DIVERSITY AND DISTRIBUTION OF FISH IN ANDHI KHOLA, SYANGJA DISTRICT, NEPAL

Entry 48.
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Submitted to

Central Department of Zoology

Institute of Science and Technology

Tribhuvan University

Kirtipur, Kathmandu

Nepal

August, 2020

DECLARATION

I hereby declare that the work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

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RECOMMENDATIONS

This is to recommend that the thesis entitled, "**Diversity and Distribution of Fish on Andhi Khola"** has been carried out by Mrs. **Bishnu Bhurtel** for the partial fulfilment of the Master's Degree of Science in Zoology with special paper **Fish Biology and 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 an institutions. I recommend that the thesis be accepted for partial fulfilment of the requirements for the Degree of Master of Science in Zoology with special paper Fish Biology and Aquaculture.

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LETTER OF APPROVAL

On the recommendation of supervisor **Prof. Dr Kumar Sapkota**, this thesis submitted by **Mrs. Bishnu Bhurtel** entitled, **"Diversity and Distribution of Fish on Andhi Khola"** is approved for the examination 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 **Mrs. Bishnu Bhurtel** entitled **"Diversity and Distribution of Fish on Andhi Khola"** has been as a partial fulfilment for the requirements Master's Degree of Science in Zoology with special paper **Fish Biology and Aquaculture.**

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LIST OF ABBEREVIATIONS

DOFD	Department of Fisheries Development
FAO	Food & Agriculture Organization
GDP	Gross Domestic product
D.O	Dissolved oxygen
AAPA	Aquatic animals protect Acts
APHA	American public Health Association
Fig	Figure
VDC	Village Development Committee

ABSTRACT

Seasonal changes in the species composition, number and abundance of fish species in Andhi Khola were investigated from September 2018 to May 2019. This study also addresses the relationship between fish and environmental variables from the Andhi Khola.

Out of 907 individual fish identified, represented a total of 15 different species belonging in four order 11 genera and six families were caught. Highest number was counted for *Barilius barila* (320) and lowest was *Heteropneustus fossilius* (2 individual) which are 35.28% and 0.22% of total individual respectively. Along the longitudinal gradient from headwater to downstream, fish species richness and abundance increased gradually, but then decreased significantly at the lower reaches. The highest species richness and abundance were observed in spring and the lowest in winter. The highest value of Shannon-Weiner diversity index (1.96) was found in spring season and lowest (1.69) was found in winter season. Highest value of evenness index (0.35) was found in autumn while lowest (0.31) in winter season .The Simpson dominance index in different sites varies from 0.75 to 0.79. The highest Simpson dominance index (0.79) was recorded at site I and site II and lowest (0.75) was recorded at site III. Highest Simpson dominance index (0.81) was recorded in autumn and lowest (0.73) was recorded in winter. The Redundancy analysis (RDA) revealed that the environmental variables of water temperature, water velocity, and dissolved oxygen were found to be most imperative variables to shape the fish assemblage structure of present study area.

1. INTRODUCTION

1.1 Background of the study

Nepal is blessed with various water resources such as rivers, streams, lakes, reservoirs ponds, swamps and paddy fields, with unique aquatic biodiversity. Among them, rivers being most important with the representative of 49% of the total water body (Swar, 2002). One of them is Andhi Khola as a good source of fish diversity. It is a large and most important river of Syangja district, originates from Dahare hill, southeast from Karkineta.

The identification of variation patterns in stream-dwelling fish assemblages along with potential contributory causes is a central theme in stream ecology (Matthews, 1998). Much research has shown that factors influencing fish assemblages involve the physiochemical environment, which is spatially heterogeneous and temporally variable, and biotic interactions such as competition and predation (Gorman 1988; Harvey and Stewart 1991; Grossman et al. 1998; Dauwalter et al. 2008). Among different environmental variables, the Dissolved oxygen and temperature are most important for fish and highly effect on fish diversity and distribution. The amount of dissolved oxygen and temperature are higher in summer than winter due to which fish diversity is higher in summer (Allen, 1995; Irz *et. al*. 2007).

Along the headwater-downstream longitudinal gradient, fish assemblages often experience an increase in species richness and abundance, mainly resulting from an increase in habitat complexity and diversity, variation in the rate of fish immigration, and extinction (Matthews 1986). However, an asymptote or a decrease in species richness is also observed in the lower reaches of some streams, which could be due to greater pollution levels (Oberdorff et al. 1993). Small streams also represent an ecological gradient along which upstream assemblages are relatively variable but downstream assemblages relatively stable. This is associated with the general pattern of upstream environments being physically variable and structurally simple while downstream environments are the opposite (Grossman et al. 1990). Riverine or stream fishes of the developing world have faced to different ecological stresses affecting fish assemblage structure of that habitat (Winemiller *et al.*, 2000). However, association between fishes and their environments play central roles for managing and saving of riverine species where any modification of it can lead to transform in their population (arrangement Kadye and Moyo, 2007).

The Andhi Khola has been found to be influenced by harmful human activities such as deforestation, direct waste disposal, discharge of toxic substances-fertilizers, pesticides through surface run-off from the agricultural field near the river and sand mining, use of soaps and detergents directly into the Khola, indiscriminate fishing, pollution are destroying the freshwater habitat and have been found to threaten the natural environment of fish diversity of Andhi Khola which ultimately lead to their extinction and must be stopped or managed in a proper way for the conservation and sustainable utilization of aquatic bio-resources of the river. Various forms of water resources of the country prove to be good shelter area to a large number of indigenous fish species of high economic and academic values. A review on the current taxonomic status of indigenous fish species revealed there are 238 fish species identified till now in Nepal (Fish Base 2013).

Fish sp. are found in various water bodies at different altitude ranging from a few hundred meters above sea level to as high as 4,000 meters. The climate of Nepal is greatly influenced by altitudinal variation. Due to the altitudinal varation, the temperature distribution in Nepal is not uniform - warmer low lands like Tarai, inner-Tarai and midlands and cooler mid-hills and the cold Himalayan region. In general, temperature increases from March to July and decreases from October to January (Pandey, 1987). In the upper part of this region, fishes like snow trout (Schizothorax spp. and Schizothoraichthys spp.), suker headed (Garra spp.), stone loaches (Nemacheilus spp.) and Glyptothorax spp. are found and in the lower part (900- 2000 m) fishes like sahar (Tor spp.), bhakur (Catla catla), rohu (Labeo spp), faketa (Barilius spp.), kabre (Pseudecheneis sulcatus) are found in lower plain of Terai (Swar and Shrestha, 1998). Nepal is a staple for freshwater fishes only because of its geographical structure (Limbu and Gupta, 2019).

1.2 Objectives:

1.3.1 General Objective:

- To explore the fish diversity and distribution in Andhi Khola, Syangja.

1.3.2 Specific Objectives:

- . To investigate the diversity and distribution of fishes.
- To describe the relationship between environmental variables and fish assemblage structure.

1.3 Significance of the study

Fishes may be declined due to pollution, harmful fishing practices, habitat Modification, environmental degradation and impact of other Developmental activities. The physicochemical parameters of water are also changing these recent years which are also the cause for the loss in fish diversity (Braimah 1995, Ntow 2003). Therefore, this study will provide information about the variation in fish assemblage of the Andhi khola, which was first work in this study area.

1.4 Limitation of the study

Paucity of the time, limited financial resources and technical facilities had limited the study work in a certain sector of the river.

