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Original Article

Fresh records on Ichthyofaunal diversity of River Panjkora Dir, Khyber Pakhtunkhwa, Pakistan

Novos registros sobre a diversidade da Ictiofauna do rio Panjkora Dir, Khyber Pakhtunkhwa, Paquistão

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Abstract

This study was designed to assess the ichthyofaunal diversity of River Panjkora, Khyber Pakhtunkhwa, Pakistan. For this purpose, a total of 1189 fish from six different sites were collected along the river and identified using standard keys. The fish collected and identified were representing 38 species, belonging to 7 families. The investigation spanned a year, from July 2021 to May 2022. The most dominant family was Cyprinidae 76% (n=906/1189), followed by Nemacheilidae 5.8% (n=69/1189), Channidae 5.2% (n=62/1189), Sisoridae 5.1% (n=61/1189), Mastacembelidae 4.9% (n=58/1189), Salmonidae 2.6% (n=31/1189) and least was Bagridae 0.17 (n=2/1189). The most abundant speices was *Schizothorax plagiostomus* with relative density of 16.8. Family Cyprinidae was represented by 21 species, Sisoridae by 7 species, Nemacheilidae by 5 species, Channidae by 2 species, while Bagridae, Salmonidae and Mastacembelidae, were each represented by a single species. PAST 3, XLSTAT and EXCEL 2019 were used for principal component analysis to study correlation of fish diversity and richness. Eigenvalue obtained from Kumrat to Busaq were 3.32, 1.01, 0.80, 0.44, 0.31 and 0.10 respectively. The higher value at Kumrat shows higher diversity. The water quality assessment showed average value of water temperature 10.4 °C, pH 7.0, electrical conductivity 184 mg/L, dissolved oxygen 7.9 mg/L, turbidity 43.73 mg/L, total dissolved solids 101 mg/L, total suspended solids 34.72 mg/L, total solids 135.53 mg/L, total alkalinity 75.77 mg/L, total hardness 58.37 mg/L, ammonia 0.46 mg/L, sulphate 26.03 mg/L, chloride 14.67 mg/L, calcium 69.11 mg/L, chromium 0.18 mg/L, copper 0.03, cobalt mg/L 0.04, nickel 0.039 mg/L, lead 0.02 mg/L and Zinc 0.35 mg/L. The findings of this study indicated that most of the physicochemical parameters remained within the acceptable limits throughout the study period. Analysis of fish gut contents included; nymphs, insect larvae, the presence of algae, protozoans and macroinvertebrates in the river ecosystem.

Keywords: ichthyofaunal diversity, River Panjkora, Dir.

Resumo

Este estudo foi projetado para avaliar a diversidade da ictiofauna do rio Panjkora, Khyber Pakhtunkhwa, Paquistão. Para isso, foram coletados um total de .1189 peixes de seis locais diferentes ao longo do rio e identificados através de chaves-padrão. Os peixes coletados e identificados representavam 38 espécies, pertencentes a 7 famílias. A investigação durou um ano, de julho de 2021 a maio de 2022. A família mais dominante foi Cyprinidae 76% (n=906/1189), seguida por Nemacheilidae 5,8% (n=69/1189), Channidae 5,2% (n=62/ 1189), Sisoridae 5,1% (n=61/1189), Mastacembelidae 4,9% (n=58/1189), Salmonidae 2,6% (n=31/1189), e o mínimo foi Bagridae 0,17 (n=2/1189). A espécie mais abundante foi *Schizothorax plagiostomus* com densidade relativa de 16,8. A família Cyprinidae foi representada por 21 espécies, Sisoridae por 7 espécies, Nemacheilidae por 5 espécies, Channidae por 2 espécies, enquanto Bagridae, Salmonidae e Mastacembelidae foram representados cada um por uma única espécie. PAST 3, XLSTAT e EXCEL 2019 foram utilizados para análise de componentes principais para estudar a correlação entre diversidade e riqueza de peixes. Os autovalores obtidos de Kumrat para Busaq foram 3,32, 1,01, 0,80, 0,44, 0,31 e 0,10, respectivamente. O valor mais alto em Kumrat mostra maior diversidade. A avaliação da qualidade da água apresentou valor médio de temperatura da água 10,4 ºC, pH 7,0, condutividade elétrica 184 mg/L, oxigênio dissolvido 7,9 mg/L, turbidez 43,73 mg/L, sólidos totais dissolvidos 101 mg/L, sólidos suspensos totais 34,72 mg/L, sólidos totais 135,53 mg/L, alcalinidade total 75,77 mg/L, dureza total 58,37 mg/L, amônia 0,46 mg/L, sulfato 26,03 mg/L, cloreto 14,67 mg/L, cálcio 69,11 mg/L, cromo 0,18 mg /L, cobre 0,03, cobalto mg/L 0,04, níquel 0,039 mg/L, chumbo 0,02 mg/L e zinco 0,35 mg/L. Os resultados deste estudo indicaram que a maioria dos parâmetros físico-químicos permaneceu dentro dos limites aceitáveis durante todo o período de estudo. Análise do conteúdo intestinal dos peixes incluiu ninfas, larvas de insetos, presença de algas, protozoários e macroinvertebrados no ecossistema fluvial.

