# ICTHYOFAUNAL DIVERSITY OF MASYAM KHOLA, PALPA, NEPAL

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**(Code no. Zoo 653)**

**Submitted to**

**Department of Zoology**

**Institute of Science and Technology**

**Amrit Campus**

**Thamel, Kathmandu**

**September, 2022**

# 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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# RECOMMENDATION

This is to recommend that the thesis entitled **ICTHYOFAUNAL DIVERSITY OF MASYAM KHOLA, PALPA, NEPAL** has been carried out by **Sangam Bhattarai** for the partial fulfilment of Master's Degree of Science in Zoology with special paper Fish Biology and Aquaculture code no zoo 563. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

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# CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Sangam Bhattarai entitled **"ICTHYOFAUNAL DIVERSITY OF MASYAM KHOLA, PALPA, 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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## LETTER OF APPROVAL

On the recommendation of supervisor "Assistant Professor Santoshi Shrestha" this thesis submitted by Sangam Bhattarai entitled **"ICTHYOFAUNAL DIVERSITY OF MASYAM KHOLA, PALPA, NEPAL" is** approved for the examination and submitted to the Tribhuvan University in partial fulfillment of the requirements for Master's Degree of Science in Zoology with special paper Fish Biology and Aquaculture code no Zoo 563.

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Sangam Bhattarai

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# LIST OF ABBREVIATION

| | |
|---|---|
| APHA | American public Health Association |
| CBS | Central Bureau of Statistics |
| CFPCC | Central Fisheries Promotion and Conservation Centre |
| GPS | Global Positioning System |
| IUCN | International Union for Conservation of Nature |
| LC | Least Concern |
| masl | Meters above sea level |
| NT | Near threatened |
| pH | Percentage ion of Hydrogen |
| VU | Vulnerable species |

# ABSTRACT

The present study deals with the fish diversity of Masyam Khola Palpa, Nepal covering two seasons winter and spring season using cast net. A total of 255 fish individuals belonging to 9 species, 7 genera and 2 families was found during study period. Cyprinidae (n=243) was the dominant family comprising of 7 species among 9 recorded species. *Barilius bendelensis* was the most common fish species on the basis of total no. of catch during the study period followed by *Opsarius barna*, *Puntius sophore* and *Garra rupecula*. Shannon-Weiner diversity index was highest (1.64) at station II and station III while lowest (1.44) at station I, simpson index was highest at station II (0.79) and lowest at station IV (0.76) and evenness index was highest in station I (0.89) and lowest in station IV (0.76). The environmental variables like DO, pH, temperature, and velocity were found to be in suitable range for fish habitat.



**Keywords:** *Cypriniformes, Fish diversity, Diversity indices, Water quality parameters, Correlation*

# 1. INTRODUCTION

Fishes are one of the diverse cold-blooded vertebrates, comprised of more than 34000 species worldwide (Fish base, 2020). Fresh water is home to one-third of all vertebrates (Dudgeon et al., 2006) and 40% of all fish species (Nelson, 2006). Fish are regarded auspicious and serve as a symbol of fertility, power, and success in Nepal (Gurung, 2012), where they may be found in a variety of aquatic bodies such as rivers, streams, ponds, lakes, reservoirs, paddy fields, and swamps (CFPCC, 2019). Fishes are utilized as food, manure, amusement, animal feed, ornament, and so on (Yadav, 2017), and they are also an essential food resource, particularly for animal protein, all over the world (Shrestha, 2016).

Nepal has a comparably large number of rivers, lakes, and ponds (Sharma, 1999). Nepal accounts for only 0.1% of global land area (CBS, 2014), yet it has a disproportionately high diversity of flora and fauna at the genetic, species, and ecosystem levels (Paudel et al., 2012) accounting for around 2.27% of the world's freshwater resources (Kafle & Savillo, 2009). Nepal has an extreme terrain that ranges from 60 to 8848 meters above sea level and has vast water bodies that encompass an area of 8,18,500 hectares of the world's natural water bodies (DoFD, 2002).

Rivers are the most important source of freshwater, accounting for 49% of the nation's total water body, with the Himalayan, Mahabharat, and Siwalik Mountain ranges as its starting points where three main rivers (Koshi, Gandaki, and Karnali) have a combined length of approximately 25000 km and a surface area of 3,95,000 hectares (Sharma, 1977). The Mahabharat range is the source of a number of medium-sized rivers, including the Rapti, Kamala, Bagmati, Tinau, and Kankai, while the Siwalik (Churia) mountains are the source of other tiny rivers, most of which are seasonal in nature and run across the Terai plain (Jha,2008).

Shrestha (1981) reported 120 species in her book entitled ‘Fishes of Nepal" with detailed description and distribution of fishes of Nepal. Later she updated number of species in 1994 (n=185) and in the year 2013 reported 228 indigenous fish species from Nepal. Rajbanshi (2005) listed 187 fish species from Nepal and later in 2013 he updated the list of 229 indigenous species of Nepal. Shrestha (2008) reported 217 indigenous and 15 exotic fish species which was updated in 2019 with 252 (236 indigenous and 16

exotic) species from Nepal. Sharma and Shrestha (2001) reported 35 existing fish fauna belonging to 25 genera, 12 families & 5 orders in Tinau river, Palpa. Ale (2020) reported 14 species from Dobhan Khola, Palpa.

Water quality parameters are important factor for the aquatic habitat. Physical characters such as water current velocity (Yu and Lee, 2002) and water temperature (Kadye et al.,2008) influence the fish diversity. Water temperature greatly affects the chemistry of water and change in water temperature cause the change in DO and pH (Jacobsen, 2008). The amount of free, non-compound oxygen that is present in water is known as the dissolved oxygen. Due to its effect on the aquatic species that inhabits a body of water, it is a crucial factor in measuring water quality. For fish, an ideal oxygen level is greater than 5 mg/l (Bhatnagar and Singh, 2010). If fish are exposed to less than 0.3 mg/l of DO over an extended length of time, they will not survive (Ekubo and Abowei 2011). Dissolved oxygen is vital factor which affects the diversity, distribution, behavior and physiology of fishes (Pokhrel et al., 2018). The pH of water is defined as the logarithm of the reciprocal of hydrogen ion concentration. Hydrogen ion concentration determines the acidity, alkalinity and neutrality. The suitable range of pH for fish is 6.5-9 (Swingle,1967). The pH more or less than this range is not suitable for most species, though certain can survive beyond this range.

The Masyam river lies in Palpa district originates from Birung khola of the Mahabharat range and flows to the southern direction joining many feeder streams and meets Tinau River at Charchare. It originates as Birung khola from Mahabharat range of Palpa district. The river in its flow downwards meets feeder streams Kusum khola and Chakaldi khola at Rajabaghi. After that the river meets another feeder stream Masure khola at Chisapani, on its way downwards after Chisapani meets feeder stream Bharkot khola at Ghorlighat, Ashrung khola at Barhabise. The river after this confluence is called Masyam khola. The river on its way downstream meets Dumre khola and meets Tinau River at Charchare.

