FISH DIVERSITY OF RAMPUR GHOL, CHITWAN, NEPAL

PUJA SHRESTHA

T.U. Reg. No: 5-2-19-309-2014

T.U. Roll No: 964/077

Batch No: 2077/78

Amrit Campus

Institute of Science and Technology

Tribhuvan University

Thamel, Kathmandu

Nepal

A dissertation submitted

In partial fulfilment of the requirements for the award of the degree of Master of Science in Zoology with special paper Fish Biology and Aquaculture (Course Code- Zoo 653)

March 2025

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PUJA SHRESTHA

T.U. Reg. No: 5-2-19-309-2014

M.Sc. Zoology (Fish Biology and Aquaculture)

T.U. Roll No: 964/077

Supervisor

Om Hari Shrestha

Assistant Lecturer

Amrit Campus

Institute of Science and Technology

Tribhuvan University

Thamel, Kathmandu

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E-mail: poozacresha007@gmail.com

Department of Zoology

Amrit Campus

Institute of Science and Technology

Tribhuvan University

Thamel, Kathmandu, Nepal

Website: https://www.ac.tu.edu.np/

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Declaration

I hereby declare that the work presented in this dissertation, **"Fish diversity of Rampur Ghol, Chitwan, Nepal,"** 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) and institution(s).

.....Puja.....

Puja Shrestha

Examination Roll No: 964/077

Email: poozacresha007@gmail.com

Date: 2081-11-19

☎ : 4411637
4410408

TRIBHUVAN UNIVERSITY
INSTITUTE OF SCIENCE AND TECHNOLOGY
AMRIT CAMPUS
P.O.Box No.:102,Thamel, Kathmandu,Nepal
E-mail: amritcampus@ntc.net.np

Ref No.:

Date:

Recommendation

This is to recommend that the thesis entitled **"Fish Diversity of Rampur Ghol, Chitwan, Nepal"** has been carried out by **Miss Puja Shrestha** for the partial fulfilment of Master's Degree of Science in Zoology with a 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 any institution.

.....

Om Hari Shrestha
Assistant Lecturer
Department of Zoology
Amrit Campus
Tribhuvan University
Thamel, Kathmandu, Nepal

Date: 02 March, 2025

☎ : 4411637
4410408

TRIBHUVAN UNIVERSITY
INSTITUTE OF SCIENCE AND TECHNOLOGY
AMRIT CAMPUS
P.O.Box No.:102,Thamel, Kathmandu,Nepal
E-mail: amritcampus@ntc.net.np

Ref No.: Date:

Letter of approval

On the recommendation of supervisor **Om Hari Shrestha,** this dissertation submitted by **Puja Shrestha** entitled **"Fish Diversity of Rampur Ghol, Chitwan, Nepal"** is approved for the examination in partial fulfilment of the requirements for Master's Degree of Science in Zoology with special paper Fish Biology and Aquaculture

.....

Shambhu Prasad Shah

Associate professor

Coordinator

M.Sc. Programme

Department of Zoology

Amrit Campus

Tribhuvan University

Thamel, Kathmandu, Nepal

Date: 02 March, 2025

☎ : 4411637
4410408

TRIBHUVAN UNIVERSITY
INSTITUTE OF SCIENCE AND TECHNOLOGY
AMRIT CAMPUS
P.O.Box No.:102,Thamel, Kathmandu,Nepal
E-mail: amritcampus@ntc.net.np

Ref No.: Date:

Certificate of acceptance

This dissertation work submitted by Puja Shrestha entitled **"Fish Diversity of Rampur Ghol, Chitwan, Nepal"** has been accepted as a partial fulfilment of the requirements of a Master's Degree of Science in Zoology with special paper Fish Biology and Aquaculture.

Evaluation Committee

.....

Supervisor
Om Hari Shrestha
Assistant Lecturer
Department of Zoology
Amrit Campus
Thamel, Kathmandu

.....

Coordinator
Shambhu Prasad Shah
Associate Professor
Department of Zoology
Amrit Campus
Thamel, Kathmandu

.....

External Examiner
Assoc. Prof. Dr. Archana Prasad
Central Department of Zoology
TU, Kritipur

.....

Internal Examiner
Asst. Prof. Dr. Dipak Gupta
Department of Zoology
Amrit Campus

Date of Examination: 28 March 2025 (2081/12/~~08~~ 15)

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Puja Shrestha

Abstract

The present study was conducted to explore the diversity of Rampur Ghol, situated in Bharatpur Municipality, Chitwan. The fieldwork was carried out from August 2023 to February 2024, covering the summer, autumn, and winter seasons. Samples were collected from four sites, and physico-chemical parameters such as temperature, depth, pH, and dissolved oxygen were analysed. The cast net (mesh size 5 mm) and ghamka (mesh size 2 mm) were used to gather fish with the help of a local fisherman. A total of 25 fish species belonging to 6 Orders, 14 Families, and 17 Genera were recorded. The dominant order was Cypriniformes (40%), with 10 species, and the dominant family was Cyprinidae (32%), with 8 species. The most abundant fish species is *Puntius sophore* with a relative abundance of 22.44%, followed by *Puntius ticto* at 14.49%. Temperature had a positive correlation with fish variety, while pH, dissolved oxygen (DO), and water depth had negative correlations. The highest Shannon Weiner diversity index was recorded at site III (2.48) and in winter (2.59), whereas the lowest was recorded at site IV (1.99) and in autumn (2.36). The evenness was found to be maximum at site I (0.87) and in winter (0.93), whereas it was minimum at site IV (0.8) and in summer (0.8). Similarly, the highest species richness was obtained at site III (3.74) and during summer (3.98), while the lowest was obtained at site I (1.99) and during autumn (2.98). The Shannon Weiner diversity index, Margalef's richness and evenness index revealed a strong relationship with overall species richness. Therefore, it can be concluded that Rampur Ghol provides a suitable habitat for a variety of fish species.

Keywords: *Diversity indices, Fish diversity, Physico-chemical parameters, Rampur Ghol*

शोध सार

प्रस्तुत अध्ययन भरतपुर महानगरपालिका, चितवनमा अवस्थित रामपुर घोलको माछा विविधता अन्वेषण गर्नका लागि गरिएको थियो । यस परियोजना कार्य २०२३ को अगष्टदेखि २०२४ को फेब्रुअरीसम्म वर्षा, सरद र जाडो गरि तिनवटै याममा गरिएको थियो । फरक/फरक चार ठाउँबाट नमूना संकलन गरि त्यसको भौतिक एवं रासायनिक मापकहरू तापक्रम, गहिराई, पी.एच., र घुलित अक्सिजन समेत अध्ययन गरियो । त्यहींका एक माछापालकको सहायतामा ५ मिमि. को फ्याँक्ने जाली र २ मि मि. को घम्का जालीको प्रयोग गरि माछा संकलन कार्य गरियो । माछाका २५ प्रजातिमा ६ प्रकार(अर्डर), १४ वर्ग(फेमिली), र १७ जेनेरा (समूह) संकलन गरियो । सबैभन्दा धेरै मात्रामा सिप्रीनिफोर्मस (४०%) १० प्रजातिका, मुख्य वर्गको रूपमा सिप्रीनिडाई (३२%) ८ प्रजातिका रहेका थिए । सबैभन्दा धेरै माछा प्रजातिहरू पन्टियस सोफोर जस्को मात्रा २२.४४% थियो भने पन्टियस टिक्टोको (१४.४९%) थिए । समातिएका माछाहरू पानीको तापक्रम र गहिराईसङ्ग सकारात्मक रूपमा र पी.एच. सङ्ग नकारात्मक सम्बन्ध रहेको पाईयो । स्थान र त्यहाँ घुलित अक्सिजनको विविधता अनुसार माछाको प्रकृति पनि फरक रह्यो । तेस्रो स्थानमा शानन वेनरको विविधता सूचकांकलाई सबैभन्दा उच्चतम (२.४८) र जाडोमा (२.५९) पाइयो जबकि चौथो स्थान (१.९९) र शरद मौसममा (२.३६) पाइयो । पहिलो स्थानमा पनि समान रूपमा (०.८७) अधिकतम नै रहेको पाइयो भने जाडोमा (०.९३) जबकि न्यूनतम मानिएको स्थान चौथोमा (०.८) र वर्षामा (०.८) पाइयो । त्यसैगरि सबैभन्दा बढी प्रजातिले भरिएको तेस्रो स्थानमा (३.७४) रह्यो भने वर्षामा (३.९८) पाइयो । यसरी सबैभन्दा कम रहेको स्थान चौथोमा (१.९९) र शरद मौसममा (२.९८) रह्यो। तिनवटै सूचकहरू; शानन वेवर, मार्गलेस र समानता सूचकले समग्र प्रजातिहरूको विकासक्रमसङ्ग बलियो सम्बन्ध देखायो । तसर्थ, उल्लेखित अध्ययन पछि यो निष्कर्ष निकाल्न सकिन्छ कि रामपुर घोलले विविध प्रकारका माछा प्रजातिका साथै अन्य जलीय जीवहरूका लागि उपयुक्त वासस्थान प्रदान गरेको छ ।