Palavras-chave: diversidade ictiofaunística, Rio Panjkora, Dir.

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1. Introduction

The study area comprises of River Panjkora, originating in Kumrat-Kohistan and flowing down to Busaq, where it merges with the Swat River. In 1996, Dir was splited into two districts: district Dir Upper and Lower (Muhammad et al., 2014). Geographically, both districts are located in the northern part of Pakistan. The region experiences an annual rainfall of 1468mm (Wahab and Yousafzai, 2017). Dir has a total of 27,33,749 population as Upper Dir has a population size of 1,083,566 which comprises of 50.63% male and 49.36% female population while that of Lower Dir has a population size of 1,650,183 which comprises of 49.57% male and 50.43% female population (Gondal, 2023). The name "Panjkora" is derived from two words, "Panj" means "five" and "Kora," mean stream (Khan et al., 2022).

River Panjkora is a dynamic and diverse aquatic ecosystem, supporting a wide array of fish species. This study insights into fish diversity, water quality, food and feeding habits provide a comprehensive understanding of the river's ecology (Ullah et al., 2014). The freshwater ecosystem experiences constant fluctuations in environmental factors such as temperature, turbidity, pH, dissolved oxygen, light penetration, and density. These variables significantly influence the abundance and distribution of organisms in diverse habitats. The prevalence and presence of fish species are intricately linked to the physical conditions and the level of adaptability that enable them to thrive varying environmental conditions (Ali, 1993).

Ichthyology has a rich history spanning centuries (Ali, 1993). Fish have been a vital food source for humans since prehistoric times due to their rich protein content and palatability (Ishaq et al., 2014). Fish diversity in rivers is intricately linked with ecological variables such as river size, surface area, temperature, depth, flow velocity, channel morphology, substrate, and climate. Fish species serve as significant indicators of ecological health, with their abundance reflecting the water body's overall well-being (Hamzah, 2007). Pakistan hosts a diverse aquatic ecosystem comprising 179 fish species, distributed across 82 genera (Mirza, 1990).

Food and feeding habits of fish yields valuable insights into their consumption rates, assimilation processes, and even instances of cannibalism. Some macro invertebrates, like planarians, leeches and water striders, are only found in water, others, like dragonflies and caddisflies, are found both on land and in water (Azevedo et al., 1998). Freshwater bodies like rivers, lakes, and canals, are rarely pure; instead, they serve as reservoirs for numerous dissolved minerals such as Mg, Ca, and Fe, vital for aquatic life. The significance of water is highlighted by its role in supporting global biodiversity. Rich biodiversity enhances environmental stability and aids in recovery from ecological stressors (Devashash et al., 2006).

The concept of water quality comprises a spectrum of physical, chemical, biological, and hydrological properties (Yousafzai et al., 2008), indicating its suitability for specific purposes. Various parameters define water quality, considering its use for humans, agriculture, and the support of regional biodiversity. Surface water, vital for irrigation, domestic use, and fisheries, is invaluable. However, rapid urbanization and growing population are threatening freshwater habitats, reshaping the fauna in these degraded environments (Khan et al., 2015). Furthermore, poor water quality doesn't just impact aquatic life; it also leads to the spread of diseases such as cholera and diarrhoea. Water quality parameters comprises a range of physical, chemical, and biological characteristics that significantly influence the reproductive growth and survival patterns of aquatic species. These factors, collectively known as water quality variables, include temperature, pH, conductivity, alkalinity, hardness, sodium, chloride, potassium ion, ammonia, sulphate, magnesium etc. Proper monitoring of these parameters is vital to understanding the suitability of water for various essential purposes, including sustaining aquatic life and providing safe drinking water (Yousafzai et al., 2010). Fish fauna, like other aquatic animals, relies heavily on water quality. Physicochemical properties such as temperature, dissolved oxygen, light, salinity, pH, turbidity, and electrical conductivity play pivotal role in the fundamental activities of fish, including feeding, digestion, assimilation, growth, and reproduction. The seasonal variations in these parameters significantly impact the distribution and abundance of aquatic fauna and flora (Yousafzai et al., 2010).

Heavy metals are threat to the environment, given their abundance, high toxicity and capacity to accumulate in plant and animal tissues. Heavy metals leach slowly from parent materials into the soil and then water, agricultural activities expedite this process by enhancing mechanical weathering and soil formation (Yousafzai et al., 2008). In aquatic ecosystems, fish play a crucial role as consumers and can accumulate high concentrations of heavy metals, including lead, copper, nickel, and zinc, leading to adverse health effects such as muscle degeneration, low metabolic rates, and renal disorders. It is essential to recognize that while some heavy metals are vital for certain physiological processes in trace amounts, their excess in water can be highly toxic, causing liver damage and dermatitis in fish (Yousafzai et al., 2008).