## 1.2 Objectives

### 1.2.1 Geneal Objective

The general objective is to study “Icthyofaunal diversity of Masyam Khola, Palpa, Nepal”.

### 1.2.2 Specific Objective

- To analyze physiochemical parameters of water.
- To explore diversity of fishes in Masyam khola.
- To analyze relation between species diversity and physiochemical parameters.

## 1.3 Rationale of study

Masyam khola is one of the important spring-fed water streams of Palpa which provides good habitat for fishes and other aquatic fauna and flora. No information about fish fauna of Masyam khola is known yet. There are no attempts made so far to explore the aquatic biodiversity in this river. Therefore, the present study helps to explore the existing ichthyofauna of Masyam khola and its relation with water quality. The fish are declining due to different environmental conditions, illegal fishing practices, habitat modifications and sand mining. So, this study helps to explore the diversity of fish and water quality of Masyam khola.

## 1.4 Limitation of the study

Due to nationwide COVID 9 pandemic lockdown the study was confined to two seasons and only the water quality parameters including pH, temperature and DO were analyzed during study period.

# 2. LITERATURE REVIEW

Ghimire and Koju (2021) studied on fish diversity and its relationship with environmental variables in Kamala River, Nepal and reported 19 species belonging to 5 orders, 8 families, and 15 genera as Cyprinids were the most dominant in the river. Water temperature ranged about 26°C to 27 °C and the river water was slightly alkaline with pH value was 7.2 to 8.31. Shrestha et al., (2021) studied on Lohore river and relationships between environmental conditions and fish assemblages, they found 11 species comprising 7 genera, 3 families and 2 orders. Cypriniformes was the most diverse order and Cyprinidae was the most diverse family. The DO, free $CO_2$, temperature, and water velocity were found to be determining factors for diversity and distribution of fish.

Ale (2020) studied on the spatio-temporal variation of the fish assemblage structure in Dobhan Khola, Palpa and collected samples covering autumn, winter and spring seasons. Family Cyprinidae (50%) and *Garra rupecula* was the most common fish species followed by *Barilius bendelensis, Garra gotyla* and *Puntius terio* among14 species belonging to 3 orders, 5 families and 10 genera. Shannon-Weiner diversity index extended between 2.19 to 2.43 and Species richness ranged from 2.28 to 3.04 among stations. The environmental variables were correlated with the fish assemblage. Limbu and Prasad (2020) studied environmental variables and fish diversity of Nuwa river, Panchthar, Nepal and collected 8 species belonging to order Cypriniformes with 2 families and 3 genera. Nemachilids were the dominant group comprising 62.5% followed by Cyprinids (37.5%). The water quality parameters (DO: 6-11.5 mg/l, pH: 7-9, temperature: 8- 24ºC, hardness: 60- 90 mg/L and velocity of water: 0.4 - 1 m/s) meets the desirable range of running water.

Prasad et al., (2020) studied the spatial and temporal variation of fish assemblages in Seti Gandaki River, Tanahu and reported 46 species belonging to 23 genera, 9 families and 4 orders. Cypriniformes (71.7% /33 species) was the most dominating order followed by Siluriformes (21.7% / 10 species). Parameters, like pH, total hardness, alkalinity, DO and water temperature have shown to be influencing factors for the fish community structure.

Limbu and Gupta (2019) reported 27 species from Ratuwa River, Jhapa. *Barilius barila, Barilius bendelesis, Guducia chapra Puntius chola, Puntius phutunio, Puntius sophore, Channa punctatus, Channa barca, Esomos danricus, Lepidocephalus guntae, Brachidanio rerio,* and *Colisa fasciatus* were the common species of Ratuwa river. Shrestha and Yadav (2019) studied on Keshalia river and caught 55 species belonging to 41 genera, 18 families and 6 orders including remarkable fish species like *Barilus shacra*, *Garra annandalei*, *Nandus nandus*, *Badis badis*, *Sisor rhabdophorus*, *Bagarius bagarius*, *Notopterus notopterus*, *Somileptes gongota*, *Channa marulius*, *Clupisoma garua* and *Hara hara*. A total of sixteen species belonging to 3 orders, 6 families and 11 genera were recorded from Dewmai khola by Limbu et al., 2018. Cypriniformes was the dominant order which represented 82 % of total catch.

Subba (2017) reported a total of 118 species spread over 11 orders, 26 families and 64 genera inhabited in different water bodies of Morang district as *Olyra longicaudata*, *Pseudecheneis sulcatus*, *Schizothorax plagiostomus*, *Schistura savona* and *Neolissochilus hexagonolepis* recorded during the survey that have not been previously reported from this district. Raymajhi (2017) reported 55 species from Chitwan National Park and its adjacent zones. Yadav (2017) studied on fish diversity and need for their conservation of Singhiya river and reported twenty-six species. Shrestha (2016) showed the presence of 48 fish species under 35 genera belonging to 17 families and 6 orders from Triyuga River. Some interesting fish species are *Barilus shacra, Garra annandalei, Psilorhynchoides pseudecheneis, Badis badis, Olyra longicoudata, Tor putitora, Labeo dero* and *Anguilla bengalensis*.

A total of 108 species (9 orders, 27 families and 70 genera) with dominancy of Cypriniformes (49%) were recorded from different sampling points of the Narayani River system by Jha and Bhujel (2014). Mandal (2013) reported 26 species belonging to 5 orders, 6 families and 18 genera from Marshyangdi River. Cyprinidae was the most dominant among the families represented by 53.8% species followed by Cobitidae (23.0%), Sisoridae (7.7%) and Channidae (7.7%) while Anguillidae and Synbranchidae accounted each by 3.9% only. Oli et al., (2013) studied seasonal variation in water quality and fish diversity of Rampur Ghol and collected fish fauna of 22 species belonging to 13 families 5 orders. The highest number of individuals was seen in post-monsoon (332) followed by monsoon (245) and pre-monsoon (147). They also revealed significant seasonal fluctuation in water quality and decline of fish species as well as

their abundance from past studies. Saund et al. (2012) recorded 24 species belonging to 3 orders, 4 families and 13 genera in Mahakali River of which Cypriniformes was the most dominant order accounting 75% of total fish species. 24 fish species belonging to 4 orders, 6 families and 16 genera were reported in West Rapti River by Pokharel (2011). Karki (2000) did study in lower Karnali River and reported 50 species belonging to 29 genera, 15 families and 8 orders. The study in Tinau river, Palpa by Sharma and Shrestha (2001) reported the species 35 species with family Cyprinidae was most abundance (51.40%) followed by Cobitidae (14.29%) & Mastacembecidae (8.57%).