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°C	Degree Celsius
%	Percentage
Σ	Summation
DO	Dissolved Oxygen
DoFD	Directorate of Fisheries Development
GPS	Global Positioning System
IAAS	Institute of Agriculture and Animal Science
IUCN	International Union for Conservation of Nature
Mg/l	Milligram per litre

1. Introduction

1.1 Background

Nepal, one of the landlocked nations, is located on the southern slopes of the Himalayas, lying between the latitudes of 26° 22' to 30° 27' N and the longitudes of 80°4' to 88°12' E (Saund & Shrestha, 2007). Nepal is one of the richest countries in the world in terms of freshwater resources, with different types of wetlands occupying at least 5.5% of its land (Shrestha, 1981) and rich in fish diversity (Oli et al., 2013). Nepal possesses abundant freshwater resources, ranging from altitudes as low as 50 meters to the world's highest peaks, surpassing 8000 meters (Khatri et al., 2020). Nepal is blessed with a variety of water resources that are dispersed around the nation in the form of rivers, streams, lakes, ponds, reservoirs, marshes, swamps, and paddy fields (Petr & Swar, 2002). These water resources offer vital aquatic environments for the survival of aquatic creatures, especially freshwater (Subba et al., 2017).

A wetland is an area of naturally occurring or artificially created permanent or temporary standing water that is fresh, brackish, or salty. Some examples of wetlands are rivers, lakes, glaciers, reservoirs, marshy and swampy terrain, floodplains, and even paddy fields (Ramsar Convention Secretariat, 2016). Wetlands, often referred to as "Simsar" in Nepal, are generally made of soggy soil that is difficult to walk on and deep enough water that is dangerous for swimming or drowning (Jha, 2008). In Nepali, marshy areas are often referred to as Ghol (Jha & Shrestha, 2000).

A highly productive ecosystem on Earth is the wetland environment. They have a significant impact on the conservation of rare and endangered species, the generation of organic material, the regulation of water quality, flood management, mitigation of sediment load, and the provision of habitat for wildlife and migrating birds (Garg, 1989). Wetlands are among the most threatened ecosystems in the world because of their vulnerability and attractiveness for development (Hollis et al., 1988). Around 1.8 million species, or nearly 6% of all known species and 12% of all animal species, are found in freshwater habitats, or freshwater wetlands, which make up only 0.8% of the Earth's surface (McAllister et al., 1997). Various terms have been used to refer to them, including slough, peat, bayous, wet meadow, muskeg, mudflat, polders, marsh, swamp, fen, mire, bog, lake or pond, and bottomland (Bhandari, 2003).

Wetlands provide a home for a variety of plants and animals including fish, amphibians, birds, mammals, and reptiles. They also provide economic and social benefits (KC et al., 2013).

1.1.1 Water resources

Nepal's wetlands comprise 819,300 hectares of inland water resources (DoFD, 2014) and contain 42 internationally endangered species, making it an important ecosystem (IUCN, 2004). From the torpid ponds of the Terai area to the glacier lakes of the high Himalayas, Nepal's wetlands are among the most endangered natural habitats (KC et al., 2013). The aquatic environment of Nepal is categorized into two types: lotic, which refers to flowing water, and lentic, which refers to stagnant water.

Table 1: Estimated water resources of Nepal

Resource detail	Estimated area (ha)	Coverage (%)
Natural resources	401,500	49
Rivers	395,000	48.21
Lakes	5,000	0.61
Reservoirs	1,500	0.012
Ponds	7,300	0.89
Swamps and wetlands	12,500	1.52
Irrigated paddy fields	398,000	48.57
Total	819,300	100

[Source: Directorate of Fisheries Development (DoFD, 2014)]

1.1.2 Fish diversity

Fish are the world's most diversified vertebrate group, with around 40% of them inhabiting freshwater environments (Ghorbani et al., 2013). Studies of freshwater fish species composition, regular distribution patterns, and ecological habitat are vital components for the fish community (Galactos & Barriga-Salazar, 2004). Fish diversity refers to the variety of fish species depending on habitat and scale (Burton et al., 1992). The diversity of fish from different wetlands in Nepal has been studied by Rayamajhi et al., (2021), Tachamo-Shah et al., (2023), Oli et al., (2013), and Bhattarai & Dahal (2017). Shrestha (2001) reported 182 species of fish from Nepal, and 228 species were reported later in 2013. According to Shrestha (2019), 252 species were reported, which belong to 15 orders and 41 families. Among them, 236 are native species, and 16 are exotic species.

1.1.3 Factors influencing fish distribution and biodiversity

Environmental factors like temperature, dissolved oxygen (DO), free carbon dioxide (CO_2), pH, alkalinity, etc., have a significant impact on fish diversity and distribution (Yan et al., 2010). The distribution, abundance, and movement of aquatic species are influenced by temperature and the concentration of dissolved oxygen (Alhassan, 2013). Several fish species were significantly correlated with factors such as water temperature, salinity, dissolved oxygen, and depth (Marshall & Elliott, 1998). According to Ye (2007), the macrophyte complex and water depth have a major impact on the spatial and temporal variation of the fish population, whereas turbidity is associated with rich feeding ground and provides shelter for fish (Blaber & Blaber, 1980). The primary hazards to fish diversity are pollution, eutrophication, sedimentation, overfishing, changing flow patterns, habitat degradation, siltation, and introduction of alien species (Helfman et al., 2009).

1.1.4 Rampur Ghol

Rampur Ghol is located in the Chitwan district of Bagmati province. It is situated at an altitude of 1,677 meters above mean sea level, with latitude 27º39´24.52" N and longitude 84º20´58.77" E (Jha & Shrestha, 2000). The water in the Ghol area flows slowly. The wetland area is situated inside the premises of the Agriculture and Forestry University. The fisheries department, AFU, is located on the edge of this marshland. Rampur Ghol is one of the main sources of water for household activities of the local people of the Sharadanagar and Rampur villages. Local people used to fish there, but now fishing is prohibited in this Ghol.

1.2 Objectives

1.2.1 General objective

The general objective of this study was to explore the fish diversity of Rampur Ghol, Chitwan.

1.2.2 Specific objectives

The specific objectives of this study were:

- To explore the diversity and distribution of fish in Rampur Ghol.
- To analyse the physico-chemical parameters of Rampur Ghol.
- To find out the correlation between species richness and physico-chemical parameters.

1.3 Significance of the study

Wetlands have the potential to reduce carbon emissions significantly in the atmosphere. They are the most productive types of ecosystems. Many ecosystems and ecological diversity can be found in the wetlands of the Terai region of Nepal. Rampur Ghol is one of the most important wetlands in the Terai region, and it is the main source of water for many fauna. There are few records of the fish fauna in the Rampur Ghol. These findings will provide basic data for future research and help update Nepal's fish diversity records.

2. Literature review

In Nepal, studies on fish diversity were first conducted by Hamilton (1822) in the 1800s, He is regarded as the first person to publish accurate details about fishes in Nepal in his book "An account of the fishes found in the River Ganges and its branches," which includes 269 species of fish.