Our province is rich in natural water resources, featuring a multitude of major rivers such as the river Swat, Kurram, Kabul and Panjkora, converging to create the Indus River (Ali et al., 2010). Additionally, many smaller rivers, including Jindi, Kalpani, etc traverse the province, ultimately flowing into the Kabul and Swat Rivers. Despite the abundance of waterways, the study area remains largely unexplored in terms of ichthyofaunal diversity, emphasizing the importance and need for water quality assessment (Ali et al., 2010). Therefore, this research was aimed to evaluate the fish diversity of River Panjkora, Dir and analyse the water for its physical and chemical properties, to investigate the feeding behaviour of fish, and assess the seasonal variation in different parameters within the river ecosystem.

2. Materials and Methods

This study, conducted from July 2021 to May 2022, focused on exploring the fish ecology along the stretch of River Panjkora from Kumrat to Busaq. A total of six sampling sites i.e. Kumrat, Sheringal, Gandigar, Khal, Shagukas and Busaq Bridge were established for sampling (Figure 1). Fish samples were collected by cast net, hand net and fishing rods with the help of professional fishermen and were taken (Figure 2) to the laboratory and sorted into appropriate plastic jars for further analysis. Larger samples were incised and preserved in 10% formalin, following the method described by Jayaram (1999). The morphometric characteristics of each fish sample were carefully recorded and organized following the protocol outlined by Jayaram (1999). Precise measurements, including eye diameter, interorbital space, and mouth gape, head length, fin length and body depth were taken using a Vernier caliper sourced from China. For detailed observations such as counting lateral line scales and examining spine serrations, a magnifying glass was utilized. Scale counting was facilitated using a sharp needle and the fishes were weighed using a Chinese-made balance with an accuracy of 0.1 gm.

The fish specimens were carefully identified using a variety of taxonomic and systematic keys and methodologies provided by renowned experts in the field, including Mirza (1982); Mirza and Sandu (2007); Jayaram (1999) and Talwar and Jhingram (1991). These extensive techniques guaranteed precise classification of the fish samples under investigation. Density, relative density, frequency and relative frequency for each fish species were calculated using the formulas reported in the literature (Haseeb and Yousafzai, 2023)

During the fish sampling process at the designated sites, the fish were dissected on-site, and their stomachs were carefully extracted from fish and preserved in solution of 70% ethanol. These preserved stomachs were transported in bottles of plastics to the Fisheries laboratory of Zoology Department, Islamia College Peshawar. In the laboratory, the stomachs were vacated into Petri dishes for a deepened analysis of their contents. Each fish specimen was properly washed with distilled water and measured for total length, standard length, and fork length, along with noting the date, time, and location following guidelines. The abdominal incision was made to remove the belly contents. Subsequently, these contents were thoroughly examined under various magnifications provided by a research microscope from Japan (No. 843883). This careful examination enabled a comprehensive analysis of the gut contents of the collected fish (Amundsen and Sánchez-Hernández, 2019; Sandford et al., 2020). The identification and taxonomy of the gut contents were carried out using a variety of taxonomic and systematic keys. The following keys were used for this purpose (Winterbourn and Gregson, 1981; Mattson, 1992).

The macro fauna was collected by using planktonic nets and Hess sampler of various sizes 40, 50 and 60 mm, and macrophytes, floating and submerged flora were gathered and identified using standard identification keys i.e. Introduction to aquatic plants of North America (Faridi, 1971; Ali and Qaiser, 2012). Macro invertebrates collected and identified using guide to aquatic insects of New Zealand (Winterbourn and Gregson, 1981).

Physiochemical parameters of water comprised a variety of characteristics such as turbidity, pH, water temperature, electrical conductivity, total solids, total suspended solids, total dissolved solids and dissolved oxygen concentration. During analysis, temperature and pH were assessed immediately on-site through pH meter and digital thermometer respectively, while analysis of electrical conductivity, dissolved oxygen, turbidity, total suspended solids, total dissolved solids, total solids, total alkalinity, total hardness, ammonia, sulphate, chloride, Calcium, heavy metals i.e. Cr, Cu, Co, Ni, Pb and Zn were carried to Pakistan Council of Scientific and Industrial