2. LITERATURE REVIEW

Vijaylaxmi et al. (2010) have indicated diversity and distribution of fishes as useful ecological indicator to assess and evaluate health of water bodies at various spatial scales. While the size of the river and net primary production plays the most important factor influencing fish species richness at the global scale (Jeppesen et al., 2000), interspecific competition, predation, habitat diversity, water chemistry (Grossman et al, 1998; Baltz et al, 1987, Gorman, 1998) temperature etc. is related to species richness on a local scale. Historical factors such as climate change, speciation and dispersal rates (Vonlanthen et al., 2012, Oberdorff et al., 1993) regulate local factors at local scale.

The Fish community structures, their distribution and diversity are co-affected by biotic and abiotic factors (Schlosser, 1990, Tonn, 1990). Many studies have shown that the changes of environmental factors, such as dissolved oxygen and pH (Matthews and Hill 1979), water depth (Harvey and Stewart 1991), current velocity (Magoulick, 2004) and turbidity (Aksnes et al. 2004) affects fish biodiversity and distribution. Moreover, air temperature, water temperature, dissolved oxygen, pH and free CO2 are positively correlated with fish assemblages and influenced the fish distribution (Negi and Mamgain 2013). Similar pattern was observed by Stalnaker (1979), Bovee (1982) and Baltz et al., 1987) who attributed the fish assemblage structure variation on various factors like river depth, velocity of water, water temperature, substrate and water quality.

Johal and Yogesh (2005) and Suvarnaraksha et al. (2012) all agreed that the geo-morphological parameters were more significant in predicting both species richness and Shannon diversity index than the physicochemical parameters, in which altitude was the most significant along with the slope gradient. The fish species abundance and their distribution is highly prejudiced by altitudinal and longitudinal zonation (Nautiyal, 2001). Zhao et al. (2015) has recognised the effects of altitude on fish diversity in accord of its co-linearity with temperature. Larger and deeper rivers in warm areas tended to be the most species rich and diverse. According to Brucet et al. (2013) also, warmer and shallower lower-altitude European water bodies had higher fish densities than cold and deeper higher-altitude lakes.

The fish communities and physiochemical parameters oscillate according to seasons (Mehner *et al.,* 2005). The fish being cold blooded, high fluctuation of water temperature seasonally effect on fish health (Bhatnagar et al., 2004; Bhatnagar & Devi., 2013). There

are some fishes which prefer cold season like *Schizothorax, Gara, Glypothorax,Pseudocheneis* (Petr et. Al., 2002) while *Labeo, Mystus, Puntius, Channa, Catla, cirrhinus* and Carp prefer war, water in hot season (Rai, *et al*., 2008).

The water temperature greatly influences on water chemistry and high water temperature cause the fluctuation in DO and pH (Jacobsen, 2008). Water temperature and oxygen are two abiotic parameters that have influence on the fish distribution and population survival. Jackson et al. 2001 discussed important relationship between these two abiotic factors as high temperatures relate to high physiological demands apart from reducing the dissolved oxygen level from the water body. According to FAO report (FAO 2010), the increase of temperature directly or indirectly impacts species distribution and the seasonality of production in fishes.

The water temperature can influence on aquatic life cycle, metabolism and behavior of fish and high water temperature leads to the thermal stratification in the river and lake which may lead to reduction in diversity and unequal distribution of fish (Jain *et al*., 2013).

Natural factors as well as uncontrolled human activities strongly pressured on the local fish diversity and distributions, therefore important to estimate their relative contribution (Dudgeon et al. 2006, Vorosmarty et al. 2010).

Despite a number of studies related with aquatic diversity from different parts of Nepal, there is still no information has been available on the diversity of fish in Andhi khola, Syanja. Therefore, this study is designed to investigate the diversity of fish in Andhi khola, Syanja, Nepal.

3. MATERIALS AND METHODS

3.1 Materials

- GPS
- fishing gears
- Camera
- PH meter
- Thermometer
- Measuring tape, nylon rope.
- Chemicals – Formalin (10%) and
- Chemicals for water parameter test (KI, $MnSO_4$, $Na_2S_2O_3$, H_2SO_4 for DO)

3.2 Study Area

Andhi Khola (Fig. 1) is a snow-fed perennial river located in western development region of Nepal. It is an important river of Syangja district and originates from Dahare hill, southeast from Karkineta. It is estimated to be 96 km long with a catchment area of 195 km2, which finally drain to Kali Gandaki. It is located between N27°50′ and N28°10′ latitude, and E83°50′ and E84°50′ longitude with altitudes from 540 to 1020 m above sea level (msl), covering an area of about 200 km^2. It flows southwards and joins Kaligandaki River near Mirmi, Syanjaa. The river basin is used for irrigation, drinking water supply, recreation and micro-hydropower generation (EMP/MWSP 2009).

3.3 Sampling sites

Altogether three sampling sites I, II and III (fig. 1) were designed along the sampling stretch of the Andhi Khola based on human disturbance and confluences meeting of other tributaries. Sampling was carried out within the river length stretch of about 17 km .Distance from Waling Bazar to Chiuri is 10km and from Chiuri to Mudkilla is 7km.

Sampling site I

The sampling site was selected at the confluence spot of two rivulets; here another rivulet joins the Andhi Khola and is near from the Waling Bazar. The rivulet bed consists of big boulders, cobbles, pebbles and a very little sand.

Sampling site II

The sampling site II was chosen near an open grass land and vicinity of Chiuri area where local people graze their cattle. The rivulet bed consists of cobble, pebble, gravel, mud and sand.

Sampling site III

The sampling station was located at Mudkilla. This station was at about 7 km distance from the second station. At this station, the river became flat with low water velocity. The river bottom consists of large amount of sand, mud, silt etc. with agricultural land on the sides.