Water quality parameters are important factor for the aquatic habitat. Physical characters such as water current velocity (Yu and Lee, 2002) and water temperature (kadye et al.,2008) influence the fish diversity. Water temperature greatly affects the chemistry of water and change in water temperature cause the change in DO and pH (Jacobsen, 2008). Dissolved oxygen in the important factor for the survival of the organism living in the water body. The favorable DO concentration for diverse biota is above 5mg/l (APHA, 1998). The pH value of water suggests the acidity, alkalinity and neutrality of water. Swingle (1967) submits the suitable range for of pH for fish is 6.5-9. The pH more or less than this range is not suitable for most species, though certain can survive beside of this range. Saund et al., (2012) documented the water quality parameters (temperature 20.5-22.6 °C; DO 8.58-11.85 mg/l and pH 6.9-7.2) from Mahakali River which was within the suitable range supporting diverse fish species in river water.

# 3. MATERIALS AND METHODS

## 3.1 Materials

- Cast net ($1\times1\times1$ $cm^3$)
- GPS: Garmin Etrex 10
- Thermometer
- Digital DO meter: Teknik EM-83B
- $P^H$ meter: HANNA: HI98107
- Sample bottles
- Formalin
- Camera: Sony W710
- Measuring scale
- Measuring tape

## 3.2 Study Area

The study was conducted in Masyam khola of Palpa district, Nepal. The Masyam river originates from the Mahabharat range of Palpa district. It flows to the southern direction joining many feeder streams covering about 18 km and meets Tinau River in Charchare.

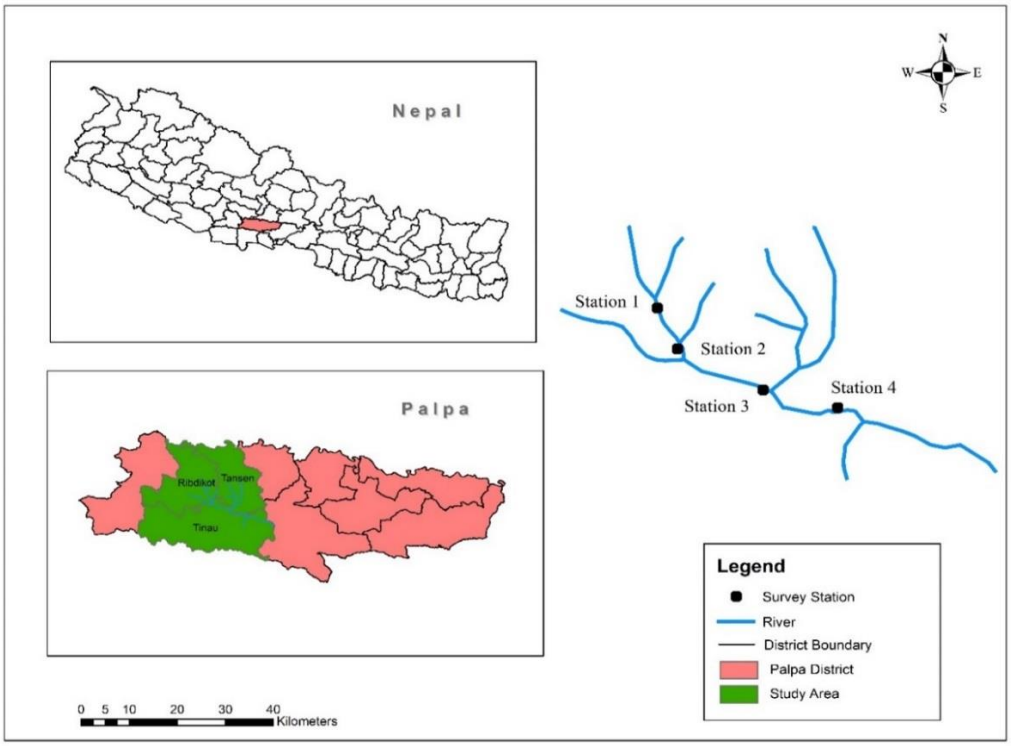


**Figure1**: Map showing the study area

### 3.3 Selection of sampling sites

The preliminary survey was done during December, 2020 to gather the necessary information about the study area and the feasibility of the research. Based on the field observation, four sampling stations were selected and designed Station I, Station II, Station III and Station IV.

#### 3.3.1 Station I: Chisapani

It lies on N 27°50’08.1” E083°28’21.2” and altitude 909 masl. The river in its flow downwards meets feeder streams Kusum khola & Chakaldi khola at Rajabaghi. and Masure khola at Chisapani. The river bed consists of big boulders, cobbles and pebbles.

#### 3.3.2 Station II: Ghorlighat

It lies on N 27°49’11.0” E083°28’48.0” and altitude 868masl. River on its way downwards meets feeder stream Bharkot khola at Ghorlighat. The river bed consists of boulders, cobbles, pebbles and sand.

#### 3.3.3 Station III: Barhabise

This station lies on N 27°48’14.3” E083°30’41.6” and altitude 700 masl. After Ghorlighat the river meets feeder stream Ashrung khola at Barhabise. The river after this confluence is called Masyam khola. The stream bottom consists of boulders, cobbles, pebbles, gravel, mud and sand.

#### 3.3.4 Station IV: Kalimati

The station lies on N 27°47’49.6” E083°32’20.7” and altitude 569 masl. The river on its way downstream meets Dumre khola. The fourth sampling station was taken after this confluence at Kalimati is about 6 km down from Barhabisye. The river bed consists of boulders, cobbles, pebbles, mud and sand.

### 3.4 Methods

#### 3.4.1 Physio-chemical analysis of water

The physio-chemical parameters of water were measured at the field using appropriate tools.

##### 3.4.1.1 Color

Color of water was taken by placing a beaker of water in white paper and the color was noted.

##### 3.4.1.2 Temperature

Temperature was recorded with the help of standard alcohol thermometer. The data was simply taken by dipping bulb of thermometer to the water until constant reading was obtained.

##### 3.4.1.3 Water velocity

The water velocity of river was measured by simple floating method with the help of a stop watch and measuring tape. The float material was left in the river for 30 meter and the time to cross the point was calculated and this velocity was expressed in m/s.

##### 3.4.1.4 pH

pH was measured by the help of HANNA'S digital pH meter (HANNA: HI98107).

##### 3.4.1.5 Dissolved oxygen (DO)

DO was measured using digital DO meter (Teknik EM-83B).

### 3.5 Fish sampling and identification

The study was conducted in 2021 covering two seasons winter and spring. A cast net of mesh size ($1\times1\times1$ $cm^3$) was used for fish sampling by hiring local fishermen. The collected fishes were counted, photographs, morphological features and measurements were taken in the field. Then, the samples were preserved in 8- 10% formalin and brought to the laboratory of Amrit Campus for further study. The collected fish species were identified using Shrestha (1981/1994), Shrestha (2019), Jayaram (2013) and

fishbase.org. The samples were deposited to museum of Department of Zoology, Amrit Campus, Kathmandu.

### 3.6 Data analysis

Data was arranged, organized and entered in MS-Excel for further analysis.