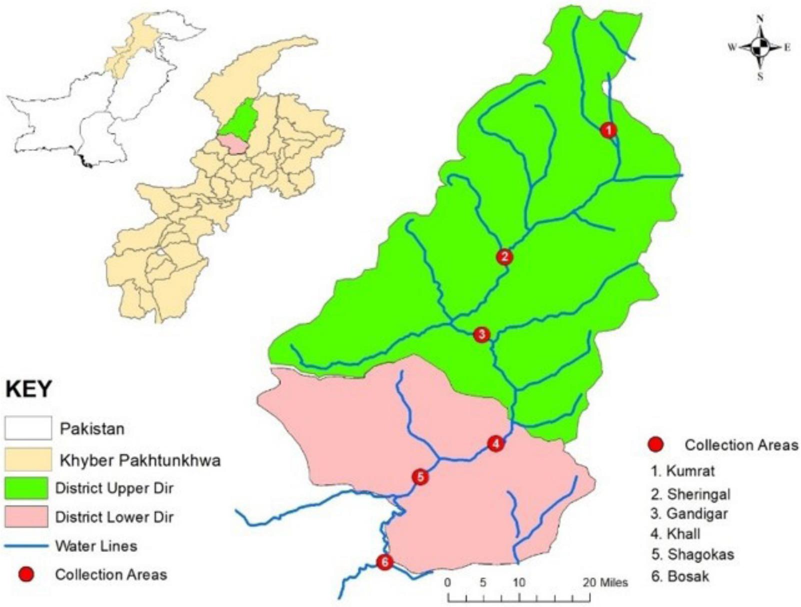

Figure 1. Study map showing different collection sites at River Panjkora.

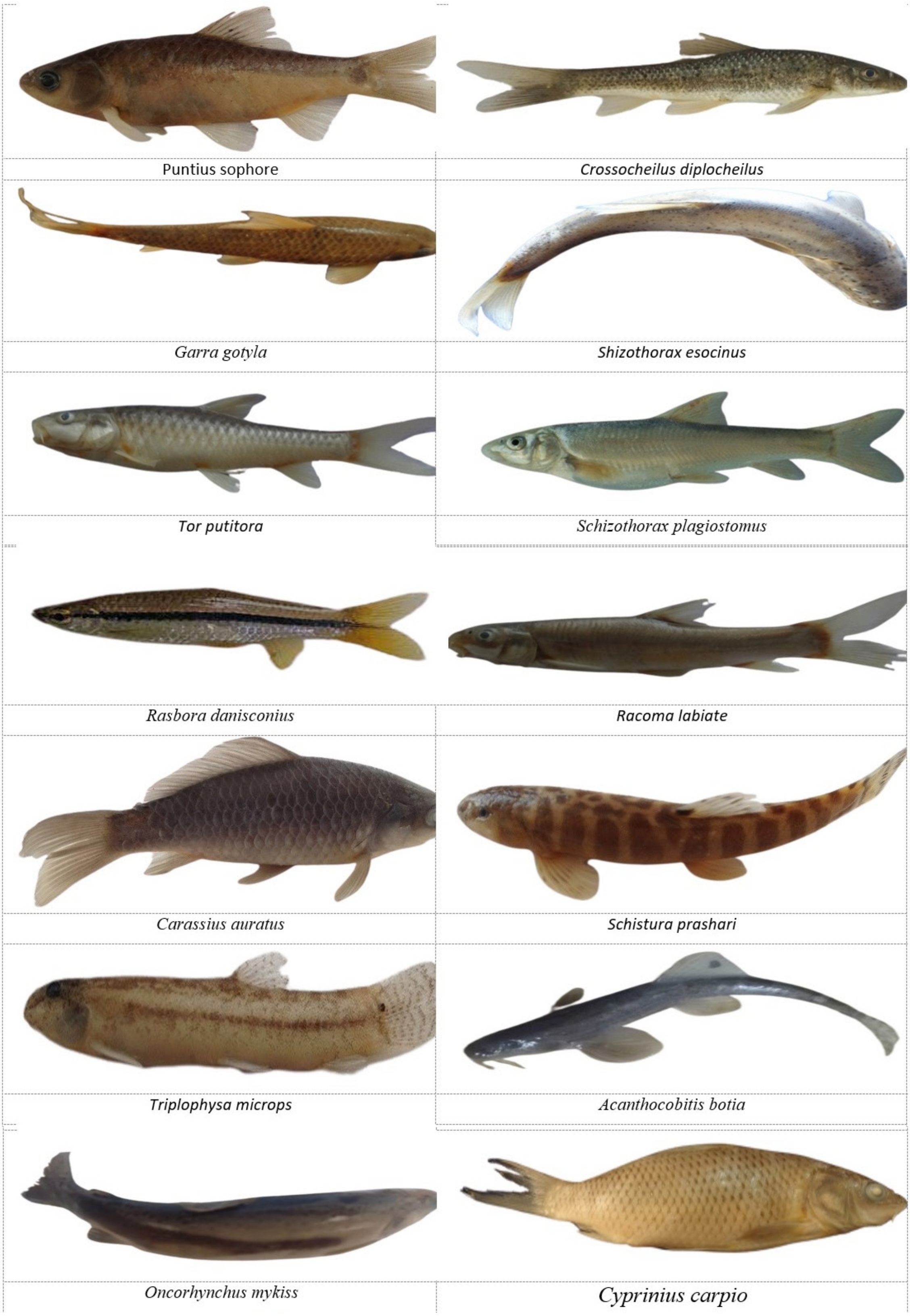

Figure 2. showing ichthyofaunal diversity collected from different regions in River Panjkora.