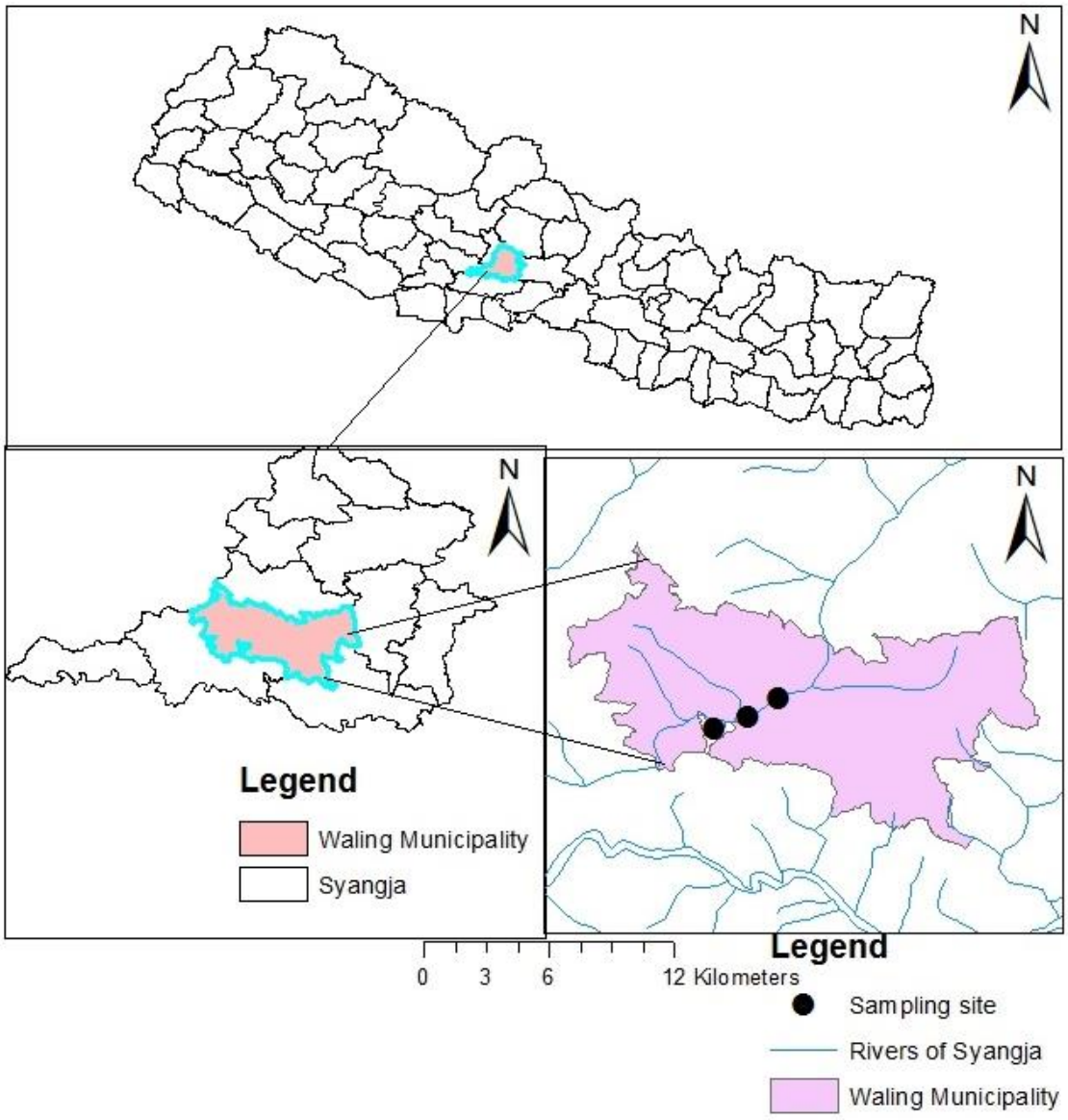

Figure 1. Study site map

3.4 Sampling and preservation techniques

For the present investigation the field work was conducted from September 2018 to May 2019 with three seasons- Autumn (September, October and November), Winter (December, January and February), Spring (March, April and May) .Fishes were sampled at 3 sites using a medium size cast net of mesh size ranging from 1.5cm to 2.5cm and Gill net having 2-3 cm mesh size, 30-35 feet length and 3-4 feet width, with the help of local fisher man. These fishing gears were operated within 500 m area of each site for 2 hour in each station at 7-9 AM. Total 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 include moving first upstream/river then downstream/river within a pre-determined length (500m) with equal effort 30 minutes for each pass at each site of the river. The number of fish species in the samples and the number of individuals in each species were counted and the local name of fish species was taken from local fishermen. . Before preservation, collected fishes were photographed with Nikon Digital Camera (D5300). After photography, the collected fishes were preserved in 30% formalin solution for 6 to 8 hours and later, the fishes were preserved in 10% formalin solution making their head upside for the protection of their caudal fin for further study and brought to CDZ lab for further identification.

3.5 Identification of specimens and deposition

The collected fish samples were identified by using standard method of Talwar and Jhingran (1991), Shrestha (1981, 1994), Shrestha (2008) and Jayaram (2010) and Collected specimens at the field survey was deposited in laboratory of Central Department of Zoology, T.U. Kirtipur, Kathmandu, Nepal.

3.6 Analysis of Environmental variables

Physico-chemical parameters of water were determined following standard methods of Adoni (1985), Trivedy and Goel (1984), and American Public Health Association (APHA, 1976).

3.6.1 Water Temperature:

The water temperature was recorded by using a standard mercury thermometer with degree celcius calibration. Thermometer was dipped directly into the water for two minutes. The result was expressed in degree Celsius. The readings were noted down in the record sheet.

3.6.2Water velocity

Water velocity of running water was measured with the help of the float method. First of all 100m distance was measured with the help of measuring tape. The starting and endpoints were marked. Then a cork was released from the middle of the river, this process was repeated at three time at each site and mean value was calculated. From starting point and the time taken by it to reach the endpoint was recorded. The velocity was expressed in meter per second.

3.6.3 Hydrogen ion concentration

The pH of water is negative Logarithm of hydrogen ion concentration. A battery Operated electrical pH meter (H196107 HANA instrument) was used to record the pH of water during the study Period at every station in Andhi Khola.

3.6.4 Dissolved Oxygen (DO)

The dissolved oxygen of water was calculated by using Winkler's method. The sample of water from every station was collected in BOD bottle without bubbling. 2 ml of manganese Sulphate and 2 ml of alkaline-iodine-azide solution were added and shaken. Brown precipitation was obtained which was again dissolved by adding 2 ml of concentrate Sulphuric acid. Then this solution was titrated against standard sodium thiosulphate solution (0.025N) and the calculation was carried out by using following formula.

. **Dissolved oxygen (mg/l) =** $\frac{ml * N\ of\ titrant * 8 * 1000}{v2(\frac{v1-v}{v1})}$

Where,

V = Volume of MnSO4 and KI added.

V1= Volume of BOD bottle

V2= Volume of the part of the content titrated

3.7 Diversity status

3.7.1 Species Diversity Index (Shannon-Weiner diversity index)

The diversity of species was calculated by using Shannon –Weiner diversity index (Shannon and Weaver 1949). Shannon Weiner diversity index is designated as H', which is calculated as:

H' = -S (Pi) log (Pi)

Where

$Pi = ni/N$

Ni = Number of all individuals in the species

N = Total number of all individuals in the sample

Log = Logarithm of base e

3.7.2 Simpson dominance index

Simpson's Index (λ) is actually a measure of dominance and as such weights towards the abundance of the most common taxa. It is the probability that two individuals drawn at random from an infinitely large community will be different species. Simpson's Index is usually expressed as the reciprocal ($DS=1-\lambda$) so that as a measure of diversity, higher values represent higher diversity. It is less sensitive to rare species than the Shannon-Wiener Index which is sometimes a positive and sometimes a negative.

As it is a probability, the Simpson's index ranges from 0 to 1.

$\lambda DS=\sum ni(ni-1N(N-1)=1-\sum ni(ni-1N(N-1)$

3.7.3 3 **Pielou evenness index**

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

$E= H'/ log S$

Where,

H' = Shannon- Weiner's diversity index.

S = Total number of species in the sample.

3.8 Statistical analysis

To estabilish the relationship between the fish abundance and the environmental variables Multivariate statistical analysis RDA) was performed .The relation between species diversity and environmental variables (water temperature, velocity, pH, and DO of water) were analysed by redundancy analysis (RDA) method (ter Braak 1988a'ter Braak and Prentice 1988) by using vegan library in 'R' (Oksanen et.al.2015)

4. RESULTS

4.1 Environmental variables

4.1.1 Temperature

Temperature plays a key role in the Fish species distribution. Water temperature of the present study area was recorded in three different seasons. The temperature of the water in the Andhi Khola was found ranging between (12.1 ℃) to (16.8 ℃). The maximum temperature (16.8 ℃) was recorded at station III in spring and lowest temperature (12.1 ℃) at station II in winter season (Fig.2).