#### 3.6.1 Species diversity indices

##### 3.6.1.1 Shannon Weiner diversity index

Species diversity was calculated by Shannon-Weiner diversity index (Shannon and Weaver, 1949). Shannon-Weiner diversity index is denoted by $H^{'}$ and calculated as,

$$H^{'} = -\sum p_i \times \log p_i$$

Where, $p_i = \frac{S}{T}$ , S =number of individual species and T=total number of individuals in sample.

##### 3.6.1.2 Simpson's index of Dominance

Dominance was calculated using Simpson's Index of Dominance. Simpson's index of dominance is denoted by D and calculated as,

$$D = 1 - \frac{n_i(n_i-1)}{N(N-1)}$$

Where, $n_i$ is total number of individuals of particular species and N= total number of species

##### 3.6.1.3 Evenness

Evenness was calculated by following formula (Pieleu, 1966),

$$J = \frac{H'}{\log S}$$

Where, H' is Shannon Weiner diversity index and S is total number of species in sample.

### 3.6.1.4 Frequency

Frequency of every fish species were obtained by using formula

$$\text{Frequency(f)} = \frac{\text{total no. of individual species}}{\text{total no. of all species}} \times 100\%$$

### 3.6.2 Statistical analysis

The coefficient of correlation between physiochemical parameters with fish diversity and probability error was calculated using Karl Pearson method.

$$\text{Correlation coefficient(r)} = \frac{N\sum XY - \sum X \sum Y}{\sqrt{N\sum X^2 - (\sum X)^2}\ \sqrt{N\sum Y^2 - (\sum Y)^2}}$$

$$\text{Probability error } (PE_{r)} = \frac{1-r^2}{\sqrt{N}} \times 0.6745$$

# 4. RESULTS

## 4.1 Physico-chemical parameters

### 4.1.1 Color

Water color was clear and transparent in both seasons at all sampling stations.

### 4.1.2 Water temperature

The water temperature was found to be highest in spring season at station IV with the value of 24°C. While the lowest temperature was observed at station I and II in winter season with value of 14°C. The average water temperature of winter season was 14.5°C and that of spring season was 22.75°C (Fig 2).

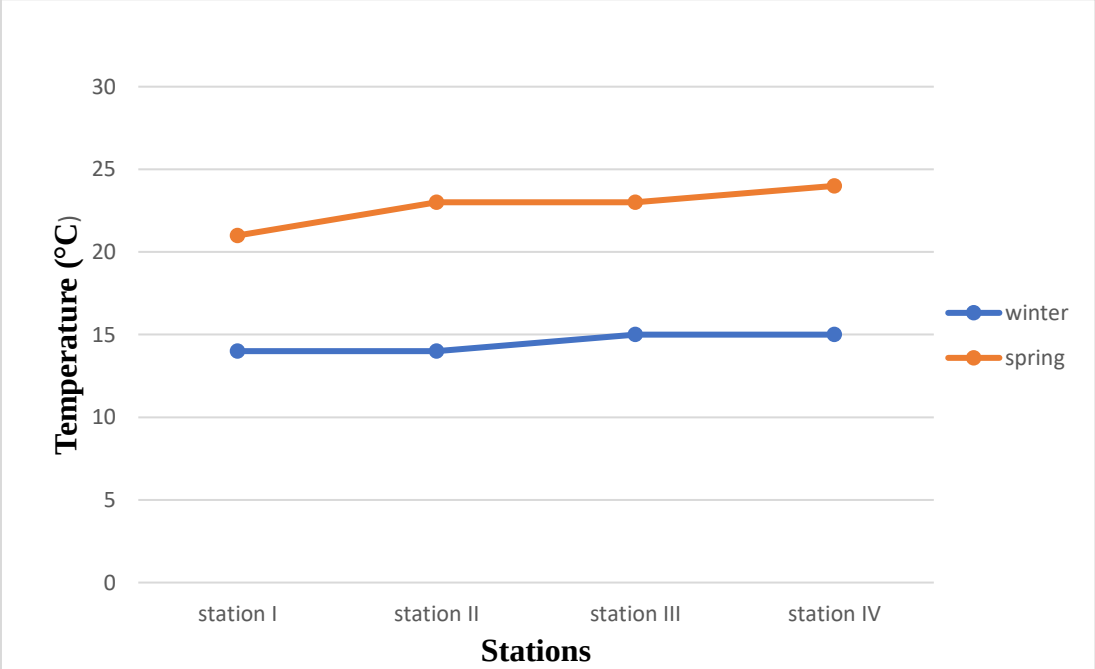


**Figure 2**: Variation of temperature at four stations

### 4.1.3 Water velocity

Water velocity of Masyam khola was found highest with value of 0.722 m/sec in spring season at station IV and lowest with the value of 0.619m/sec in winter season at station I (Fig 3).

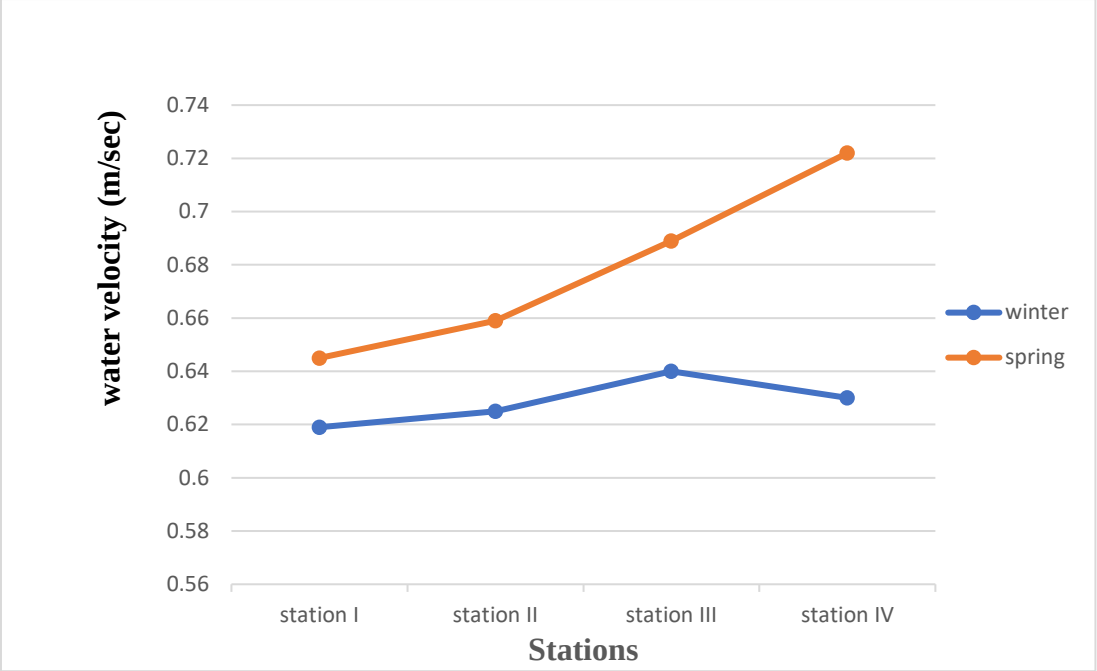


**Figure 3**: Variation of water velocity at four stations

### 4.1.4 Hydrogen ion concentration(pH)

The pH of water in all stations of Masyam khola was noted slightly alkaline. The lowest value of pH was noted 8.4 during winter season at station III and IV. The highest value was noted 8.7 during spring season at station I and II (Fig 4).