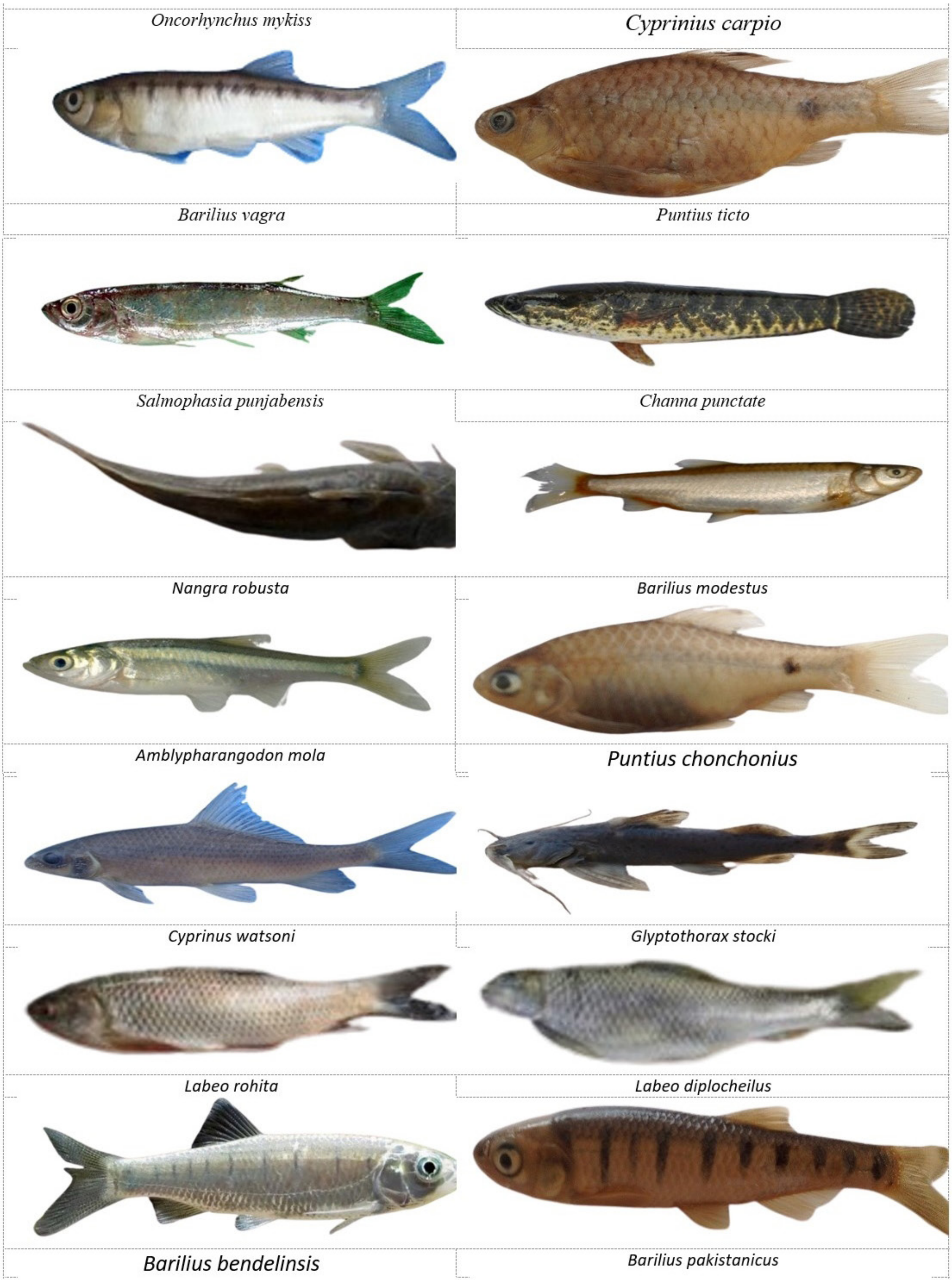

Figure 2. Continued...

