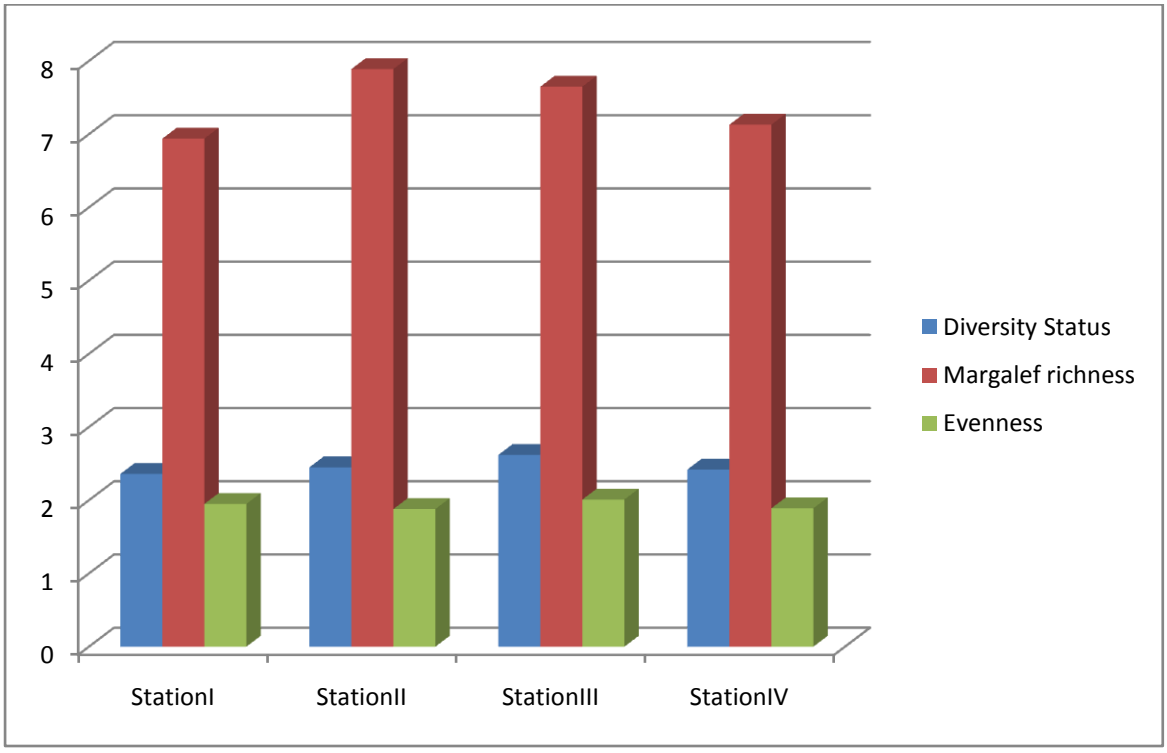

Fig 4: Variation of Shannon-Wiener index, Margalef species richness and evenness index at station I, II, III and IV.