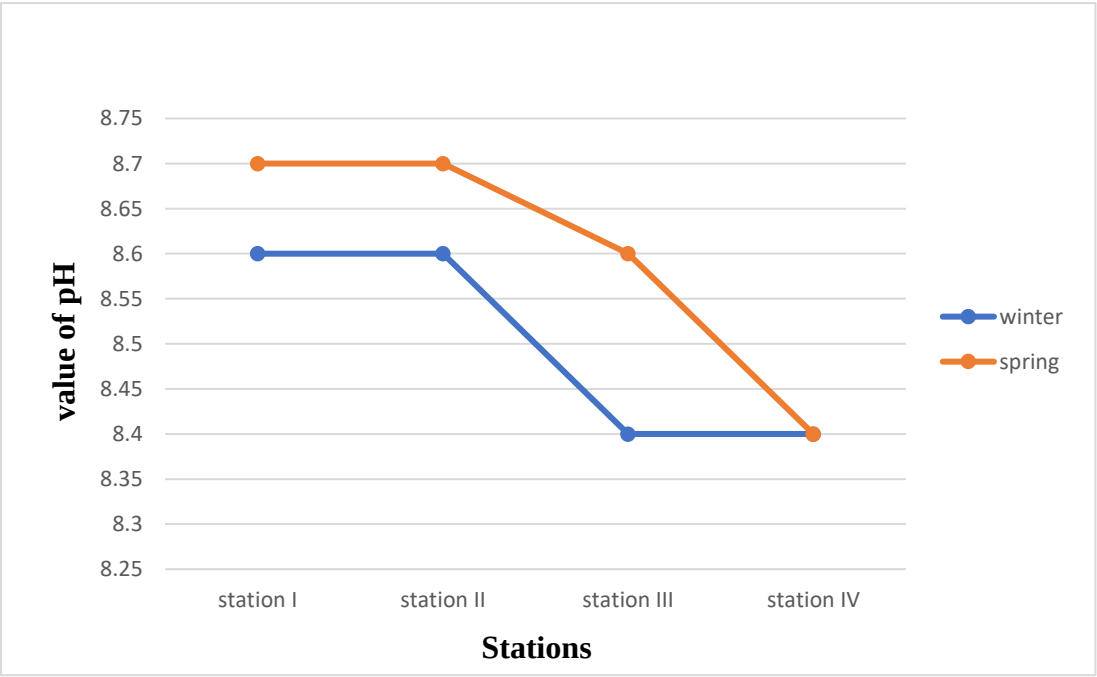


**Figure 4**: Variation of pH at four stations

### 4.1.5 Dissolved oxygen

The highest value of dissolved oxygen in water was recorded 8.2 mg/l at station IV and II in winter season. The lowest value of DO was recorded 7.5 mg/l at station III in spring season (Fig 5).

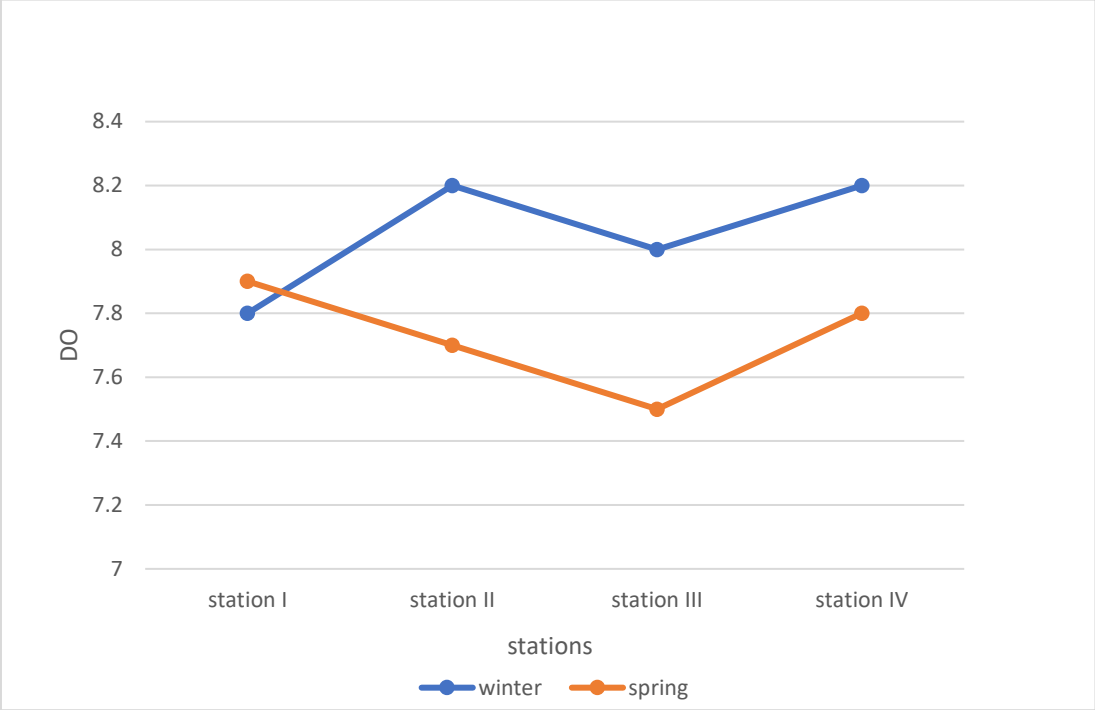


**Figure 5**: Variation of dissolved oxygen (DO) at four stations

### 4.2 Ichthyofaunal Diversity

During the study period a total of 9 species were found belonging to order Cypriniformes, 2 families (Cyprinidae and Cobitidae) and 7 genera. 6 species under least concerned (LC) species, 2 species under near threatened (NT), and one species was of vulnerable threat status (Table 1). The conservation status was adopted from IUCN Redlist of Threatened Species 2019.