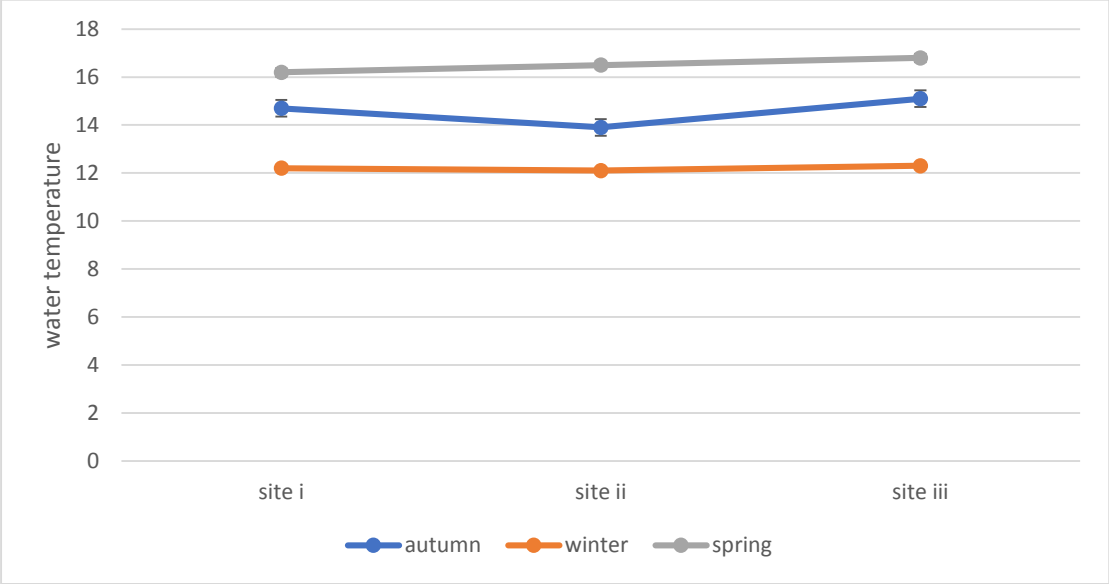

Figure 2. Temperature recordings of Andhi Khola in respective sites and seasons

4.1.2 Velocity

The velocity of water is one of the affecting factors for determining the distribution pattern of fish species. Water velocity of the present study area was also recorded different in three different season. During the study period the maximum velocity of Andhi Khola is 0.83 m/s at station I in autumn and the minimum velocity is 0.64 m/s at station I and II in spring (Fig 3).

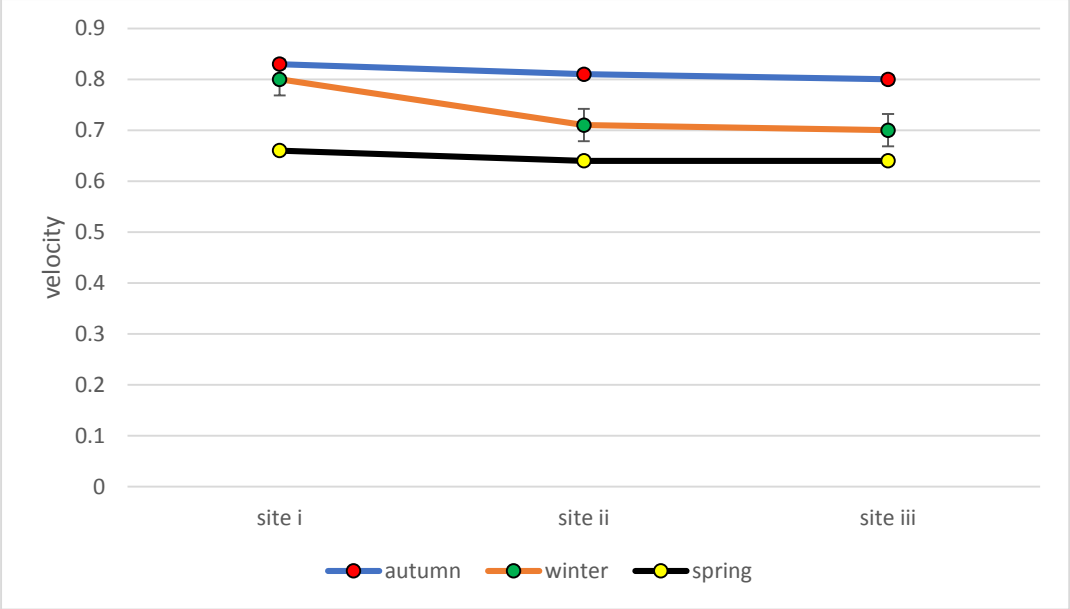

Figure 3. Water velocity recordings of Andhi Khola in respective sites and seasons

4.1.3 pH

The pH was found different in different seasons. It found to be varied between 7. 1 to 7.6 (Fig.4). Maximum pH was recorded at station III in spring and minimum at station I and II in winter

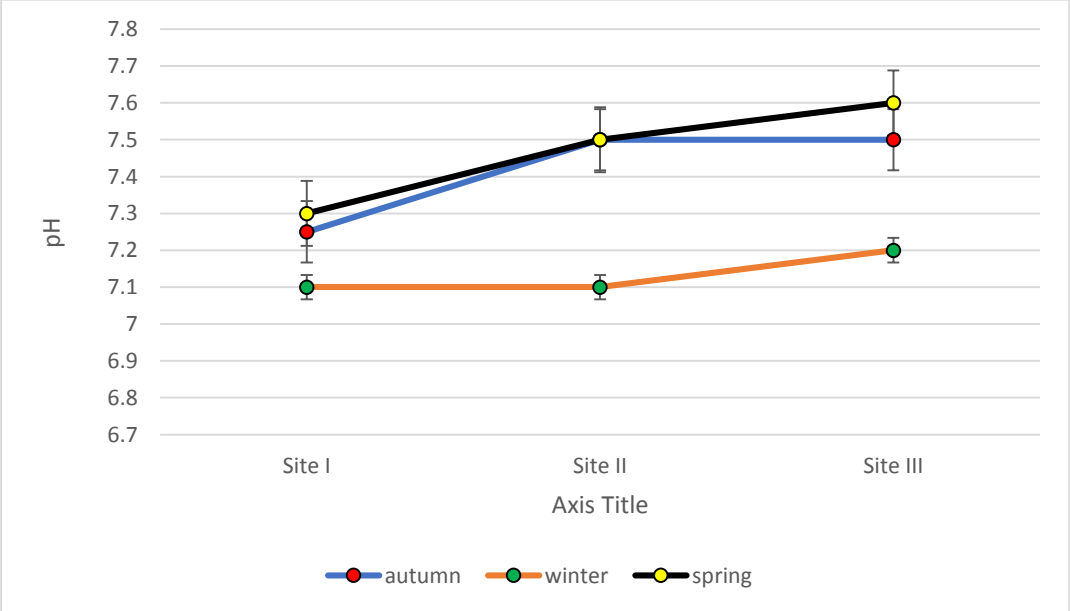

Figure 4. pH recordings of Andhi Khola in respective sites and seasons

4.1.4 Dissolved oxygen (DO)

The dissolved oxygen content in the sample was found to be ranged from 6.5 to 9. The DO was found minimum at the station III during spring and maximum at station I during winter (fig.5).