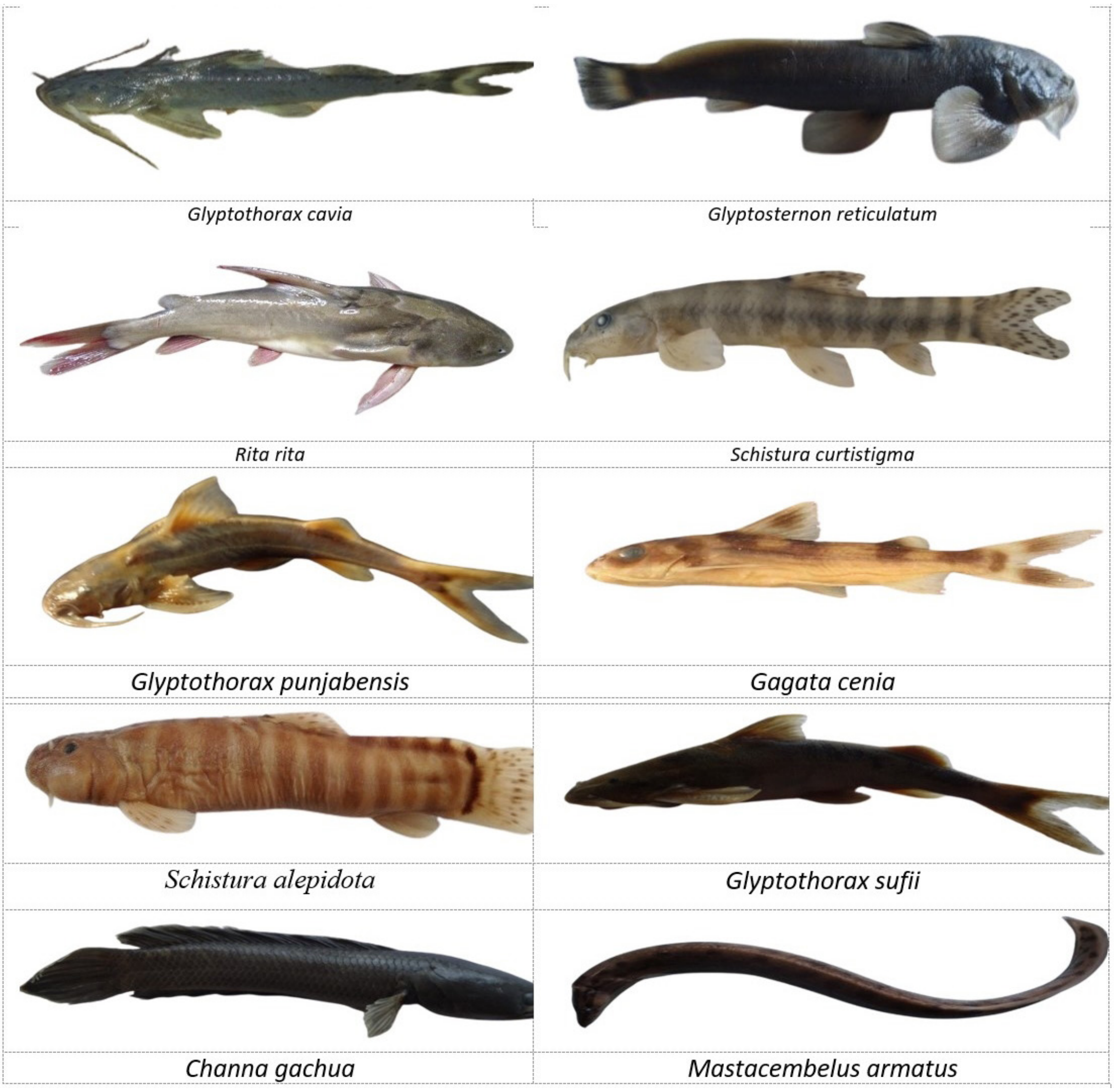

Figure 2. Continued...

Research Centre (PCSIR) Lab Peshawar for analysis. Density, relative density, frequency and relative frequency were determined by using below given formulae (Haseeb and Yousafzai, 2023) (Formulas 1-4).

$$\textbf{Density} = \frac{\substack{Number\ of\ fish\ sample\ of\ a\ specie \\ collected\ from\ all\ monitoring\ sites}}{Total\ number\ of\ monitoring\ sites} \tag{1}$$

$$\textbf{Relative Density} = \frac{Density\ of\ particular\ fish\ species}{Total\ densities\ of\ all\ fish\ species} x100 \tag{2}$$

$$\textbf{Frequency} = \frac{\substack{Number\ of\ monitoring\ sites\ at \\ which\ a\ fish\ species\ was\ found}}{Total\ number\ of\ monitoring\ sites} \tag{3}$$

$$\textbf{Relative Frequency} = \frac{Frequency\ of\ particular\ fish\ species}{Total\ frequencies\ of\ all\ fish\ species} x100 \tag{4}$$

2.1. Principal Component Analysis (PCA)

Principal component analysis is a linear dimensionality reduction method with applications in exploratory data analysis, visualization and data processing. In this research most analysis was done with, PAST3 and XLSTAT.

3. Results

A total of 1189 specimen of fish representing 38 species, belonging to 5 orders, 7 families, 10 subfamilies and 24 genera, were caught during the study period (Table 1). These families are Cyprinidae, Nemacheilidae, Sisoridae, Bagridae, Channidae, Salmonidae and Mastacembelidae. The most dominants families were Cyprinidae 76% (n=906/1189), followed by Nemacheilidae 5.8% (n=69/1189), Channidae 5.2% (n=62/1189), Sisoridae 5.1% (n=61/1189), Mastacembelidae 4.9% (n=58/1189), Salmonidae 2.6% (n=31/1189) and least was Bagridae 0.17 (n=2/1189).