**Table 1**: Fish diversity of Masyam Khola with its local name and conservation status.

| S.N. | Order | Family | Scientific name | Local name | Conservation status |
|---|---|---|---|---|---|
| 1 | Cypriniformes | Cyprinidae | *Barilius bendelensis* (Hamilton, 1822) | Fageta | LC |
| 2 | Cypriniformes | Cyprinidae | *Opsarius barna* (Hamilton, 1822) | Fageta | LC |
| 3 | Cypriniformes | Cyprinidae | *Puntius sophore* (Hamilton, 1822) | Sidra | LC |
| 4 | Cypriniformes | Cyprinidae | *Garra rupecula* (McClelland, 1839) | Buduna | NT |
| 5 | Cypriniformes | Cyprinidae | *Garra gotyla* (Menon, 1964) | Buduna | LC |
| 6 | Cypriniformes | Cyprinidae | *Schizothorax richardsonii* (Gray, 1832) | Asala | VU |
| 7 | Cypriniformes | Cyprinidae | *Neolissochilus hexagonolepis* (McClelland, 1839) | Katle | NT |
| 8 | Cypriniformes | Cobitidae | *Schistura beavani* (Gunther, 1868) | Gadela | LC |
| 9 | Cypriniformes | Cobitidae | *Schistura rupecula* (McClelland, 1839) | Gadela | LC |

### 4.3 Distribution and frequency occurrence of fishes in Masyam Khola

In the present study, a total 255 fishes of different species were captured. 7 species (n = 100) was captured in winter season and 9 species (n = 155) was captured in spring season. 12 fishes were of Cobitidae family while other 243 fishes were under Cyprinidae. The dominant family was Cyprinidae (77.77%) with 7 species and Cobitidae (22.23%) had only two species under Genus *Schistura* during study period (Table 2).

**Table 2:** Distribution and frequency occurrence of fishes in Masyam khola.

| **S.N.** | **Name of species** | **Winter** | | | | **Spring** | | | | **Total** | **Frequency (%)** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **St. I** | **St. II** | **St. III** | **St. IV** | **St. I** | **St. II** | **St. III** | **St. IV** | | |
| 1 | *Barilius bendelensis* | + | + | + | + | + | + | + | + | 88 | 34.51 |
| 2 | *Opsarius barna* | + | + | + | + | + | + | + | + | 48 | 18.82 |
| 3 | *Puntius sophore* | - | - | - | + | - | - | + | + | 46 | 18.04 |
| 4 | *Garra rupecula* | + | + | + | - | + | + | + | + | 30 | 11.76 |
| 5 | *Garra gotyla* | - | + | + | - | - | + | + | + | 14 | 5.49 |
| 6 | *Schizothorax richardsonii* | - | - | - | - | + | + | - | - | 13 | 5.10 |
| 7 | *Neolissochilus hexagonolepis* | - | - | - | - | - | + | - | + | 4 | 1.57 |
| 8 | *Schistura beavani* | - | - | + | - | - | - | + | + | 3 | 1.18 |
| 9 | *Schistura rupecula* | - | - | + | - | + | + | - | + | 9 | 3.53 |
| | **Total** | | | | | | | | | **255** | **100** |

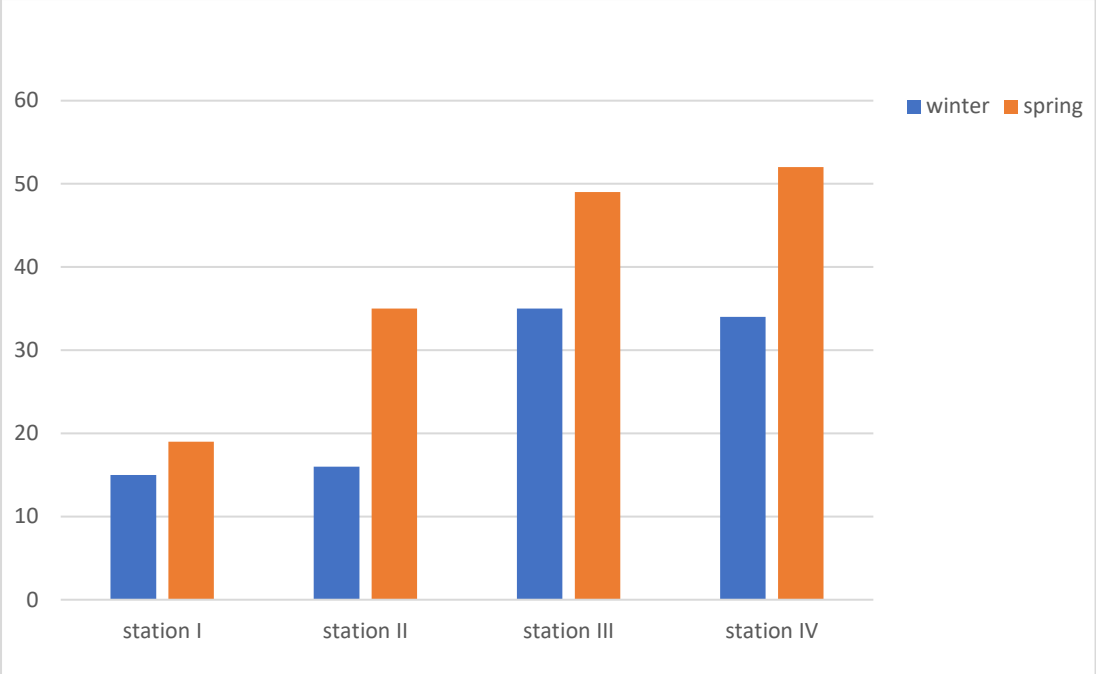


**Figure 6**: Seasonal fish diversity at different stations.

During the study period, all together 7 genera were enumerated. The highest number of fishes were from genus *Barilius* (34.51%) followed by *Opsarius* (18.824%), *Puntius* (18.039%) and *Garra* (17.255%). Similarly, *Schizothorax* and *Schistura* were found in 5.098% and 4.706% respectively. The lowest number was found of genus *Neolissochilus* with 1.569% (Figure 7).