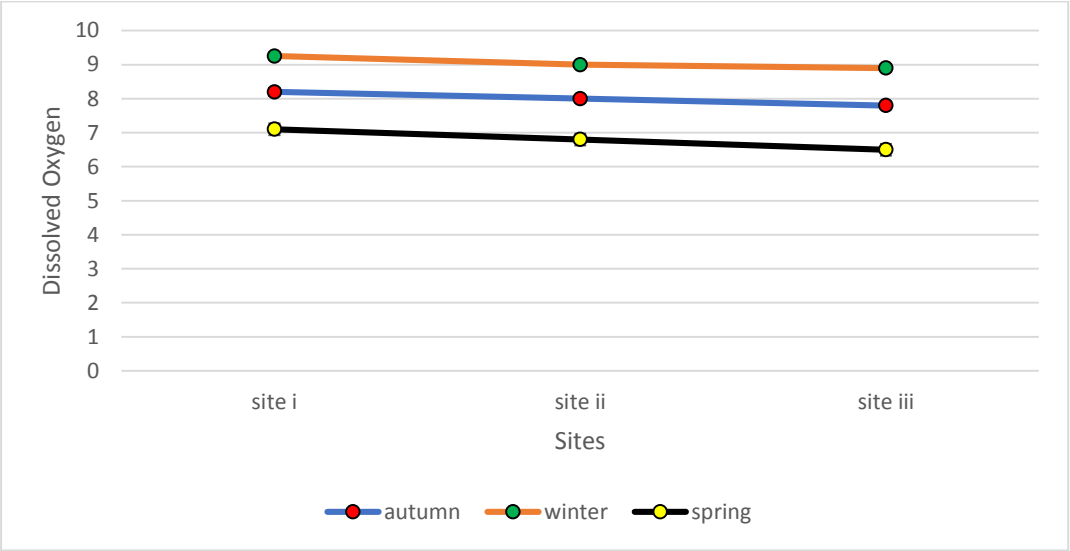

Figure 5. Dissolved Oxygen recordings of Andhi Khola in respective sites and seasons

4.2 Fish diversity

The Andhi Khola endows a habitat for fresh water fishes of various types. A total of 15 different fish species were collected during study period which included four orders, six families, six sub families and 11 genera. 11 fish species belongs to Order Cypriniformes was found as dominant with frequency 73.33 % followed by order Siluriformes comprises two fish species with frequency 13.33 %, while order Syanbranchiformes and perciformes belonged to single fish species (6.67 % each).

Out of 907 fish catch, 777 specimens belonged to order Cypriniformes with about 85.67% of total fish catch which was most abundant order among fish catch during study period. The lowest number of fish catch was only 13 fishes (1.43%) of total catch belonged to Order Perciformis. Similarly, family Cyprinidae was found as dominant with eight fish species and lowest number of fish species belongs to families Mastacembelidae, Sisoridae Channidae and Heteropneustidae with single fish species, while remaining Cobitidae was represented by three species. Out of total fish catch, 749 fishes belongs to family Cyprinidae with highest frequency (82.58%). The fish species belonging to families Mastacembelidae, Sisoridae Channidae and Heteropneustidae were represented with

different fish catch frequency 7.17%, 1.43%, 2.76% and 0.22% respectively. During study period, family Heteropneustidae comprised least number of fish catch (2 individuals).

Table 1. List of Fish Collected from Andhi Khola

Order	Family	Sub Family	Genus	Species	Local Name
Cypriniformes	Cyprinidae	Danioninae	*Barilius*	*Barila*	Fageta
				Vagra	Fageta
				Bendelisis	Fageta
		Cyprininae	*Neolissochilus*	*hexagonolepis*	Katlae
			Puntius	*Terio*	Pothi
		Schizothoracinae	*Schizothorax*	*Plagostium*	Asala
		Garrinae	*Garra*	*Mullya*	Budna
				Rupecula	Buduna
	Cobitidae	Nemacheilinae	*Schistura*	*Horai*	Gadela
				Savona	Gadela
		Cobitinae	*Lepidocephalus*	*Guntea*	Kande
Siluriformes	Heteropneustidae	-	*Heteropneustidae*	*fossilis*	Singhi
	Sisoridae	-	*Glyptothorax*	*trilineatus*	Telcrape
Synbranchiformes	Mastacembelidae	-	*Mastacembelus*	*armatus*	Bam
Perciformes	Channidae	-	*Channa*	*punctatus*	Bhoti

The dominant fish species of Andhi khola were *Barilius barila*, *Barilius vagra* and *Mastacembelus armatus* (Table 2). The most abundant fish species of Andhi khola was *Barilius barila* with highest fish catch of 320 (35.3%) and lowest fish catch was of *Heteropneustus fossilius* with two individuals (0.22%) recorded.

Table 2. Temporal and spatial species abundance and distribution

Code	Species	Total	%	siteI	siteII	siteIII	Aut/Sep	Win/Dec	Spr/Apr
C1	*Barilius barila*	320	35.28	87	133	100	58	119	143
C2	*Barilius vagra*	248	27.34	67	98	83	40	98	110
C3	*Barilius bendelisis*	33	3.64	13	14	6	0	15	18
C4	*Lepidocephalous guntea*	7	0.77	2	5	0	0	0	7
C5	*Gara rupecula*	32	3.53	11	14	7	6	5	21
C6	*Gara mullayu*	36	3.97	16	13	7	11	8	17
C7	*Neolissochilus hexagonolepis*	26	2.87	12	9	5	0	11	15
C8	*Puntius terio*	32	3.53	5	16	11	3	2	27
C9	*Glyptothorax trilineatus*	25	2.76	7	13	5	1	10	14
C10	*Schistura horai*	21	2.32	8	9	4	10	3	8
C11	*Schistura savona*	25	2.76	7	10	8	6	3	16
C12	*Heteropneustus fossilius*	2	0.22	0	0	2	0	0	2
C13	*Channa puctatus*	13	1.43	0	5	8	13	0	0
C14	*Schizothorax plagostomes*	22	2.43	5	12	5	6	16	0
C15	*Mastacembelus armatus*	65	7.20	14	29	22	11	13	41
Total		**907**	**100**	**254**	**380**	**273**	**165**	**303**	**439**

Order cypriniformes comprised of two families: Cyprinidae and Cobitidae with 11 species while order Synbranchiformes comprised of one family: Mastacembelidae with single species and Perciformes also comprised of a single family: Channidae with single species. Order Siluriformes comprised of two familes: Heteropneustidae and Sisoridae with two species (Fig. 6, 7).