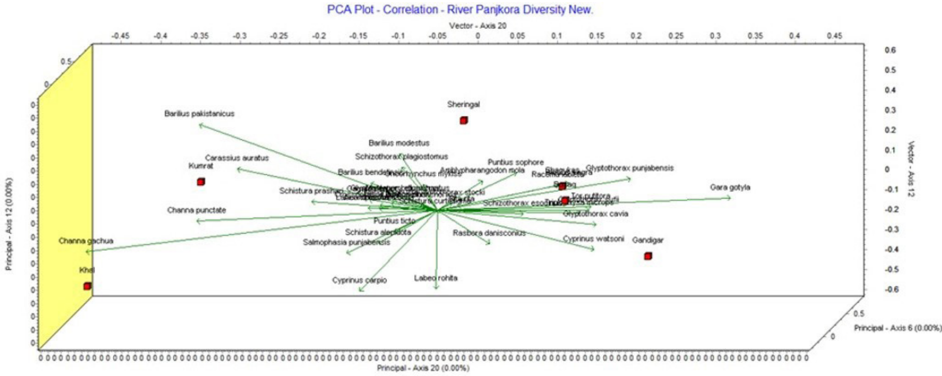

Figure 3. Showing 3D PCA plots of different species collected at different sites of River Panjkora.

Family Cyprinidae was represented by 21 species (*Cyprinus carpio*, *Cyprinus watsoni, Carassius auratus, Schizothorax esocinus, Puntius sophore, Puntius chonchonius, Schizothorax plagiostomus, Puntius ticto, Racoma labieta, Tor putitora, Gara gotyla, Labeo diplocheilus, Crossocheilus diplocheilus, Labeo rohita, Barilius pakistanicus, Barilius vagra, Amblypharangodon mola, Barilius modestus, Salmophasia punjabensis, Rasbora danisconius* and *Barilius bendelinsis*). Family Cyprinidae was represented by 6 subfamilies; sub-family Lebeoninae contain 6 species, Barbinae and Danioninae each 5 species, Cyprinidae 3, Schizothoracinae and Rasborinae each contain 1 specie.

The most abundant specie in family Cyprinidae was *Schizothorax plagiostomus* with relative density 16.8 followed by, *Gara gotyla* 10, *Barilius vagra* 6.7, *Crossocheilus diplocheilus* 6.3, *Barilius pakistanicus* 5.7, *Racoma labieta* 5.6, *Cyprinus carpio* 3.8, *Carassius auratus* 3.2, *Tor putitora* 2.1, *Schizothorax esocinus* 1.9, *Salmophasia punjabensis* 1.7, *Amblypharangodon mola* 1.6, *Puntius sophore* 1.5, *Labeo diplocheilus* 1.4, *Barilius modestus* 1.4, *Cyprinus watsoni* 1.3, *Labeo rohita* 1.3, *Rasbora danisconius* 1.2, *Puntius ticto* 1.1, *Puntius chonchonius* 1.0, *and Barilius bendelinsis* 0.3. Family Sisoridae was represented by 7 species (*Gagata cenia, Glyptothorax punjabensis, Glyptothorax cavia, Glyptothorax stocki, Glyptosternon reticulatum, Glyptothorax sufii* and *Nangra robusta*). The most abundant species in family Sisoridae was *Glyptothorax punjabensis* with relative density of 1.6 followed by, *Nangra robusta* 1.4, *Gagata cenia* 0.8, *Glyptothorax sufii* 0.8, *Glyptosternon reticulatum* 0.3 and *Glyptothorax cavia* 0.08. Family Nemacheilidae was represented by five species (*Schistura curtistigma, Triplophysa microps, Acanthocobitis botia, Schistura prashari* and *Schistura alepidota*). Among them most abundant species was *Acanthocobitis botia* with relative density of 1.7 followed by *Schistura alepidota* 1.5, *Schistura prashari* 1.4, *Triplophysa microps* 1.0 and *Schistura curtistigma* 0.2. Family Bagridae was represented by a single specie *Rita rita* with relative density of 0.17. Family Channidae was represented by 2 species in which most abundant specie was *Channa punctate* with relative density of 2.9 and *Channa gachua* 2.4. Salmonidae and Mastacembelidae were also represented by a single species *Oncorhynhus mykiss* and *Mastacembelus armatus* with relative density of 2.6 and 4.9 respectively (Table 2).

This data provides valuable information for ecological studies and conservation efforts, aiding in the understanding of the river's ecosystem and the species inhabiting it. The specie richness was higher at Gandigar 29 followed by Khal 27, Shagukas 26, Sheringal 19, Busaq 15 and least at Kumrat as 4 (Table 2). The morphometric characteristics of each fish were carefully recorded and summarized in (Table 3 and 4).

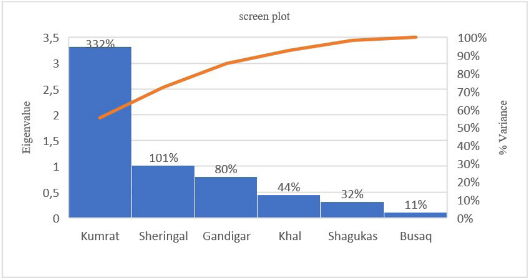

Figure 4. Showing Eigenvalue at different collection sites of River Panjkora.