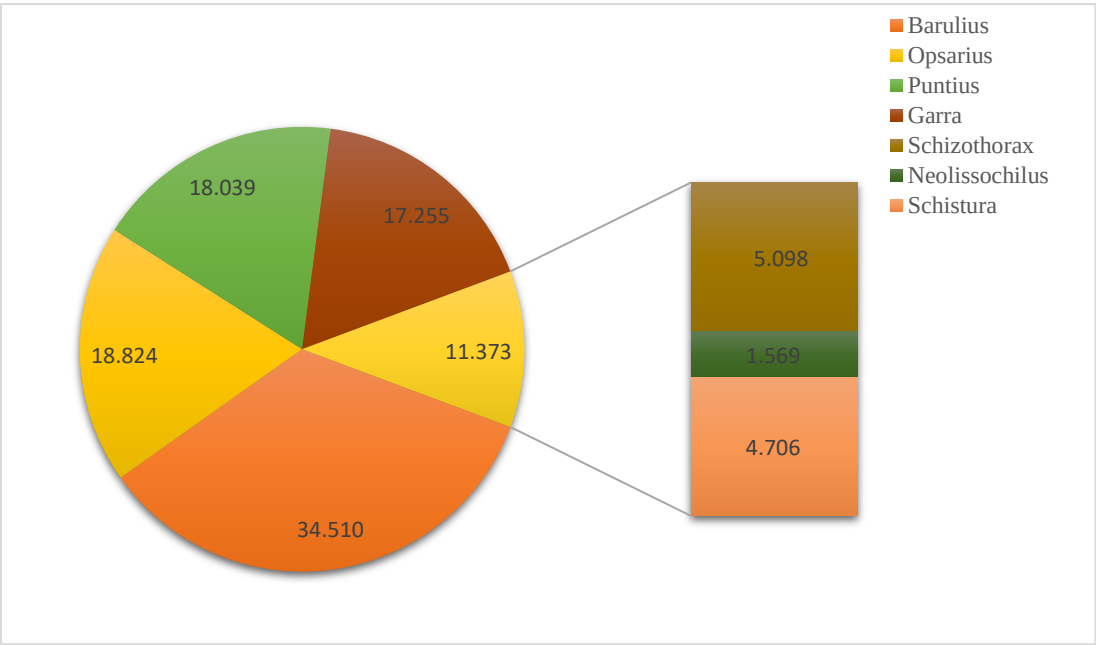


**Figure 7**: Genus wise species composition (%) of Masyam khola.

### 4.4 Diversity indices

#### 4.4.1 Season wise diversity indices of Masyam khola

The highest value of Shannon-weiner diversity index was seen in spring (1.91) and lowest in winter (1.20). The simpson index was 0.61 in winter and 0.83 in spring.and evenness index was 0.62 in winter and 0.87 in spring.

**Table 3:** Seasonwise diversity indices of study area

| S.N. | Diversity indices | Season | |
|---|---|---|---|
| | | Winter | Spring |
| 1 | Shannon-Weiner diversity index | 1.20 | 1.91 |
| 2 | Simpson dominance index | 0.61 | 0.83 |
| 3 | Evenness index | 0.62 | 0.87 |

#### 4.4.2 Station wise fish diversity indices of Masyam khola

Shannon-Weiner diversity index was highest 1.64 at station II and station III while lowest 1.44 at station I. Simpson index was highest at station II (0.79) and lowest at station IV (0.76). Evenness index was highest in station I (0.89) and lowest in station IV (0.76).

**Table 4:** Stationwise fish diversity indices of study area

| S.N. | Diversity indices | Station | | | |
|---|---|---|---|---|---|
| | | St.1 | St.2 | St.3 | St.4 |
| 1 | Shannon-Weiner diversity index | 1.44 | 1.64 | 1.64 | 1.59 |
| 2 | Simpson dominance index | 0.77 | 0.79 | 0.78 | 0.76 |
| 3 | Evenness index | 0.89 | 0.84 | 0.84 | 0.76 |

### 4.6 Correlation between different physico-chemical parameters and fish diversity in study area.

Karl Pearson's correlation coefficient method was used to calculate coefficient of correlation for analyzing statistical relation between physicochemical parameters with the number of fish species collected. Also, probability error for each correlation coefficient was calculated. The correlation between water temperature and number of fish species was positive (0.664). The correlation between no. of fish species and pH was negative (-0.463). The correlation between number of fish species and DO was positive (0.481). The water velocity and fish species were positively (0.863) correlated.

**Table 5:** Correlation between different physico-chemical parameters and fish diversity in study area.

| S.N. | Variables | Correlation | Probable error (PEr.) |
|---|---|---|---|
| 1 | Temperature with fish species | 0.664 | 0.133 |
| 2 | Water velocity with fish species | 0.863 | 0.061 |
| 3 | DO with fish species | 0.481 | 0.183 |
| 4 | pH with fish species | -0.463 | 0.187 |

# 5. DISCUSSION

The diversity of species in the water bodies depends on the physical (i.e., temperature, turbidity, transperancy, water colour, water velocity) as well as chemical properties (i.e., pH, total hardness, total alkalinity, dissolved oxygen, free carbondioxide) of water. Water quality parameters are important factor for the aquatic habitat. Physical characters such as water current velocity (Yu and Lee, 2002) and water temperature (Kadye et al.,2008) influence the fish diversity.

The increase of temperature directly or indirectly impacts species distribution and the seasonality of production in fish (FAO, 2010). A rise in water temperature accelerates the chemical reaction of water, reducing the solubility of gases and amplifying the taste and smells (Trivedy & Goel, 1984). Water temperature greatly affects the chemistry of water and change in water temperature cause the change in DO and pH (Jacobsen, 2008). The water temperature of study area ranged from 14°C to 24°C during the study period. The lowest temperature was at station I and II (14°C) in winter season and highest at station IV (24°C) in spring season with high fish abundance. Water temperature is positively correlated with fish. Mishra and Gupta (2015) also reported water temperature high during spring and low in winter. Water velocity of Masyam Khola was found highest with value of 0.722 m/sec in spring season at station IV and lowest with the value of 0.619m/sec in winter season at station I. The velocity is positively correlated with fish species and mostly hill stream fishes were found in river.

Dissolved oxygen is important factor which affects the diversity, distribution, behavior and physiology of fishes (Pokhrel et al. 2018). The suitable oxygen level for fish growth is greater than 5 mg/l (APHA,1998); less than 0.3 mg/l of DO for long period of time they could not survive (Ekubo and Abowei 2011). DO of study area ranged between 7.5mg/l to 8.2mg/l during study period. Similar results were analyzed by Shrestha et al., (2009) in Tamor river, Sharma and Shrestha (2001) in Tinau river and Ale (2020) in Dobhan Khola. Positive correlation between DO and fish diversity was seen indicating DO is significant for distribution of fish. The suitable range of pH for fish is 6.5-9 (Swingle,1967). The pH more or less than this range is not suitable for most species, though certain can survive beside of this range. The pH of water in all stations of Masyam khola was noted slightly alkaline (lowest 8.4 during winter at station III and IV and highest 8.7 during spring at station I and II. This result resemblance with Mishra

and Baniya (2016), Limbu et al., (2018) and Rashid et al., (1999). There was negative correlation found between pH with fish diversity in Masyam khola. Similar results were found to that of Saund et al., 2012 as they found the water temperature (20.50-22.63 °C), DO (8.58-11.85 mg/l) and pH (6.93-7.20) in Mahakali River within the suitable range supporting diverse fish species.

The present study revealed total of 9 species of Cypriniformes belonging to 2 families and 7 genera. The most common fish species on the basis of total no. of catch during the study period was *Barilius bendelensis* (88) followed by *Opsarius barna* (48), *Puntius sophore* (46) and *Garra rupecula* (30). Cyprinidae was the dominant family including 77.77% of species composition that is 7 species among 9 recorded species and total 243 individuals out of 255 captured fish. Sharma and Shrestha (2001), Ale (2020), Ahmed et al. (2013), Jha and Bhujel (2014), Shrestha (2001) and Limbu and Prasad (2020) also reported the Cypriniformes and Cyprinidae as dominant order and family. Sharma and Shrestha (2001), Mandal (2013) and Ale (2020) also found the abundancy of family Cyprinidae from Tinau, Marshyangdi and Dobhan River.