Ferro & Badagami (1980) identified twenty-two fish species from lakes Begnas and Rupa in the Pokhara Valley. Saund & Shrestha (2007) conducted a study on the biodiversity of fish and benthic fauna in Kulekhani Reservoir, Makwanpur. They found that while exotic fish species like Bighead carp (*Aristichthys nobilis*) and Silver carp (*Hypophthalmichthys molitrix*) contributed 96.24% of the total, there were only two native fish species present in the reservoir: *Neolissocheilus hexagonolepis* and *Nazirator chelynoides*. The study found that the water quality parameters were within satisfactory levels, with surface temperature ranging from 13.4°C to 24.5°C, pH between 8.2 and 9.4, transparency from 75.2 cm to 245.1 cm, dissolved oxygen (DO) between 6.2 mg/l and 10.4 mg/l, carbon dioxide (CO_2) ranging from 0.1 mg/l to 0.15 mg/l, total alkalinity between 38 mg/l and 85 mg/l, and total hardness varying from 36 mg/l to 65 mg/l. Giri (2010) discovered 21 distinct species of native fish in Phewa Lake, representing 5 orders, 6 families, and 16 genera. In the lake, *Puntius sp., Barilius sp., Garra annandalei,* and *Channa gachua* were the most prevalent native fish. A total of 2273 fish were harvested using gill nets from the Jagadispur reservoir. 42 fish species, spanning 6 orders, 18 families, and 34 genera, were identified from the reservoir throughout the study. Cypriniformes and Cyprinidae were the primary Orders and Families in terms of species composition and catch composition, respectively. *Nandus nandus* was the most common fish, accounting for 16.50% of the total catch. The water quality parameters were within an optimal range for warm-water fish, with surface water temperatures ranging from 20.7°C to 31°C, pH levels between 6.8 and 7.6, dissolved oxygen levels from 5.2 mg/l to 8.7 mg/l, free carbon dioxide between 11.1 mg/l and 23.6 mg/l, total hardness from 68.2 mg/L to 137.5 mg/, and total alkalinity ranging from 69.6 mg/l to 192 mg/l (Gautam et al., 2010).

Oli et al. (2013) recorded 22 species of fish from Rampur ghol, which belongs to 5 orders, 13 families, and 22 genera, with Cypriniformes as the dominant order. Gautam et al. (2016) conducted research on the fish population inhabiting Lake Rupa, a tectonic lake situated in the mid-hill region of Central Nepal. Their research showed that there are 23 different

species of fish in this aquatic habitat, representing 5 orders, 6 families, and 18 genera. Four of these are introduced species, and the remaining 19 are native to the area.

Joshi & K.C. (2017) studied the fish diversity of Ghodaghodi Lake in Kailali and reported thirteen fish species, representing five orders, eight families, and eleven genera. Rayamajhi (2017) reported 55 fish species from Chitwan National Park, which belong to 38 genera, 20 families, and 7 orders. According to Subba et al. (2017), a total of 118 fish species living in various water bodies, such as rivers, reservoirs, streams, ponds, lakes, canals, ditches, and paddy fields in the Morang district, are distributed throughout 11 orders, 26 families, and 64 genera. A study conducted in Budhoholi wetland, Jhapa, East Nepal, reported 21 species of fish, some of which are decorative fish like zebra and colisa. The majority of fish species had a larvivorous habit (Bhattarai & Dahal, 2017).

Thapa (2018) listed 15 fish species from the Dipang Lake in the Kaski district, comprising 5 orders, 7 families, and 12 genera. Concerning species composition and individual capture, Cypriniformes constituted the dominant order with 46%, while Cyprinidae was the major family with 29.43%. With 18.33% of the entire catch, *Puntius sophore* was the most prevalent species. The water quality parameters ranged from water temperature; 23 ℃-30 ℃, pH; 6.2-8, DO; 5.1 mg/l-8.38 mg/l, CO2; 0.8 mg/l-3.2 mg/l, total alkalinity; 50 mg/l-100 mg/l, total hardness; 12 mg/l- 36 mg/l.

Chaudhary (2019) examined the fish diversity in Koilahee taal, Kailali Municipality, Nepal. They found 13 species of fish belonging to 5 orders, 8 families, and 11 genera, with the Order Cypriniformes accounting for 46% of the fish population and the Family Cyprinidae accounting for 28.08%. The fish species *Amblyphryngodon microlepis* was determined to be prevalent. The water quality parameters (temperature: 26.5 ℃-31 ℃, pH: 7.5 -8.5, DO: 5.5 mg/l-6.8 mg/l, CO2: 2.08 mg/l -4.7 mg/l, hardness: 42 mg/l-46.5 mg/l) were observed within a desired range, which was favorable for lentic fishes. A total of 26 fish species, 20 indigenous and 6 exotic fish species, were gathered from three lakes in the Pokhara valley: Phewa, Rupa, and Begnas (Husen et al., 2019).

Rayamajhi et al. (2021) researched fish ichthyofauna in six wetlands in the Bardiya and Kailali districts. In the surveyed wetlands, twenty-six species were represented by eighteen genera, twelve families, and six orders. Out of the 26 species in the collection, the Order Cypriniformes constituted the majority with 38.5%. The order with the highest number, Order Cypriniformes, was composed of 10 (38.5%), followed by Order Perciformes with 8

(30.77%), Order Channiformes with 4 (15.4%), and Order Cyprinidontiformis with 2 (7.7%). The lowest species number, Order Siluriformes and Synbranchiformes, constituted 1 (3.8%).

According to Bista et al. (2022), Bhagairia Lake is home to thirty different species of fish, which are divided into eight orders, thirteen families, and twenty-three genera. Of these, the Cyprinidae and Cypriniformes were the largest order and family, making up 44% and 50% of fish species, respectively. With a catch composition of 12%, *Puntius sophore* was discovered to be the dominating fish species. A study conducted in Shuklaphanta National Park, Kanchanpur, revealed to have 53 fish species belonging to 6 orders, 17 families, and 31 genera (Poudyal, 2022).

Choudhary (2023) listed a total of 27 fish species from Barju Lake, comprising two foreign and 25 native species, grouped into seven orders, 14 families, and 20 genera. Among which the leading families and orders were Cyprinidae (57.43%) and Cypriniformes (62.97%), respectively. A total of 19 distinct fish species from 6 orders, 7 families, and 16 genera were discovered in Tulsihawa Lake. *Amblyphryngodon microlepis, Chanda nama*, and *Puntius sophore* were the most abundant species. Seasonal variations affected species diversity, with the highest catch (17) in spring and the lowest (13) in autumn. Summer recorded the highest diversity index (2.24) and evenness (0.80), while autumn had the lowest (1.49). Species richness was highest in summer (6.78) and lowest in winter (4.73) (Raut, 2023). Tachamo-Shah et al. (2023) conducted a study on the biodiversity of wetlands in the Ramaroshan Lake complex and identified three species of fish from the Cyprinidae family, namely *Schizothorax nepalensis*, *S. richardsonii*, and *Garra gotyla.*

3. Materials and methods

3.1 Study Area

The present study was conducted in Rampur Ghol of Chitwan district, Province No. 3, Ward No. 16 of Bharatpur Municipality. The Ghol marsh is situated on the Institute of Agriculture and Animal Science (IAAS) campus at Tribhuvan University in Rampur. It is located at a latitude of 27º39´24.52"N and a longitude of 84º20´58.77" E, at an elevation of 167 meters above mean sea level. The Ghol encompasses 23 hectares and lies approximately 9 Km southwest of Narayangadh Bazar.