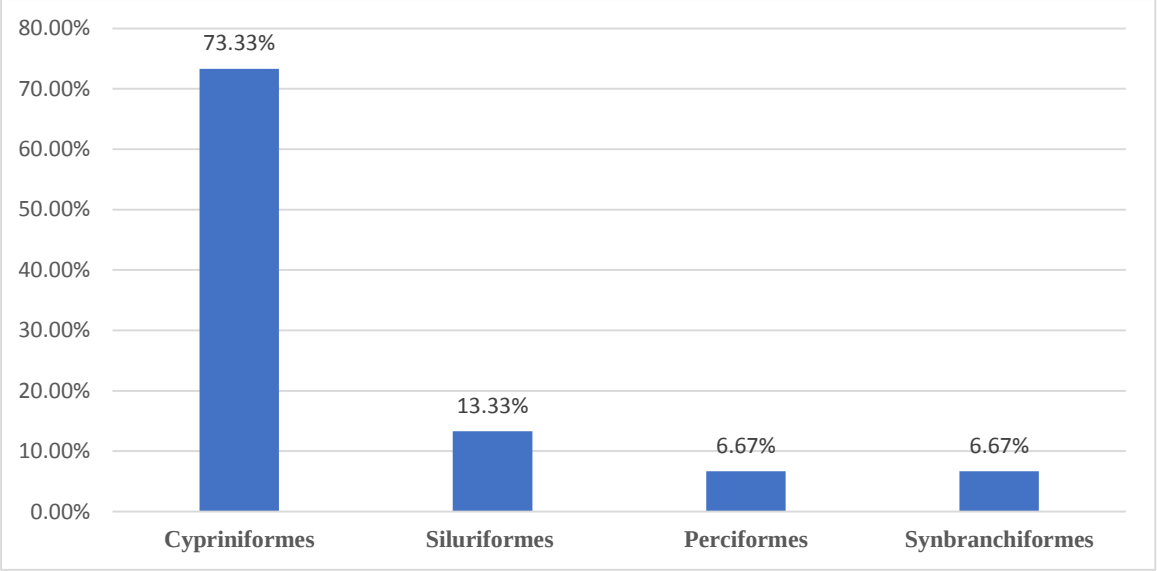

Figure 6. Order wise percentage compositions of fishes of Andhi Khola.

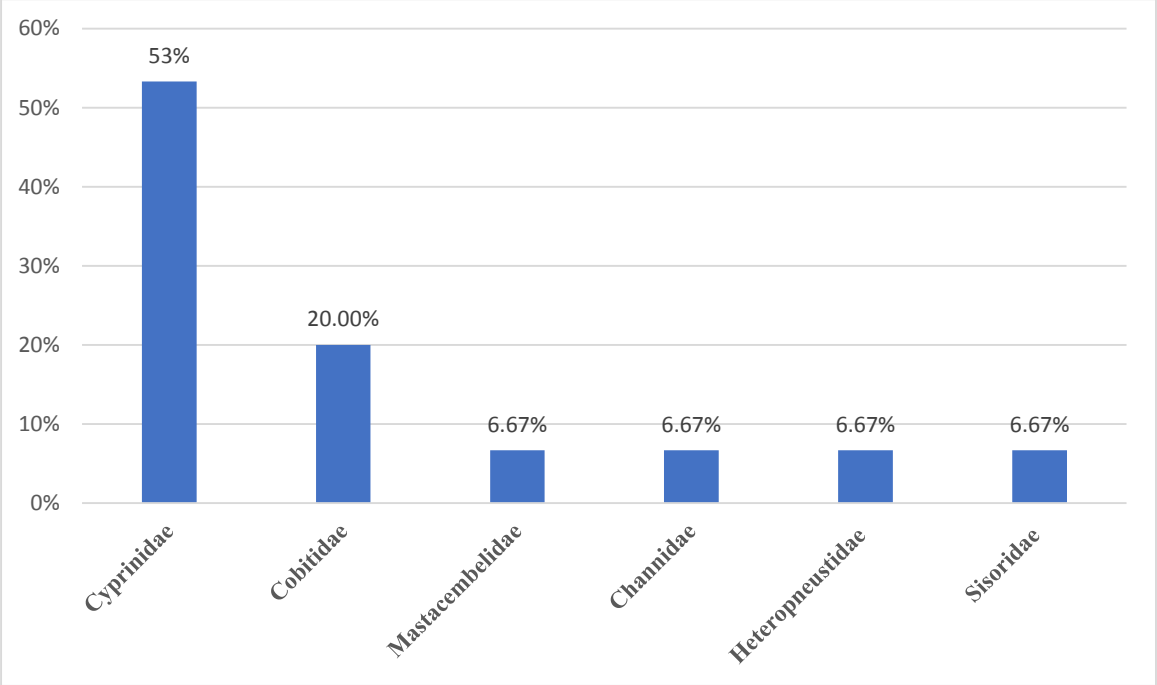

Figure 7. Family wise percentage compositions of fishes of Andhi Khola.

4.3 Species abundance and distribution

Highest Shannon-Weiner diversity index was found in site II where lowest was observed at site III. In each case, high Shannon diversity index is involved with high individuals and low diversity involved with low number of individuals. Simpson dominance diversity index value was highest in site I and site II and lowest value observed in site III. The maximum

evenness value was observed at site I and site II whereas minimum value was observed at site III (Fig8).

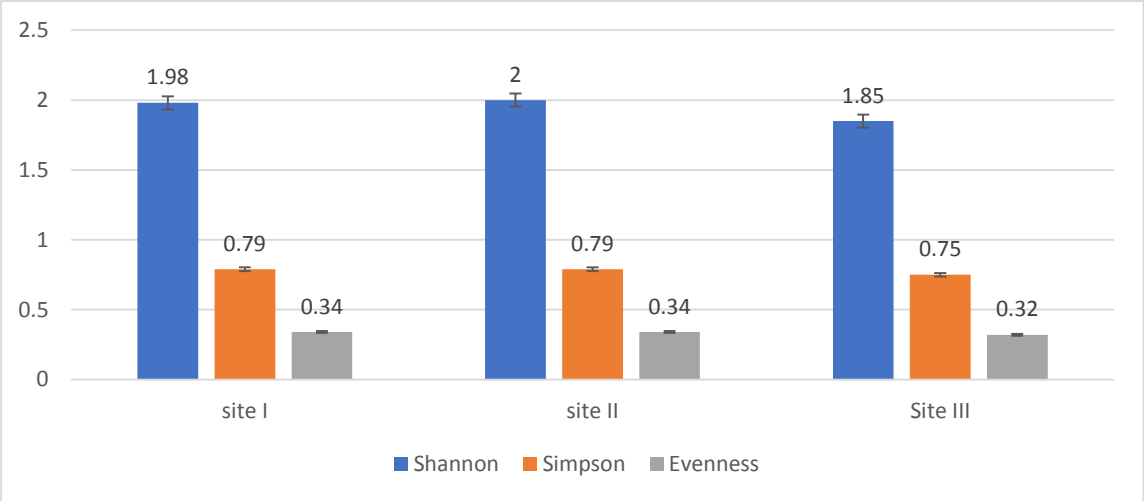

Figure 8. Species abundance and distribution according to sites

Highest Shannon-Weiner diversity index was found in spring (April) where lowest was observed during winter (Dec). In each case, high Shannon diversity index is involved with high individuals and low diversity involved with low number of individuals. Highest seasonally/Monthly dominance diversity index value was in autumn and lowest value in during winter. Seasonally/monthly higher evenness value was found high in autumn where lowest value observed during winter (Fig9).