*Barilius bendelensis* was found most frequently with frequency 34.51% followed by *Opsarius barna* (18.82%) and *Puntius sophore* (18.04%) whereas *Schistura beavani* (1.18%) had the least frequency. Out of 9 species *Barilius bendelensis* was dominant species which exactly reveals the findings of Sharma and Shrestha, 2001 in Tinau river, Shrestha (2005) in Dano river while Ale (2020) found second high abundancy of *B. bendelensis*. *Puntius sophore* was found only lower region of river at station III and IV while *Scizothorax richardsonii* was captured in upper part of river at station I and II. *Neolissochilus hexagonolepis* and *Schizothorax richardsonii* were only found in spring season. Station IV has the highest fish diversity including 8 species and has highest number of catch of 86 individuals. The lowest fish species was found in station I (5 species) and has lowest number of catch of 34 individuals. The number of individuals was gradually increasing downstream i.e, lowest in station I and highest in station IV. Progressive increase in number of fish species in downstream from upstream was found by Negi and Mamgain (2013).

A diversity index is a mathematical measure of species diversity in a given community. The Shannon diversity index is commonly used to characterize species diversity in a community. If each individual belongs to a different species, the diversity index is the

largest. If value of Shannon diversity index is 0 indicates a community that only has one species. Shannon-Weiner diversity index was highest 1.64 at station II and station III while lowest 1.44 at station I. Between seasons highest value of Shannon-weiner diversity index was found in spring (1.91) and lowest in winter (1.20). The value of Shannon-wiener diversity of study area indicates that there was diverse fish species. Simpson's diversity index measures the community diversity and ranges between 0 to 1. The high Simpson's diversity index (SDI) indicates high diversity and low value (i.e., close to 0) indicates low diversity. Simpson index was highest at station II (0.79) and lowest at station IV (0.76) and during seasons it was 0.61 in winter and 0.83 in spring. This indicates that diverse fish species were found in Masyam Khola. Evenness index measures the evenness of the community and ranges from 0 to 1. The high value of evenness index indicates the species are evenly distributed and low value indicates the less evenness in communities between the species. Evenness index was highest in station I (0.89) and lowest in station IV (0.76). Seasonally it was found 0.62 in winter and 0.87 in spring. The value of evenness index indicates the species being evenly distributed.

# 6. CONCLUSION AND RECOMMENDATIONS

## 6.1 Conclusion

A total of 255 individuals were caught which comprises of 9 species belonging to single order Cypriniformes. The study explores the existing fish fauna including 2 families and 7 genera. Cyprinidae was the dominant family and *Barilius bendelensis* was most abundance species. *Neolissochilus hexagonolepis* and *Schistura rupecula* have less abundancy. Mostly hill stream fishes were reported. The water quality parameters (DO, pH, temperature, and velocity) were found within the desirable level for lentic water so Masyam river provides suitable habitat for fishes.

## 6.2 Recommendations

Based on the study, some recommendations are listed.

- Because the study was limited only two seasons, the study covering all seasons are recommended for distribution and diversity of fishes throughout the year.
- The diversity is declining due to illegal fishing practices and habitat modifications so the local authority should concern to stop illegal fishing practices and minimize habitat modification.
- The use of small mesh-sized nets should be prohibited.
- A community awareness programme about species conservation and habitat conservation should be implemented.

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Http://www.fishbase.org/ Assessed on 22 january 2022

https://www.iucnredlist.org/ Assessed on 22 january 2022

# APPENDICES

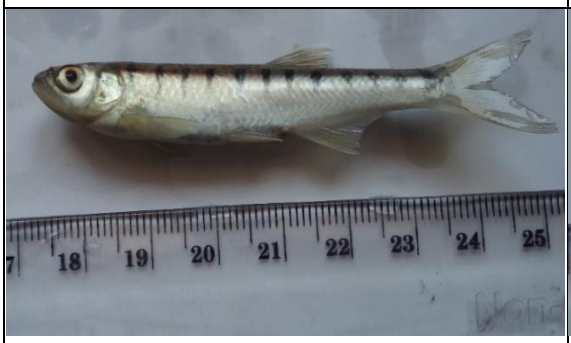
**Appendix 1 Physico-chemical parameters of Masyam Khola**

| S.N. | Parameters | Winter | | | | Spring | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | St.1 | St.2 | St.3 | St.4 | St.1 | St.2 | St.3 | St.4 |
| 1 | Temperature(°C) | 14 | 14 | 15 | 15 | 21 | 23 | 23 | 24 |
| 2 | pH | 8.6 | 8.6 | 8.4 | 8.4 | 8.7 | 8.7 | 8.6 | 8.4 |
| 3 | DO (mg/l) | 7.8 | 8.2 | 8.0 | 8.2 | 7.9 | 7.7 | 7.5 | 7.8 |
| 4 | Water velocity(m/sec) | 0.619 | 0.625 | 0.64 | 0.63 | 0.645 | 0.659 | 0.689 | 0.722 |

**Appendix 2: Total number of fishes in Masyam khola in different stations**

| S.N. | Name of species | Winter | | | | Spring | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **St. 1** | **St. 2** | **St. 3** | **St. 4** | **St. 1** | **St. 2** | **St. 3** | **St. 4** | |
| 1 | *Barilius bendelensis* | 4 | 9 | 22 | 20 | 6 | 10 | 6 | 11 | 88 |
| 2 | *Opsarius barna* | 9 | 5 | 7 | 9 | 2 | 2 | 5 | 9 | 48 |
| 3 | *Puntius sophore* | 0 | 0 | 0 | 5 | 0 | 0 | 23 | 18 | 46 |
| 4 | *Garra rupecula* | 2 | 1 | 1 | 0 | 5 | 8 | 10 | 3 | 30 |
| 5 | *Garra gotyla* | 0 | 1 | 1 | 0 | 0 | 5 | 4 | 3 | 14 |
| 6 | *Schizothorax richardsonii* | 0 | 0 | 0 | 0 | 5 | 8 | 0 | 0 | 13 |
| 7 | *Neolissochilus hexagonolepis* | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 4 |
| 8 | *Schistura beavani* | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 3 |
| 9 | *Schistura rupecula* | 0 | 0 | 3 | 0 | 1 | 1 | 0 | 4 | 9 |
| | **Total** | **15** | **16** | **35** | **34** | **19** | **35** | **49** | **52** | **255** |

**Appendix 3:** Plate-I

| | |
|---|---|
|  |  |
| *Garra gotyla* | *Schistura rupecula* |
|  |  |
| *Schistura beavani* | *Barilius bendelensis* |
|  |  |
| *Opsarius barna* | *Schizothorax richardsonii* |

*Puntius sophore*

*Garra rupecula*

*Neolissochilus hexagonolepis*