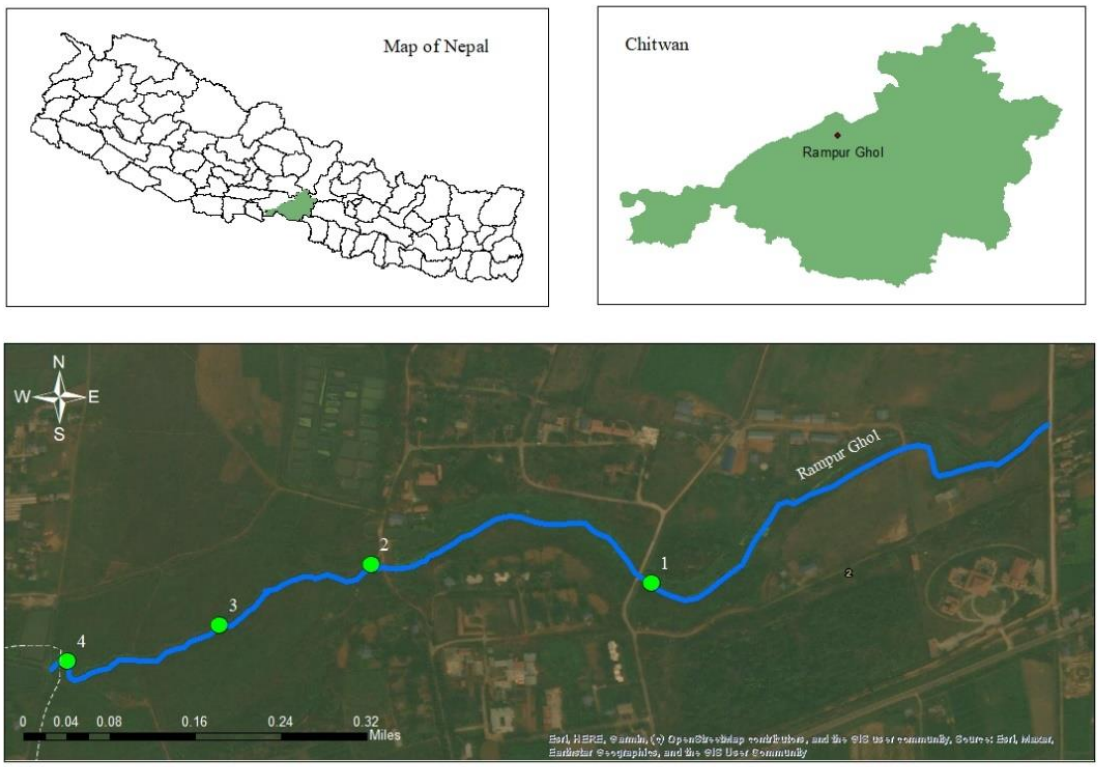

Figure 1: Map of study area with sampling sites

3.2 Study period

The fieldwork was conducted from August 2023 to February 2024 to encompass three different seasons (summer, autumn, and winter). Samples were gathered from four sites over three different months (August, November, and February) to ensure a comprehensive and representative analysis.

3.3 Sampling sites

Site I: The first site was selected near the second bridge of Ghol. This site was close to the National Cattle Research Program. It lies between 27°65’656” N and 84°35’248” E. Aquatic vegetation and small herbs are in and around the Ghol area.

Site II: The second site was near the Aquaculture Department’s bridge. It lies on 27°65’679” N and 84°34’923” E. The Ghol mostly consisted of pebbles, sand, and mud.

Site III: This site was selected at the confluence where the two tributaries mix. It lies between 27°65’583” N and 84°34’651” E. This site was surrounded by agricultural land.

Site IV: Site IV was selected at the outlet of the Ghol area. It lies between 27°65’564” N and 84°34’334” E. This site was close to a human settlement area.

3.4 Materials used

1. Cast net
2. Ghamka
3. Thermometer
4. DO meter
5. pH meter
6. Measuring tape
7. Rope
8. GPS
9. Mobile camera

3.5 Chemical used

10. Formalin (10%)

3.6 Sampling method

3.6.1 Sample collection

Fishes were gathered from four different sites in the morning (9 am to 11 am), and the water parameters were recorded at each site. Fish samples were collected by hiring local fishermen. Locally prepared cast net (mesh size 5mm) and ghamka (mesh size 2mm) were used to capture fish at each sampling site. Fish were sampled at each site for two hours, and water quality parameters were also measured. The number of each species was recorded, and the local name of the fish species was noted with the help of the local fishermen.

3.6.2 Preservation of specimens

The collected fish species were photographed, preserved in 10% formalin solution, and stored in plastic jars. The preserved specimens were then brought to the laboratory of Amrit Campus for identification.

3.6.3 Identification of specimens

The fish were identified at the species level using the identification keys of Shrestha (2008), Jayaram (2010), and Shrestha (2019).

3.7 Physico-chemical parameters of water

Various physicochemical parameters like temperature, water depth, pH, and dissolved oxygen were measured at every sampling site. These parameters were determined following the guidelines of APHA (1998) and Trivedy & Goel (1986).

3.7.1 Water temperature

A standard alcohol thermometer was used to record the water temperature. The thermometer's bulb was submerged in the water surface to measure the temperature until a stable reading was obtained. Three temperature readings were taken at each sampling site, and the average value was used for the analysis.

3.7.2 Water depth

The depth of the ghol area was measured by using a rope with hanging the stone, and a measuring tape was used to record the depth in centimeters. Depth was measured three times at each sampling site, and the average value was recorded.

3.7.3 pH

A pH meter was used to measure the pH of the water during the study period. Readings were taken three times at each sampling site, and the average value was noted down.

3.7.4 Dissolved oxygen (DO)

A dissolved oxygen meter was used to measure the amount of dissolved oxygen in the water. The probe was dipped just below the water surface to obtain readings. Readings were taken three times at each sampling site, and the average value was recorded.

3.8 Diversity indices

3.8.1 Shannon-Weiner diversity index (H')

The Shannon-Weiner diversity index (Shannon and Weiner,1949) was calculated by using the given formula:

$H' = -\sum(Pi) \times \ln(pi)$

Where,

Pi= ni/N

ni= Number of individuals in each species

N= Total no. of all individuals in all samples

ln= Logarithm of base e

3.8.2 Margalef's Species richness index (d)

The richness of species was calculated using Margalef's species richness index (Margalef, 1968).

Margalef species richness index (d)= S-1/ lnN

Where,

S= Total number of species

N= Total number of individuals

3.8.3 Pielou's Evenness index (J)

To assess the species distribution of species among seasons and sampling sites, Pielou's evenness index (Pielou, 1966) was used. It is calculated as,

Pielou's evenness index (J)= H′/ lnS

Where,

H'= Shannon-Weiner's diversity index

S= Total number of species in the sample

3.9 Statistical analysis

The relation between fish species richness and water parameters was calculated using the Karl Pearson correlation coefficient formula (Gupta, 1988).

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

Probability of Error (P.Er.) = $\frac{1-r^2}{\sqrt{N}}$ 0.6745

4. Results

4.1 Fish Diversity of Rampur Ghol

A total of 25 fish species belonging to 6 Orders, 14 Families, and 17 Genera were recorded from the Rampur Ghol during the present study. The order and families of species with their local names are given in Table 2.

Table 2: Systematic position of fishes with their local name

S.N	Order	Family	Name of species	Local name
1	Cypriniformes	Cyprinidae	*Brachydanio rerio* (Hamilton, 1822)	Chitharipothi
2	Cypriniformes	Cyprinidae	*Danio devario* (Hamilton, 1822)	Chitharipothi
3	Cypriniformes	Cyprinidae	*Esomus danricus* (Hamilton, 1822)	Dedhawa
4	Cypriniformes	Cyprinidae	*Puntius chola* (Hamilton, 1822)	Sidhre
5	Cypriniformes	Cyprinidae	*Puntius conchonius* (Hamilton, 1822)	Sidhre
6	Cypriniformes	Cyprinidae	*Puntius gonionnotus* (Bleeker, 1849)	Sidhre
7	Cypriniformes	Cyprinidae	*Puntius sophore* (Hamilton, 1822)	Pate sidhra
8	Cypriniformes	Cyprinidae	*Puntius ticto* (Hamilton, 1822)	Tite pothi
9	Cypriniformes	Cobitidae	*Acanthocobitis botia* (Hamilton, 1822)	Pate gadela
10	Cypriniformes	Cobitidae	*Lepidocephalus guntea* (Hamilton, 1822)	Sim gadera
11	Siluriformes	Bagridae	*Mystus bleekeri* (Day, 1877)	Tenger
12	Siluriformes	Bagridae	*Mystus tengara* (Hamilton, 1822)	Tenger

13	Siluriformes	Clariidae	*Clarias batrachus* (Linneaeus, 1758)	Mangur
14	Siluriformes	Heteropneustidae	*Heteropneusteus fossilis* (Bloch, 1794)	Singhi
15	Siluriformes	Siluridae	*Ompok pabda* (Hamilton, 1822)	Nauni
16	Perciformes	Ambassidae	*Chanda nama* Hamilton, 1822	Chanerbijuwa
17	Perciformes	Belontiidae	*Colisa faciatus* Bloch and Schneider, 1801	Vansari
18	Perciformes	Channidae	*Channa orientalis* Bloch and Schneider, 1801	Bhoti
19	Perciformes	Channidae	*Channa punctatus* (Bloch, 1793)	Helae
20	Perciformes	Nandidae	*Badis badis* (Hamilton, 1822)	Khesalei
21	Synbranchiformes	Synbranchidae	*Monopterus cuchia* (Hamilton, 1822)	Andho bam
22	Synbranchiformes	Mastacembelidae	*Macrognathus aral* (Bloch and Schneider, 1801)	Gainchi
23	Synbranchiformes	Mastacembelidae	*Macrognathus pancalus* Hamilton, 1822	Kathgainchi
24	Beloniformes	Belonidae	*Xenentodon cancila* (Hamilton, 1822)	Kauwa
25	Gobiformes	Gobiidae	*Glossogobius giuris* (Hamilton, 1822)	Bulle

4.1.1 Fish composition in Rampur Ghol

A total of 704 individuals (253 in the summer season, 302 in autumn, and 149 in winter), representing 25 species, were collected from the Ghol, as shown in Table 3. The distribution of these fish species varied across different sites and seasons. The maximum number of fish species (23) was recorded in summer, while the minimum (16) was recorded in winter. *Puntius sophore* and *Puntius ticto* were the most prevalent species, with 158 and 102 individuals, respectively. Rare species included *Glossogobius giuris, Monopterus cuchia, Ompok pabda,* and *Puntius gonionotus*, each represented by a single individual.