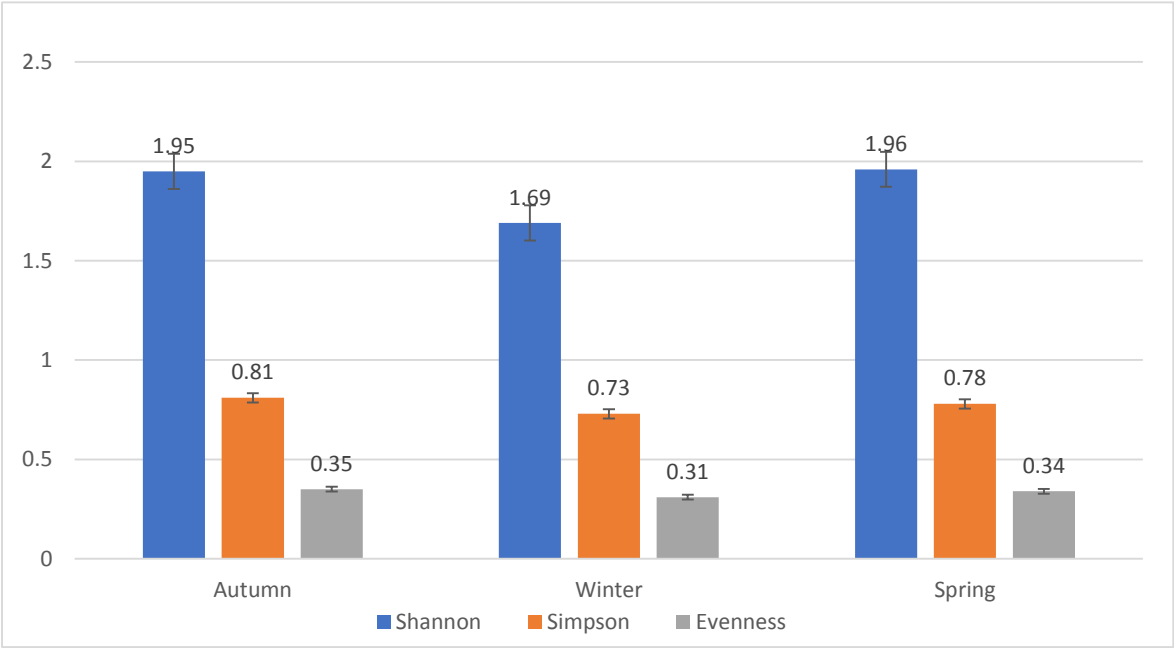

Figure 9. Species abundance and distribution according to Season

4.4 Ordination

The axis length of the first axis of Detrended Correspondence Analysis (DCA) was found 1.02 standard deviation unit (SD unit) that followed by 0.55 by the second DCA axis (Table 3). The overall variance explained by the data matrix was 8.4 %. Thus, application of RDA was justified.

Table 3. Fish species, season, and environmental variables and sites relationships

	DCA1	DCA2	DCA3	DCA4
Eigenvalues	0.08406	0.03119	0.012276	0.0177652
Decorana values	0.13459	0.02350	0.002933	0.0002974
Axis lengths	1.02184	0.55606	0.313044	0.3525540

The relationship between distribution, abundance of fish species and environmental Variables in months was established by using multivariate analysis investigated with Redundancy analysis (RDA). RDA is direct gradient multivariate analysis, which can Reveal the relationships among community structure, sites and environmental variables by a stepwise multiple regression (Ter Braak, 1986), was applied by using vegan library in 'R' (Oksanen et al. 2015).In the biplot, the importance of each environment characteristic was indicated by the length and angle of the vectors.

The analysis of environmental factors such as water temperature, water velocity, DO and pH plotted in RDA ordination plot biplot were Generated using RDA after extracting and integrating data from the fish community Indices with the environmental variables (water temperature, water velocity, DO, and pH). The vector length of a given variable indicates the importance of that variable in RDA Analysis and the longest vector length pH and water velocity describes significant relation with Occurrence of *Mastacembelus armatus,Puntius terio Gara rupecula, Schistura savona,* and *Lepidocephalous guntea* are highly associated with water temperature and also showed positive relation with site II and spring season but negatively related to DO and water velocity.

The variables of DO and water velocity showed positively relation to site I and III but negatively related to site II, spring season and water temperature. Species of *Barilius bendelisis, Barilius vagra and Neolissochilus hexagonolepis* are positively related to winter season but negatively related to autumn season. . Species of *Schistura horai* and

.

Channa puntatus showed positive relation with autumn season and are not related with any environmental variables.). The biplot was done to show the relation between seasons, environmental variables and fish abundance. The RDA biplot showed that the spring season is the important seasons for the occurrence of fish species during study period. The ordination plot (Fig 10) revealed that the environmental variables like pH and water temperature play a crucial role to shape the fish assemblage structure of the present study area

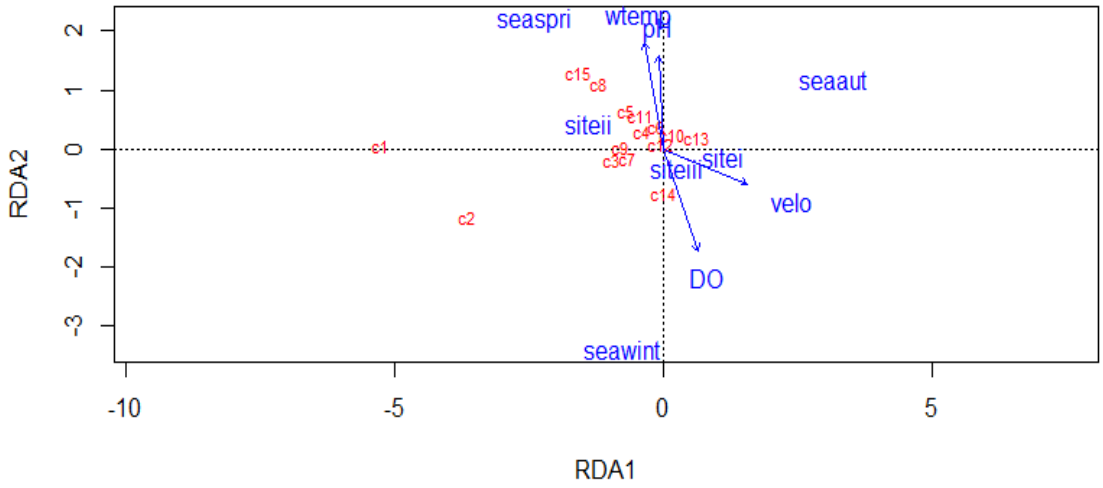

Fig.Ordination biplot of fish species abundance and environmental variables obtained by RDA across sampling periods (seasons) and sites

5. DISCUSSION

The healthy aquatic ecosystem is dependent on the physico-chemical characteristics (Surana et. al. 2010). The present study approaches were to analyze fish distribution and water quality of Andhi Khola. The studied were analyzed on autumn, winter and on spring. Running water system provides a diverse range of habitats for different types of indigenous fishes. The physico-chemical parameter of an aquatic environment exhibit influencing factor for the quantity of aquatic life. In the present study, the water temperature was recorded increases in spring and decreases in winter.

The concentration of dissolved oxygen is the most important factors in water which required above 5 mg/l to support diverse biota (Stickney 2000). The DO was found to be highest value of 9.25mg/l in winter season. The lowest value was 6.5mg/l in spring. Paudel (2012) and Gautam (2012) also reported that it was maximum in winter, the decreased water temperature during winter season has a greater capacity to hold DO than warm water and led to a lower rate of respiration thereby allowing maximum DO in winter.

Water velocity plays important role in determination of habitat and abundance of flora and fauna in a river by grading the riverbed material and maintainance of high level of dissolved oxygen (Whiton 1975). The water velocity of Andhi Khola at different station was recorded. The maximum velocity was recorded o.83m/s at station I in september.The minimum velocity of Andhi Khola was recorded 0.64m/s at station I and II in spring.