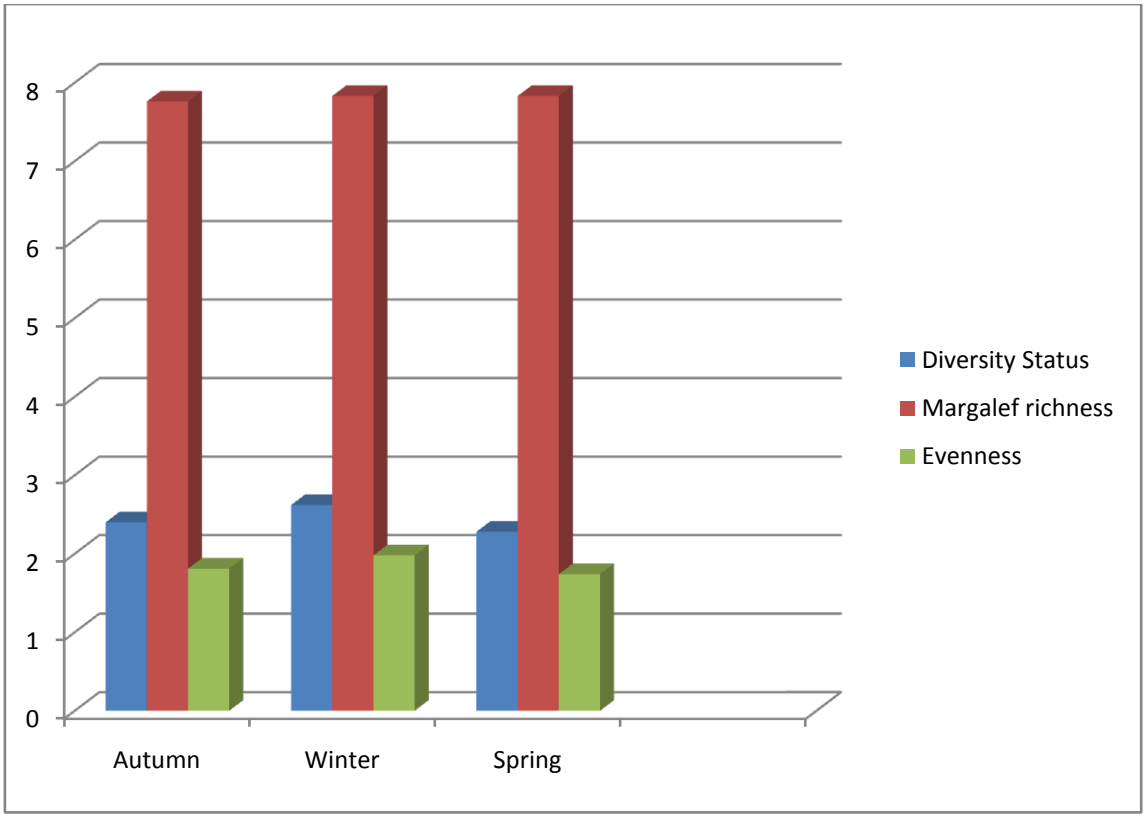

Fig 5: Variation of Shannon-Wiener index, Margalef species richness and evenness index in Autumn, Winter and Spring.

4.6 Ordination

The axis length of the second axis of Detrended Correspondence Analysis (DCA) is found 1.50 standard deviation unit (SD unit) that followed by 1.43 of the first DCA axis (Table 7). The overall variance explained by the data matrix was 20%. Thus, application of RDA is justified.

Table 7: DCA summary

	DCA1	DCA2	DCA3	DCA4
Eigen values	0.20	0.10	0.05	0.067
Decorana values	0.21	0.67	0.01	0.006
Axis length	1.43	1.50	0.80	0.95

4.6.1 Relationship between different seasons, stations, environmental Variables and abundance of fish species

The result obtained after the redundancy analysis (RDA) was plotted in Figure 11. The ordination plot revealed that water temperature, free carbon dioxide (FCO2) and pH are found significantly correlated and shows negative relation with dissolved oxygen (DO) and water velocity. It also shows that water temperature and free carbon dioxide are strongly correlated with Station IV. Velocity and dissolved oxygen are strongly correlated with each other. It means that when water velocity increases, dissolved oxygen also increases. The RDA plot also shows that winter is more suitable for the existing fish fauna.The vector lines are radiated from the mean of all environmental variables. An angle and the length of the line indicate the strength of that value. Here, in ordination plot the highest abundance of *Puntius sophore* correspondence to autumn and was characterized significantly by the lowest value of FCO_2, pH and water temperature.