Table 3: Relative abundance of fish species recorded at different sites in three seasons in Rampur Ghol

S.N	Name of species	Season												Total	R.A(%)
		Summer				Autumn				Winter					
		I	II	III	IV	I	II	III	IV	I	II	III	IV		
1	*Acanthocobitis botia*	-	-	2	-	-	-	-	-	-	-	-	-	2	0.28
2	*Badis badis*	-	-	-	-	-	3	3	-	-	-	-	-	6	0.85
3	*Brachydanio rerio*	2	4	13	9	1	7	10	8	-	-	2	1	57	8.1
4	*Chanda nama*	-	-	2	1	-	-	-	2	-	-	-	1	6	0.85
5	*Channa orientalis*	3	-	-	-	5	19	7	-	2	16	2	-	54	7.67
6	*Channa punctatus*	2	5	7	-	2	12	-	-	1	9	-	-	38	5.4
7	*Clarias batrachus*	-	-	-	1	-	-	1	3	-	8	-	1	14	1.99
8	*Colisa faciatus*	-	1	-	-	-	1	3	-	1	2	-	-	8	1.14
9	*Danio devario*	4	6	4	3	2	-	23	8	2	-	13	5	70	9.94
10	*Esomus danricus*	2	16	-	-	3	2	7	-	4	3	5	-	42	5.97
11	*Glossogobius giuris*	-	1	-	-	-	-	-	-	-	-	-	-	1	0.14
12	*Heteropneustes fossilis*	-	-	1	-	-	7	-	-	-	10	3	-	21	2.98
13	*Lepidocephalus guntea*	-	4	8	7	-	-	14	5	-	-	-	2	40	5.68
14	*Macrognathus aral*	-	-	3	-	-	-	-	-	-	-	-	-	3	0.43
15	*Macrognathus pancalus*	-	1	1	-	-	-	-	-	-	1	-	-	3	0.43
16	*Monopterus cuchia*	-	-	-	1	-	-	-	-	-	-	-	-	1	0.14
17	*Mystus bleekeri*	-	-	6	3	1	-	5	2	-	-	1	-	18	2.56
18	*Mystus tengara*	-	2	8	-	-	-	4	-	-	-	1	-	15	2.13
19	*Ompok pabda*	-	-	-	-	-	-	1	-	-	-	-	-	1	0.14
20	*Puntius chola*	5	8	8	2	6	-	-	-	7	-	-	-	36	5.11
21	*Puntius conchonius*	-	-	4	1	-	-	-	-	-	-	-	-	5	0.71
22	*Puntius gonionotus*	-	-	-	1	-	-	-	-	-	-	-	-	1	0.14
23	*Puntius sophore*	10	24	13	11	7	15	30	16	5	9	12	6	158	22.44
24	*Puntius ticto*	4	4	19	5	5	28	23	-	7	3	4	-	102	14.49
25	*Xenentodon cancila*	-	-	1	-	-	1	-	-	-	-	-	-	2	0.28
	Total	32	76	100	45	32	95	131	44	29	61	43	16	704	100

4.1.2 Relative abundance of fish species of Rampur Ghol

The relative abundance of 25 species is shown in Table 3. The highest relative abundance was observed in *Puntius sophore*, which was 22.44%. The next species with a higher relative abundance was *Puntius ticto* (14.49%), followed by *Danio devario* (9.94%). Other notable species include *Brachydanio rerio* (8.1%) and *Channa orientalis* (7.67%). Several species, such as *Glossogobius giuris*, *Monopterus cuchia*, *Puntius gonionotus*, and *Ompok pabda*, had the lowest relative abundance of 0.14%.

4.1.3 Order-wise fish composition of Rampur Ghol

A total of 6 orders were recorded in Rampur Ghol. Among them, Cypriniformes dominated with 10 species, which represents 40% of total fish species, followed by Perciformes and Siluriformes (5, 20%), Synbranchiformes (3, 12%). Each of Gobiformes (*Glossogobius giuris*) and Beloniformes (*Xenentodon cancila*) had only one species, representing just 4% of the total species.

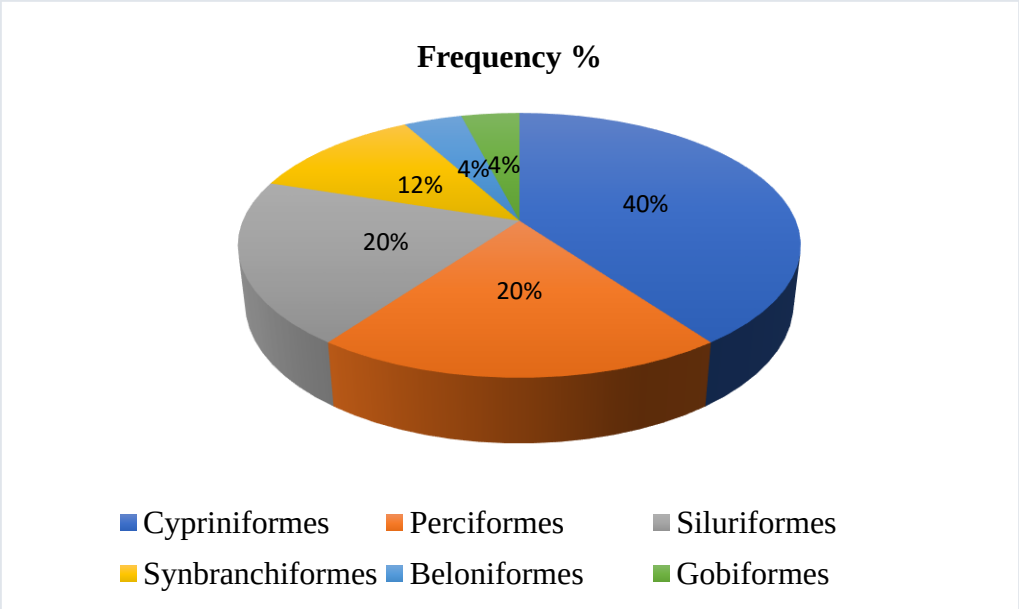

Figure 2: Order-wise species composition (%) of Rampur Ghol

4.1.4 Family-wise fish composition of Rampur Ghol

Throughout the research period, a total of 14 families were recorded. The family Cyprinidae had the highest number of species (8, 32%), followed by Bagridae, Channidae, Cobitidae, and Mastacembelidae with an equal number of two species (8%). Each of the families Ambassidae, Belonidae, Belontiidae, Claridae, Gobiidae, Heteropneustidae, Nandidae, Siluridae, and Synbranchidae consisted of only one species (4%).