The pH of natural water is an important environmental factor, the variation of which is linked with the species composition and life process of animal and plant community inhabiting there (Jhingram 1991). The pH value of Andhi Khola was almost same in all season and site. The fishes of Nepal have wide distribution according to the climatic condition and altitudinal variation. A total of two hundred and thirty two fish species belonging to 114 genera, 37 families and 11 orders are distributed in different river systems and other water bodies of Nepal (Shrestha 2008). In present investigation, a total of 15 fish species were recorded from Andhi Khola. Majority of the fish species collected from the river fall under the order cypriniformes. This is the largest order of fresh water fishes, which includes 2,422 species (Nelson 1984). Edds (1886) had reported the order cypriniformesas the most common order of Kaligandaki/Narayani River. Andhi Khola is also the tributaries of the Kaligandaki river.

Barilius barila was the widely distributed species of Order cypriniformes as comprises highest frequency of 35.28% of the total catch. *Heteropneustus fossilius* was only found at station III in spring season only. Two different species were recorded from order Siluriformes with the frequency of 13.33%. Order Synbranchiformes and Perciformes represented by single species each viz. *Mastacembalus armatus* and *Channa punctatus* of family Mastacembalideae and Channideae respectively with 6.67% each. *Lepidiocephalus guntea* and *Heteropneustes fossillis* were the species only found in spring season while contrastingly, *Schizothorax plagostium* and *Channa punctatus* were absent only in that season. *Neolissochilus hexagonolepis* was only absent in autumn

Majority of the fish species collected from the river fall under the family Cyprinidae. *Barilius barila, Barilius vagra, Barilius bendelisis, Schizothorax plagostium, Garra mullya, Garra rupecula, Puntius terio* and *Neolissochilus hexagonolepis* were the total species falling under this commonest family found in Andhi Khola. Second most common family Cobitidae with three species namely *Schistora horai, Schistora savona* and *Lepidiocephalus guntea* were in catch. Few species like Barilius widely distributed in all three stations. Cyprinidae was the most common family with highest frequency of 53.33% of total species. Families Mastacembelidae, Channidae, Heteropneustidae and Sisoridae were with only one species in each. Order Siluriformes was the second common order of Andhi River. Family Heteropneustidae and Sisoridae were recorded. *Heteropneustes fossillis* from Heteropneustidae, *Glyptothorax trilineatus* from Sisoridae, *Mastacembalus armatus* from Mastacembelidae and *Channa punctatus* from Channidae were collected from this river.

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).

The biodiversity index values (H') obtained from present study values and they do not exactly show the differences occurring among the Sites either. According to Keskin and Unsal (1998) the reason for showing lower species biodiversity is that fishing gears used have high selectivity effect. Highest Shannon-Weiner diversity index was found in site II and spring (April) where lowest was observed at site III and during winter (Dec). In each

case, high Shannon diversity index is involved with high individuals and low diversity involved with low number of individuals. The main causes of the differences occurring in the biodiversity indexes are seasonal variations of nutrients at the sea grass beds affecting the coexistence of many fish species (Huh and Kitting, 1985), atmospheric air currents and environmental conditions (Keskin and Unsal, 1998), and seasonal fish migrations (Ryer and Orth, 1987).

Simpson dominance diversity index value was highest and equal in site I and site II and lowest value observed in site III. Highest seasonally/Monthly dominance diversity index value was in autumn and lowest value in during winter. The maximum evenness value was observed at site I and site II whereas minimum value was observed at site III and in case of Season/month higher evenness value was found high in to 0.35 where lowest value observed during winter. In Shannon (H'), Evenness (e) and Dominance (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.

6. CONCLUSION

Total of 907 individual fish comprising 15 species belonging to four order 11 genera and 6 families were Caught from Andhi Khola during the sampling period. Total number was counted for *Barilius barila* (320) and minimum for *Heteropneustus fossilius* (2 individual) which are 35.28% and 0.22% of total individual respectively. Abundant number of 380 individuals were counted at site II throughout the study period where lowest number of 254 individuals where found in site I. Seasonal abundance (individuals) variation was notable in all sampling sites. Maximum individuals were recorded in winter season.The highest value of Shannon-Weiner diversity index (1.96) was found in spring season and lowest (1.69) was found in winter season. Highest value of evenness index (0.35) was found in autumn while lowest (0.31) in winter season. There was no significant effect of season on fish abundance and diversity indices values.The Simpson dominance index in different sites varies from 0.75 to 0.79. The highest dominance index (0.79) was recorded at site I and site II and lowest (0.75) was recorded at site III. Highest Simpson dominance index (0.81) was recorded in autumn and lowest (0.73) was recorded in winter.

The Redundancy analysis (RDA) revealed that the environmental variables of water temperature, water velocity, and dissolved oxygen were found to be most imperative variables to shape the fish assemblage structure of present study area

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APPENDICES

Appendix 1. Fishes of Andhi Khola

Photo plate 1. *Barilius barila* (C1)

Photo plate 2. *Barilius vagra* (C2)

Photo plate 3. *Barilius bendelisis* (C3)

Photo plate 4. *Lepidiocephalus guntea* (C4)

Photo plate 5. *Gara rupecula* (C5)

Photo plate 6. *Gara mullya* (C6)

Photo plate 7. *Neolissochilus hexagonolepis* (C7)

Photo plate 8. *Puntius terio* (C8)

Photo plate 9. *Glyptothorax trilineatus* (C9)

Photo plate 10. *Schistura horai* (C10)

Photo plate 11. *Schistura savona* (C11)

Photo plate 12. *Heteropneustes fossillis* (C12)

Photo plate 13. *Channa punctatus* (C13)

Photo plate 14. *Schizothorax plagostomus* (C14)

Photo plate 15. *Mastacembelus armatus* (C15)

Appendix 2. Photo-plates from work

Photo plate 16. Collecting fish from Andhi Khola with the help of Local Fisherman

Photo plate 17. Analyzing fishes in CDZ lab after collection from Andhi Khola

Appendix 3. Mean value± Standard Error

Table 1: Mean value of environmental variables at site I in Andhi Khola (2018-19).

Seasons	Dissolved oxygen (DO, mg/l)	Water temperature (^oC)	Velocity (m/second)	pH
Winter	9.3 ± 0.30	12.2± 0.10	0.8 ± 0.06	7.1 ± 0.4
Spring	7.1 ± 0.22	16.2± 0.22	0.66 ± 0.22	7.1 ± 0.2
Autumn	8.2 ± 0.29	14.7 ± 0.21	0.83 ± 0.05	7.5 ± 0.1

Table 2: Mean value of environmental variables at site II in Andhi Khola (2018-19).

Seasons	Dissolved oxygen (DO, mg/l)	Water temperature (^oC)	Velocity (m/second)	pH
Winter	9.0 ± 0.21	12.1 ± 0.34	0.71 ± 0.24	7.1 ± 0.2
Spring	6.8 ± 0.17	16.5 ± 0.36	0.64 ± 0.12	7.5 ± 0.2
Autumn	8.0 ± 0.05	13.9 ± 0.10	0.81 ± 0.15	7.5 ± 0.3

Table 3: Mean value of environmental variables at site III in Andhi Khola (2018-19).

Seasons	Dissolved oxygen (DO, mg/l)	Water temperature (^oC)	Velocity (m/second)	pH
Winter	8.9 ± 0.12	12.3 ± 0.61	0.70 ± 0.10	7.2 ± 0.2
Spring	6.5 ± 0.24	16.8 ± 0.10	0.64 ± 0.19	7.6 ± 0.1
Autumn	7.8 ± 0.13	15.1 ± 0.10	0.80 ± 0.15	7.5 ± 0.3