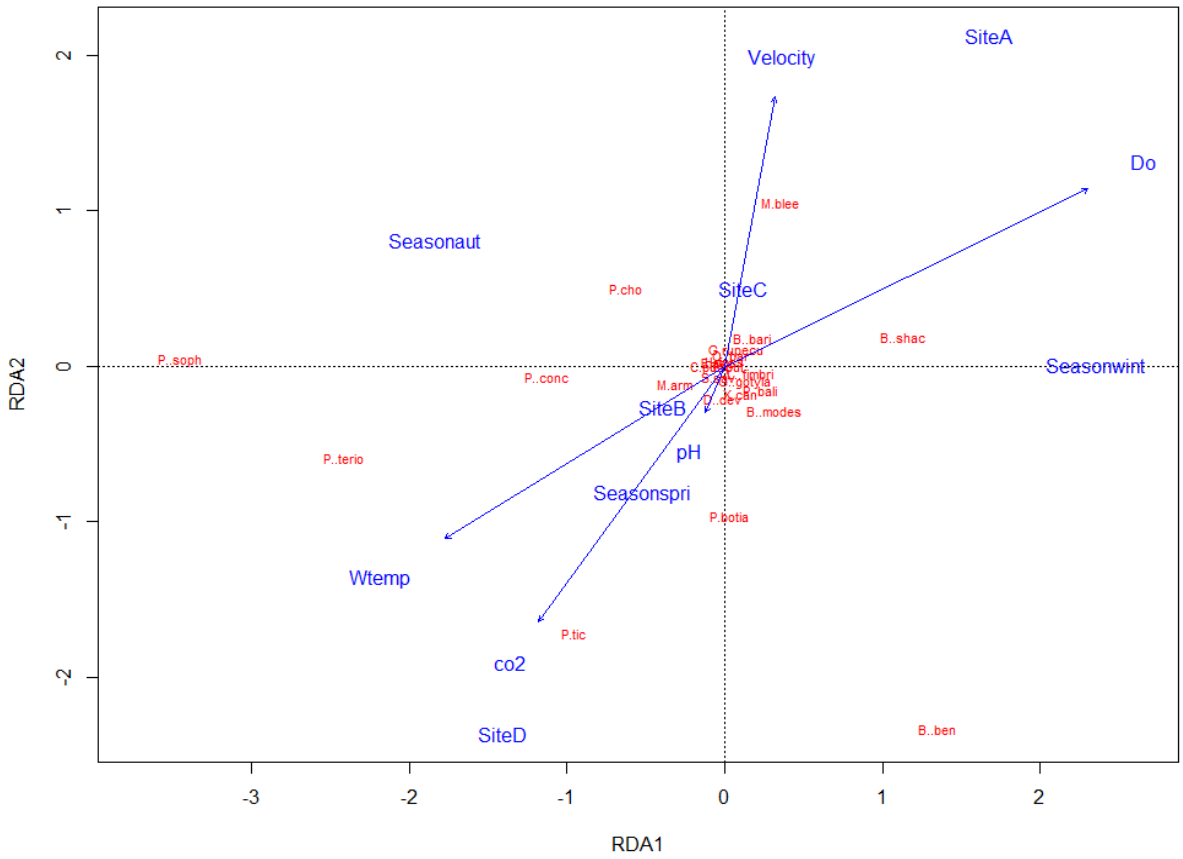

Fig 11: RDA analysis of species abundance,stations and environmental variables.

5. DISCUSSION

A total of 24 species are reported from four different sampling stations of Babai River Dang belonging to 5 orders, 9 families and 15 genera. Among 24 species, *Puntius sophore* is the dominant species which comprises 17.40% followed by *Barilius bendelensis* 15.18%. Singh (2001) identified 40 species from the Babai River Bardiya, among them *Barilius barila, Barilius barna, Channa punctata, Heteropnestus fossilis,Mystus bleekeri, Puntius sophore, Puntius conchonius Xenentodon cancila and Mastacembalus armatus,* are common species in both study.

Shrestha (2019) recorded 252 fish species which includes 15 orders, 35 families and 104 genera from Nepal. Cypriniformes is the most dominating order which comprises 135 species. Majority of the fish species from the river fall under the order Cypriniformes, this is the largest order of fresh water fishes which include 2,422 species (Nelson, 1948).The present study also revealed Cypriniformes as the dominating order with 18 species which is 75% of total fish species followed by Siluriformes (3 species) 12.5%. The result of this research is also similar to the findings of (Jha and Bhujel 2015) reported Cypriniformes consisiting 49% of total fish species followed by Siluformes 29% from Narayani river system. Singh (2001) also reported Cypriniformes as a dominating order consisting 44.73% of total catch from Babai River, Bardiya.

Barilius modestus and Barilius barna were not found from Station I throughout the study period. It might be due to the presence of stagnant water in Station I. Station I, which is near to human settlement area and thus, exposed to pollution and overfishing, accounted to only 13.9% of total catch. *Labeo fimbriatus and Danio devario,* were recorded from Station II, III and IV. It might be due to favorable environmental condition at these stations. *Mastacembelus armatus* was recorded from under the rocks, stones at Station II and IV. *Heteropnestus fossilis, Channa punctata,* were caught from nearby ditches and edges of the river of Station III and IV respectively. *Erethistes pussilus, Tor putitora, Psilorhynchus balitora* and *Schistura savona* were sparsely found throughout the study.

Puntius sophore, Barilius bendelensis, Puntius terio and *Puntius ticto* are the most common species of the present study recorded from all four sampling stations which comprises 17.40%, 15.18%, 11.41% and 10.44% of total catches respectively. Similarly other *Puntius* species like *Puntius chola* and *Puntius conchonius* were also found in all four stations. It means that present study area is favorable for *Puntius* species. Generally these fishes are found near the bottom along with aquatic vegetations. *Garra gotyla* was caught from slightly dull running water from all four stations but only comprises 1.06%

of total catch and is considered as the hill stream fish with special adaptive modification of their barbels, lips and adhesive discs. *Garra rupecula* was recorded from Station II, III and IV and shows almost similar habitat status as that of *Garra gotyla*.