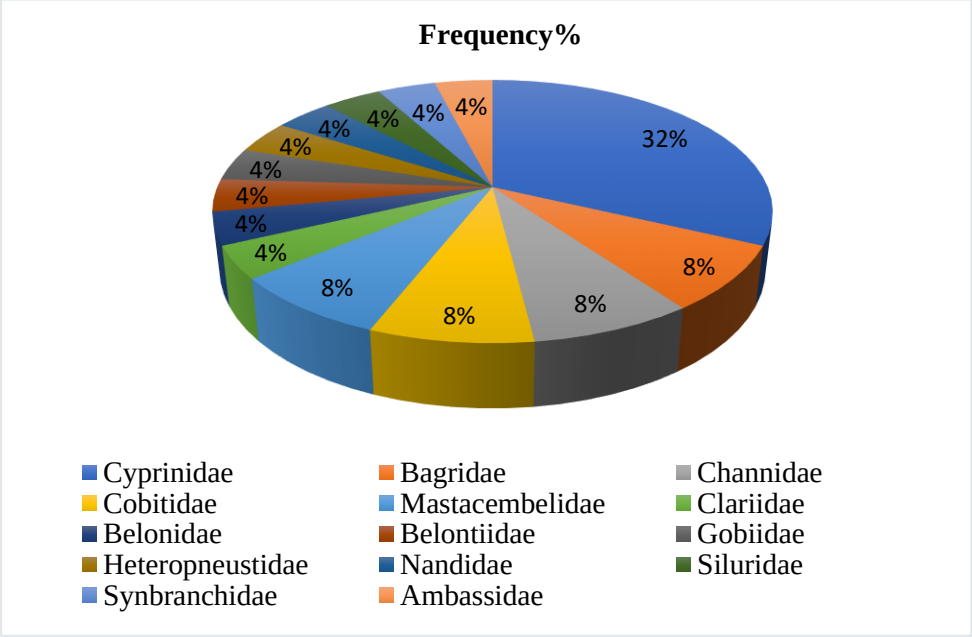

Figure 3: Family-wise species composition (%) of Rampur Ghol

4.2 Species diversity indices

The Shannon-Weiner diversity index, Margalef's richness index, and Pielou's evenness index were calculated season-wise and site-wise.

4.2.1 Season-wise diversity indices of Rampur Ghol

The highest number of species (23) was recorded in summer, while the lowest number of species (16) was recorded in winter. The highest Shannon-Weiner diversity index value (2.59) was observed during the winter, while the lowest value (2.36) was observed during the autumn season. The highest value of Margalef's richness (3.98) was recorded in the summer, while the lowest value (2.98) was recorded in the autumn. The results showed that winter had the highest evenness index (0.93), while summer had the lowest value of evenness index (0.8).

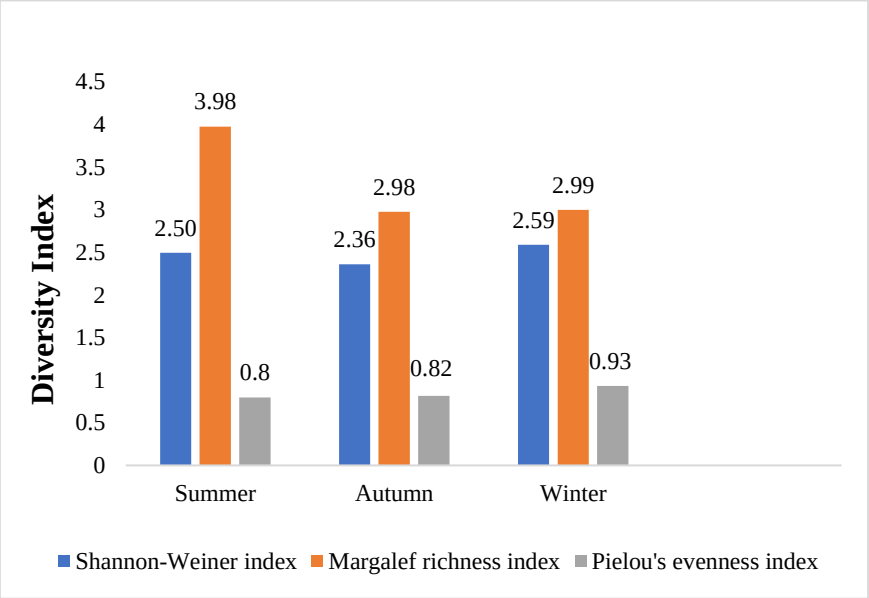

Figure 4: Season-wise species diversity indices in different sites

4.2.2 Site-wise diversity indices of Rampur Ghol

The highest value of the Shannon-Wiener diversity index (2.48) was recorded at site III, and the lowest value (1.99) at site IV. The site I had the lowest Margalef's richness value (1.99), whereas site III had the highest value (3.74). Similarly, the maximum Pielou's evenness index (0.87) was recorded at site I, and the minimum (0.8) at site III and site IV.

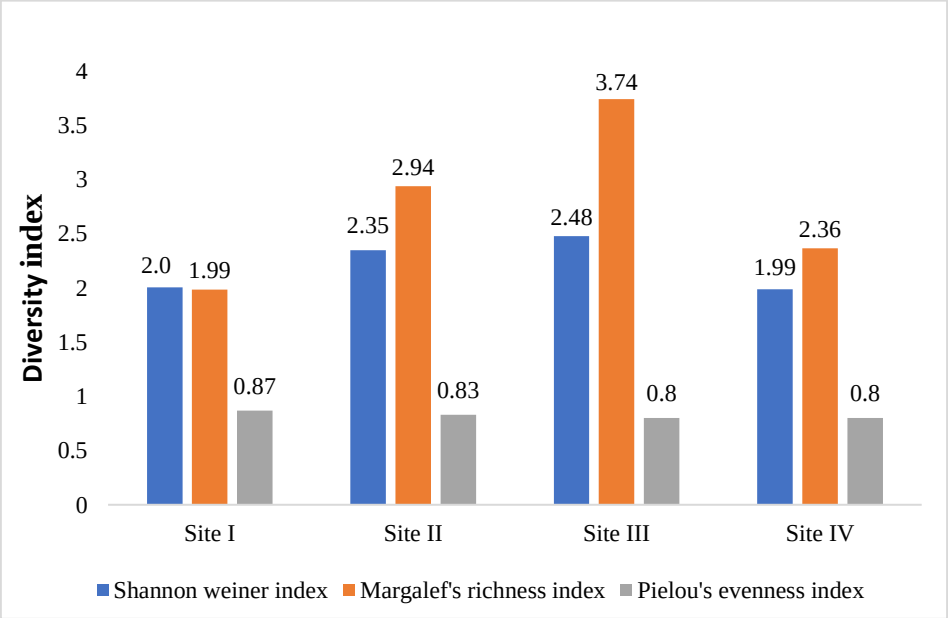

Figure 5: Site-wise species diversity indices in different sites

4.3 Physico-chemical parameters

4.3.1 Water temperature

The temperature ranged from 16℃ to 31.5℃ in Rampur Ghol throughout the study period. The highest temperature (31.5℃) was recorded at site III during the summer season, whereas the lowest temperature (16℃) was recorded at site II during the winter season.

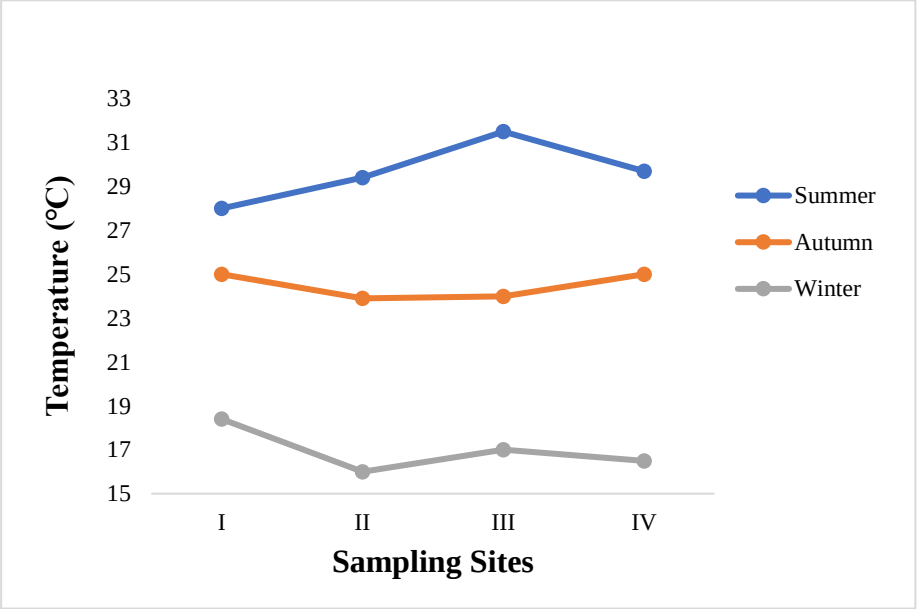

Figure 6: Variation of water temperature at four sampling sites in three seasons

4.3.2 Water depth

The depth of water ranged from 21cm to 89cm. The deepest water (89cm) was measured at site IV during the summer, while the shallowest water (21cm) was measured at site I during the winter season.