Barilius barila, Barilius shacra were also recorded from all four stations and has almost similar habitat with *Barilius bendelensis*. *Acanthocobotis botia* was also reported all four stations from the edges of the river. This fish prefer to hide below the sand and small algae of stagnant water. Cat fish *Mystus bleekeri* is another fish species recorded from Station I, II and III during present field visit. This fish was caught from stagnant as well as moderately running water. Fish with special modification of mouth teeth, *Xenentodon cancila* was recorded from all stations except station IV with only 0.77% of total catch. This fish has high demand of ornamental value rather than table fish (Gupta and Banerjee 2016).

Most of the fishes were recorded from all three seasons. *Puntius sophore* was found in all three seasons during the present field visit and is the most common and dominating species of Babai River. Highest number of individuals was recorded in autumn and least number of individuals was recorded in spring. *Barilius bendelensis, Puntius terio* and *Puntius ticto* were found in all three seasons; autumn, winter and spring. *Barilius bendelensis* had highest catch number in winter whereas *Puntius terio and Puntius ticto* in autumn. Similarly, *Garra gotyla* and *Garra rupecula* were also reported from all three seasons while *Erethistes pussilus* reported only in autumn with only 0.096% of total catch is very rare species. Likewise, *Channa punctata* recorded in spring only is also a very rare species with only 0.19% of total catch in present study.

Acanthocobotis botia had the highest number of catch in autumn while same number of individuals was caught in Winter and Spring. *Puntius chola, Puntius conchonius, Barilius barila, Barilius modestus, Danio devario* and *Mystus bleekeri* were found in all three seasons with the common status. *Barilius shacra* was recorded from winter only but not from autumn and spring. Present study shows that *Tor putitora* is a most rare species as it has only 0.19% of total catch and recorded in winter and autumn. *Heteropnestus fossilis* was recorded in spring and winter with very low catch percentage 0.19 and considered as a rare species. *Labeo fimbriatus* was found in winter and spring while *Barilius barna* was recorded in all three seasons. *Mastacembelus armatus* was recorded from all two seasons except winter. *Xenentodon cancila, Schistura savona* and *Psilorhynchus balitora* were recorded in all three seasons with only 0.77%, 0.38% and 0.96% of total catch.

In terms of sampling stations and seasonal variation of fish assemblage structure of Babai River, highest number of individuals was found at station IV and in term of seasonal variation, highest numbers of individuals were found in winter. During the present study, as the river flows downstream, maximum number of fishes was found to be observed. Station I and Station II are near the human settlement area, highly disturbed area, picnic spot which caused more water pollution but Station III and IV are near the forest area and favourable for fish species. This might be the main reason behind the presence of more fishes in Station III and IV. Increased fishing pressure is the main triggering factors for diversity loss (Hossain et al. 2016) and in the present study area, electro fishing was found at Station I and less number of fishes was captured than that of other Stations. Present study suggests that highest number of fishes can be found in winter and the number gradually decrease in spring and again the number of individuals increase from autumn.

A biodiversity index seeks to characterize the diversity of sample or community by a single number (Magurran 1988). The concept of the species diversity involves two components: the number of species or richness and the distribution of individuals among species. However, the formal treatment of the concept and its measurement is complex (Williamson 1973). Highest Shannon-Weiner diversity index was found in site C and winter where lowest was observed at site 1 and during summer.

Highest seasonal Shannon Weiner diversity index value was found in winter (2.62) and lowest value in spring (2.28) and in case of station highest diversity index was found in station III (2.62) and lowest value was found in station I (2.36). The maximum margalef richness value was also observed in winter (7.83) whereas minimum value was observed in spring (7.67) and in case of station, maximum margalef value was observed at station II (7.89) and minimum value was observed in station I (6.94). Similarly evenness index was found to be highest in winter (1.98) and lowest in spring (1.74) and in case of station, higher evenness value was observed at station III (2.01) and minimum was recorded at station II (1.88). In diversity index (H'), Evenness (E) and Margalef richness (d), there was no significant difference observed. Therefore, it may be concluded that the seasonal difference in species diversity is a common phenomenon in the studied area.

The ordination plot (fig.11) revealed that water temperature, free carbon-dioxide (FCO2) and pH are found significantly correlated and shows negative relation with dissolved oxygen (DO) and water velocity. Water temperature and free carbon dioxide are strongly correlated with Station IV. High values of CO_2 are strongly associated with *Puntius ticto.*

High value of dissolved oxygen (DO) and water velocity is associated with species like *Barilius shacra* and *Mystus bleekeri. Puntius sophore* is the dominating species of present study area and found maximum in autumn. Ordination plot also shows that Velocity and dissolved oxygen are strongly correlated with each other. It means that when water velocity increases DO also increases. *Danio devario* and *Acanthocobotis botia* both are associated with season spring and winter (fig.11).

The physico-chemical parameters like water temperature, DO, CO_2, pH, are the influencing factor for the diversity of fish in the river. Among the chemical parameters, the concentration of dissolved oxygen of water is most important factor and DO above 5mg/l is suitable to support diverse biota (APHA 1978). The DO of Babai River ranges from 7.2mg/l in spring at station III to 8.5mg/l in winter at station I which indicates river is suitable for fish fauna. DO shows positive correlation with the fishes at station III. Gautam, Saund and Shrestha (2010) also recorded nearly similar value of DO that ranges from 5.2- 8.7 mg/l from Jagadishpur reservoir, Kapilvastu district. High dissolved oxygen at station I is due to the low water temperature which was found in winter and lowest level of oxygen. Carbon dioxide in the water is formed by decomposition of organic matters and from respiration of aquatic organisms and normally increases with increase in water temperature. FCO_2 of river varied from 8.24mg/l at station I in winter season to 12.01mg/l at station IV in spring season.

Generally low pH is harmful to fishes. Water having pH value below 5mg/l and above 9.5mg/l are not suitable (APHA 1967). The pH ranging from 7 to 8.5 is considered to support rich biota and fish (Bell 1971). The pH value of present study ranges from 7.8 at station I in spring to 8.4 at station II in winter which indicates that water is alkaline in nature and suitable for fish fauna. Temperature also plays vital role in distribution of fish fauna. Maximum water value (25 ^{o}C) was found in spring at station III and IV whereas lowest temperature (18 ^{o}C) was recorded at station I in winter. Result of the present study is nearly same with the findings of (Sharma and Shrestha 2001) from Tinau River, Western Nepal.

Water velocity of the present study was found to be gradually decreases from the month of February to May. It is due to decrease in the level of water from the February to May. Babai River in the present study area lies in plain area, so there is no more variation in the velocity within the station. Water velocity mainly depends upon the structure, characteristic features and water volume of rivers, streams etc.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

A total of twenty four species of fishes belonging to five orders, nine families and fifteen genera (Table 1) were recorded from the total catch of 1024 fishes. *Puntius sophore* (180 individuals) with 17.40% of total catch was the dominant species while *Erethistes pussilus* (1 individual) with 0.096% of total catch was the rarest species. Maximum number of individuals was recorded from Station IV with 332 catches and minimum number was recorded from Station I with 144 catches. Seasonal variation and abundance of fishes increased in autumn and decreased in spring. Highest number of individuals (377) was recorded in autumn and least number of individuals (299) was recorded in spring.

Highest seasonal Shannon Weiner diversity index value was found in winter (2.62) and lowest value in spring (2.28) and in case of station highest diversity index was found in station III (2.62) and lowest value was found in station I (2.36). The maximum Margalef richness value was also observed in winter (7.83) whereas minimum value was observed in spring (7.67) and in case of station, maximum Margalef value was observed at station II (7.89) and minimum value was observed in station I (6.94). Similarly evenness index was found to be highest in winter (1.98) and lowest in spring (1.74) and in case of station, higher evenness value was observed at station III (2.01) and minimum was recorded at station II (1.88). In diversity index (H'), Evenness (E) and Margalef richness (d), there was no significant difference observed.

The ordination plot (fig.11) showed that water temperature, free carbon dioxide (FCO2) and pH are found significantly correlated and shows negative relation with dissolved oxygen (DO) and water velocity. Water temperature and free carbon dioxide are strongly correlated with Station IV. Ordination plot also shows that Velocity and dissolved oxygen are strongly correlated with each other. It means that when water velocity increases DO also increases. The RDA ordination plot showed that the winter is the suitable season for the existing fish fauna.

6.2 Recommendation:

After the present study, for successful conservation and management of indigenous fish species in the Babai River following recommendation are suggested.

- Use of inappropriate mesh sized nets should be strictly avoided.
- Many non-convention method of fishing like poisoning, electro fishing are being used in this river. Such activities should be controlled.

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