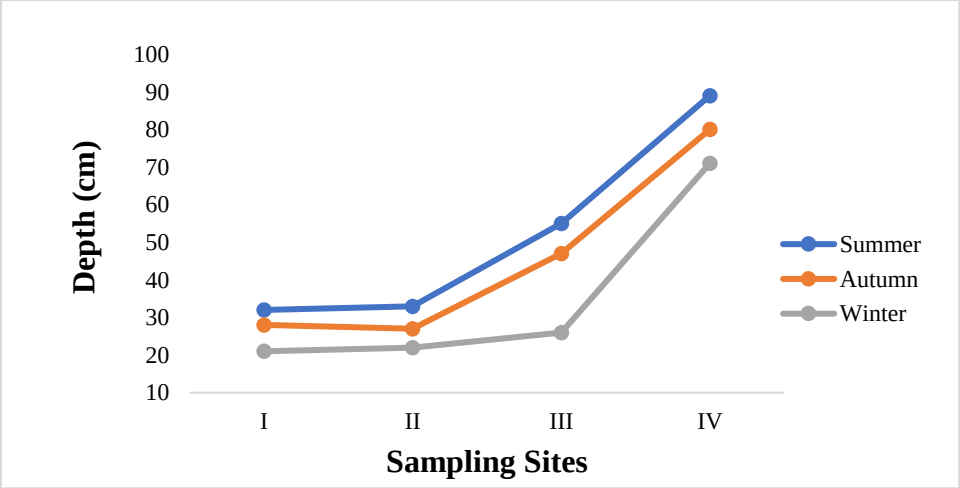

Figure 7: Variation in depth at four sampling sites in three seasons

4.3.3 pH

The pH levels in the study area fluctuated between 6.8 and 8.8 ppm. The highest pH (8.8) was measured at site IV during the winter season, while the lowest pH (6.8) was measured at sites I and II during both the autumn and summer seasons.

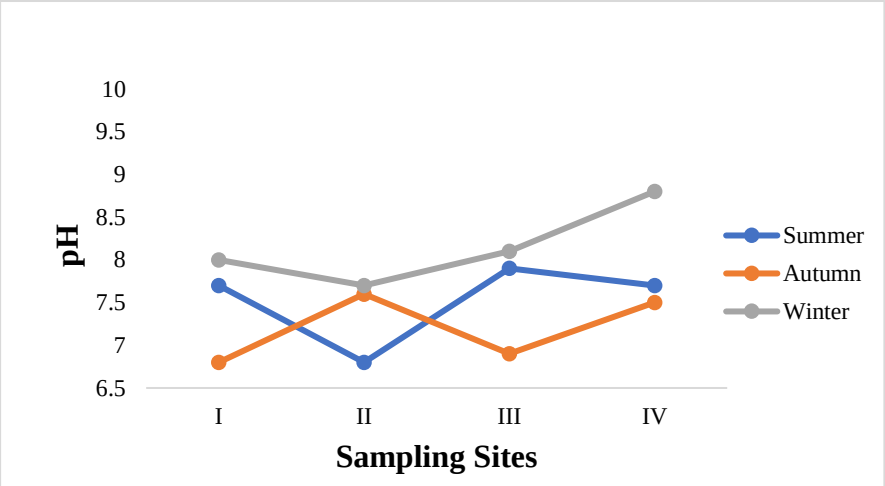

Figure 8: Variation in pH at four sampling sites in three seasons

4.3.4 Dissolved oxygen

The dissolved oxygen level varied between 6.6 and 13.6mg/l during the study period. The highest concentration of DO (13.6 mg/l) was found at site I during summer, and the lowest concentration of DO (6.6 mg/l) was found at site IV during the autumn season.

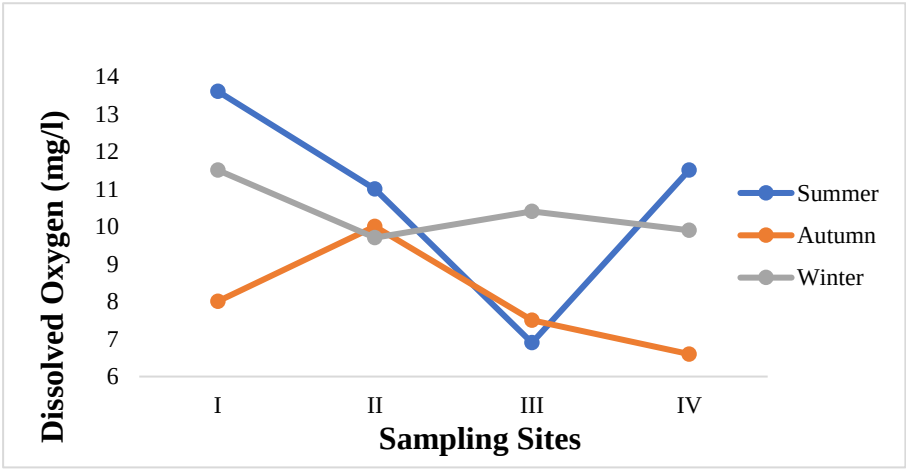

Figure 9: Variation in Dissolved Oxygen at four sampling sites in three seasons

4.4 Correlation between physico-chemical parameters and fish species richness of Rampur Ghol

The coefficient of correlation between several physico-chemical parameters and fish diversity was determined by using the Karl Pearson method. A positive correlation (0.36) was observed between temperature and fish diversity. The relationship between pH and fish diversity showed a moderate negative correlation (-0.47). Dissolved Oxygen exhibited a very weak negative correlation (-0.14) with fish diversity, while water depth had an even weaker negative correlation (-0.08) with fish diversity.

Table 4: Correlation coefficient between physico-chemical parameters and fish species richness in Rampur Ghol

Water parameters	Correlation coefficient (r) with fish species richness	Probable Error (P.E)
Temperature	0.36	0.65
pH	-0.47	0.63
Dissolved Oxygen	-0.14	0.67
Water depth	-0.08	0.673

5. Discussion

The present study was conducted in Rampur Ghol, which was carried out in three seasons, from August 2023 to February 2024. Altogether, 25 fish species representing 6 Orders, 14 Families, and 17 Genera were recorded from various sampling sites in Rampur Ghol.

During the study, the results showed that Cypriniformes was the most dominant order, representing 40% of the total fish species. Similarly, previous studies by Gautam et al. (2010), Joshi & K.C. (2017), Thapa (2018), and Bista et al. (2022) also reported Cypriniformes as the most dominant order. At the family level, the Cyprinidae accounted for the highest number of species (32%). Cyprinidae is the largest freshwater fish family in the world, consisting of around 210 genera and about 2,010 species (Nelson, 2016). Chaudhary (2023) also identified Cyprinidae as the most dominant family in Barju Lake. Similarly, Gautam et al. (2010), Chaudhary (2023), and Raut (2023) also recorded Cyprinidae as the most dominant family.

Among the 25 species, *Puntius sophore* had the highest relative abundance at 22.44%. The high relative abundance of *Puntius sophore* may be due to the ghol's suitable habitat, abundant food supply, and favourable water quality. Thapa (2018) and Bista et al. (2022) also reported *Puntius sophore* as the most prevalent species. However, *Amblyceps mangois*, which were recorded by Oli et al. (2013), were not found during my study. The number of species was highest (23) during the summer. This might be due to warm temperature, spawning season, optimal water quality, and increased biological activity. The number of fish species (16) was lowest in the winter, this might be due to colder water temperature, less water flow, and overfishing.

The goal of a biodiversity index is to assess and represent the biological diversity present in a sample, which is significantly influenced by factors such as the number of specimens, sampling size, and ecological conditions (Magurran, 1988). The Shannon diversity index accounts for the richness and proportion of each species, while the evenness and dominance indices show the proportion of common species and the relative number of individuals in the sample (Hossain et al., 2012). The Shannon-Weiner diversity index values obtained from the present study were not particularly high. The reason for the lower species biodiversity is due to the high selectivity effect of the fishing gears used (Keskin & Unsal 1998). According to Hossain et al. (2012), a high Shannon diversity index is associated with a smaller number of individuals, whereas a low diversity index is associated with a

larger number of individuals. The highest value of the Shannon diversity index was found in site III (2.48) and in the winter (2.59) whereas lowest value was recorded at site IV (1.99) and in the autumn (2.36), which is similar to findings of Singh and Bhattarai, (2021) where they recorded high diversity index (2.93) during the winter. The primary causes for the variations in the diversity indexes are atmospheric air currents and environmental conditions (Keskin & Unsal, 1998). The highest Pielou's evenness index was observed at site I (0.87) and during the winter season (0.93), whereas the lowest was observed at site IV (0.8) and during the summer season (0.8). The maximum Margalef richness was observed at site III (3.74) and during the summer (3.98), whereas the minimum value was observed at site I (1.99) and during the autumn (2.98). Gautam et al. (2016) recorded the highest species richness (3.69) and evenness (0.85) in September, whereas the lowest species richness (2.15) was in August and evenness (0.72) in June from Lake Rupa.

Fish abundance is influenced by physicochemical factors such as temperature, pH, dissolved oxygen, and water velocity that vary with the seasons (Sharma et al., 2007). According to Hutchinson (1957), the seasonal variations in water temperature are caused by the meteorological conditions. In the present study, water temperature ranged from 16℃ to 31.5℃, with the highest recorded at Site III during summer and the lowest at Site I during winter. These findings align with those of Thapa (2018), who also recorded the highest temperature in summer but reported the lowest in autumn. Similarly, Raut (2023) found the highest temperature in summer and the lowest in winter. Gautam et al. (2010) reported a slightly narrower temperature range (20.7℃ to 31℃), suggesting possible site-specific or methodological differences. Temperature showed a weak positive correlation with fish diversity ($r = 0.36$, P.Er = 0.65), which is consistent with Joshi & K.C. (2017), who also observed a positive correlation. The weak correlation may indicate that while temperature influences fish diversity, other environmental factors, such as water quality, habitat complexity, or food availability, could play a more significant role.

The pH of natural water bodies varies and influences fish metabolism (Bhatnagar & Devi, 2013). Das (1996) suggested an optimal pH range of 6.8 to 8.5 for fish growth. In this study, the highest pH (8.8) was recorded at site IV in winter, while the lowest (6.8) occurred at site I in autumn and summer. The higher winter pH may be due to lower temperatures slowing organic matter decomposition and reducing acidic substance production. Raut (2023) similarly recorded the highest pH (9) at station IV in winter and the lowest (6.8) at

station I in autumn. However, Chaudhary (2023) observed the highest pH (7.9) in summer and the lowest (7.1) in winter. The correlation between pH and fish diversity in Rampur Ghol was negative, consistent with Raut (2023), but in contrast to Bista et al. (2022), who found a positive correlation. These differences may result from variations in study locations, fish species, and pH ranges considered. Other environmental factors, such as water quality, pollution, and habitat conditions, might also affect this relationship. Additionally, cattle grazing in Ghol increases organic waste, erosion, and nutrient runoff, which can impact pH levels.

Dissolved oxygen plays a vital role in fish diversity. The maximum dissolved oxygen (13.6 mg/l) was found at site I in the summer, whereas the minimum DO (6.6 mg/l) was found at site IV in the autumn season. The maximum amount of dissolved oxygen in summer may be due to the increased photosynthetic activity of aquatic plants and algae, which produce more oxygen. In all seasons, the DO levels at all sites remained above 5 mg/L, indicating favorable oxygen conditions for fish. This finding is consistent with Saund & Shrestha (2007), who reported similar results. The correlation between DO and fish diversity was negative in Rampur Ghol. This aligns with Chaudhary (2023), who also found a negative correlation between DO and fish diversity.

The depth of water is an important physical parameter that directly or indirectly influences the diversity of fish species. The depth of the lake varies across different stations. The deepest depth (89 cm) was recorded at site IV during summer, and the shallowest depth (21 cm) was recorded at site I during the winter season. The results showed a negative correlation between water depth and fish diversity. Similarly, Joshi & K.C. (2017) observed a positive correlation at stations I, II, and IV, whereas station III exhibited a negative correlation between depth and fish diversity.

6. Conclusions and recommendations

6.1 Conclusions

The study conducted in Rampur Ghol revealed a diverse ichthyofauna comprising 25 fish species belonging to 6 Orders, 14 Families, and 17 Genera. Cypriniformes and Cyprinidae were found as the most dominant order and family in this study. *Puntius sophore* was found to be the most abundant species with high relative abundance (22.44%), while *Glossogobius giuris, Monopterus cuchia, Ompok pabda,* and *Puntius gonionotus* were the rare species, each showing a relative abundance of 0.14%. Seasonal variations influenced the diversity indices, with the highest Shannon-Weiner diversity index (2.59) recorded in winter and the lowest (2.36) in autumn. The physico-chemical parameters of Rampur Ghol exhibited seasonal and spatial variations. Water temperature, depth, pH, and dissolved oxygen levels fluctuated throughout the study period, influencing the distribution and diversity of fish species. The study found a positive correlation between temperature and fish diversity, whereas pH, DO, and water depth showed negative correlations. The very weak negative correlation between water depth and fish diversity suggests that this parameter may play a less direct role compared to others. This study demonstrated that Rampur Ghol is rich in fish diversity, making it a significant foundation for future research on the ichthyofauna of Rampur Ghol.

6.2 Recommendations

- Regular training and awareness programs should be conducted at the local level for the conservation and management of Ghol.
- Aquatic weeds should be removed periodically using eco-friendly methods to protect fish habitats.
- Cattle grazing is common in the Ghol area, which should be controlled.

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Photo plates

Photo plate- I

Photo 1: *Badis badis*

Photo 2: *Brachydanio rerio*

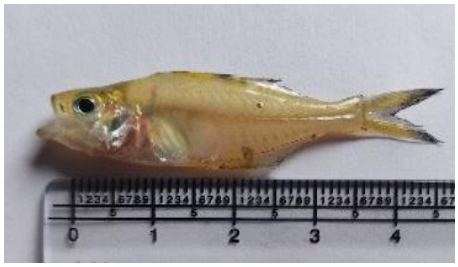

Photo 3: *Chanda nama*

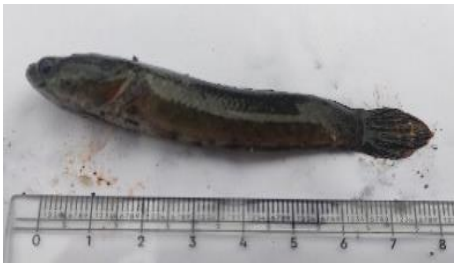

Photo 4: *Channa orientalis*

Photo 5: *Channa punctatus*

Photo 6: *Clarias batrachus*

Photo 7: *Colisa faciatus*

Photo 8: *Danio devario*

Photo plate- II

Photo 9: *Esomus danricus*

Photo 10: *Glossogobius giuris*

Photo 11: *Heteropneustes fossilis*

Photo 12: *Lepidocephalus guntea*

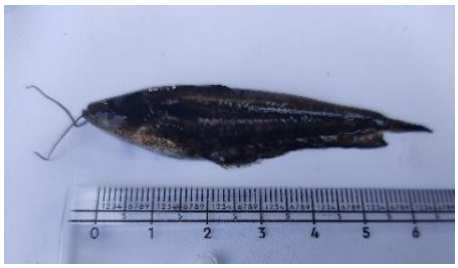

Photo 13: *Ompok pabda*

Photo 14: *Xenontodon cancila*

Photo 15: *Puntius gonionotus*

Photo 16: *Puntius sophore*

Photo plate- III

Photo 17: *Puntius ticto*

Photo 18: *Puntius chola*

Photo 19: *Puntius conchonius*

Photo 20: *Macrognathus aral*

Photo 21: *Macrognathus pancalus*

Photo 22: *Mystus tengara*

Photo 23: *Mystus bleekeri*

Photo 24: *Acanthocobitis botia*

Photo plate- IV

Photo 25: *Monopterus cuchia*

Photo plate- V

Photo 26: Site I

Photo 27: Fishing using a ghamka (Site II)

Photo 28: Fishing using a cast net (Site III)

Photo 29: Site IV

Photo 30: Identification of fish species