Gut contents collected from dissected fishes were debris, mud, Chironomus larvae, nymphs of dragon fly, caddis fly larvae, may fly, daphnia, protozoans, paramecia and dragonfly. Macro invertebrates collected included Caddisfly, Midge, Leech, Planarian, Stone fly, mayfly, stonefly, dragonfly, dams fly, water scorpion, strider, beetle, boatman and bugs, snails, Riffle beetle and Crab. Aquatic algae i.e. *Oocystus borgei, Oedogonium angustissimum, Hydrodactylon reticulatum, Cladophora glumerata, Ulothrix aequalis, Volvox globator, Volvox tertius* and *Spirogyra acquinocitialis*. Aquatic angiosperm collected were; *Azolla pinnata, Hydrilla verticillata, Potamogeton crispus, Potamogeton natans, Potamogeton pectinatus, Marsilea minuta,* and *Vallisneria* (Table 5). Correlation obtained at all collection sites indicated values of Kumrat was correlated with Sheringal that shows that fish diversity is correlated with each other (Table 6).

The factor loading shown in Table 7 can be divided as strong, weak and moderate according to principal component analysis, as shown in (Figure 3). It is considered strong if factor loading is above 0.75, moderate when factor loading is between 0.75 to 0.50 and weak if FL is between 0.50 to 0.30 (Shaw, 2009). Eigenvalue obtained from Kumrat to Busaq are 3.32, 1.01, 0.80, 0.44, 0.31 and 0.10 respectively. Kumrat has higher diversity as shown in (Figure 4).

Table 1. Showing systematic position of fish.

S.No	English name	Local name	Common name	Order	Family	Sub-family	Genus	Specie
1	Common Carp	Common Carp	Carp	Cypriniformes	Cyprinidae	Cyprininae	*Cyprinus*	*carpio*
2	Watson's barb	Barb	atson's barb					*watsoni*
3	Goldfish	Paplate	Sona Machli				*Carassius*	*auratus*
4	Snowtrout	Chirruh	Snowtrout			Barbinae	*Schizothorax*	*esocinus*
5	Chush Snowtrout	Swati	Khont					*plagiostomus*
6	Two-spot Barb	Ticto barb	Ticto barb				*Puntius*	*Ticto*
7	Pool barb	Spot fin swamp barb	Pool barb					*sophore*
8	Blackspot barb	Barb	Blackspot barb					*chonchonius*
9	Snow trout	Chirruh	Deccan Mahseer			Schizothoracinae	*Racoma*	*labieta*
10	Golden Mahseer	Mahasher	Golden Mahseer			Danioninae	*Tor*	*putitora*
11	The Spotted Garra	Kanesatt	The Spotted Garra				*Gara*	*gotyla*
12	Rahu	Rahu	Rahu				*Labeo*	*rohita*
13	Black-lipped labeo	Rui	Roho labeo				*Labeo*	*diplocheilus*
14	Common stone loach	spena deqa	Common stone loach				*Crossocheilus*	*diplocheilus*
15	Pakistani hill trout	Patty mahay	Pakistani chawla			Lebeoninae	*Barilius*	*pakistanicus*
16	Oriental Flying Barb	Mahseer	Silver fish					*vagra*
17	Spotted barb	Mola chilwa	Highfin spotted barb				*Amblypharangodon*	*Mola*
18	Spotted Barb	Mola chilwa	Highfin Spotted Barb				*Barilius*	*modestus*
19	Punjab snow trout	khurdni machhli	Punjab salmon				*Salmophasia*	*punjabensis*
20	Platinum Rasbora	Darikhana	Long fin rasbora				*Rasbora*	*danisconius*
21	Bendel's Minnow	Tilla	Indian Hill trout			Rasborinae	*Barilius*	*bendelinsis*
22	Short strip loach	Shistora	Trout		Nemacheilidae	Squaliobarbinae	*Schistura*	*curtistigma*
23	Small-eyed Snowtrout	Leh triplophysa loach	Small-eyed Stone Loach				*Triplophysa*	*microps*
24	Pointed tail loach	Bilturi	Pointed tail loach				*Acanthocobitis*	*botia*
25	Prashar Loach	Parashari	Parshar				*Schistura*	*prashari*
26	False zebra loach	zebra loach	Scaleless loach					*alepidota*
27	River catfish	Barituky	River catfish	Siluriformes	Sisoridae		*Gagata*	*Cenia*
28	Punjab Glyptosternon	Sulamanne	Punjab Glyptosternon				*Glyptothorax*	*punjabensis*
29	Hearth throat catfish	Epithet cavia	Cat e-long					*Cavia*
30	Snow trout	Asala	Snow trout					*stocki*
31	Reticulated Hillstream loach	Yoyo loach	Chines sucker fish				*Glyptosternon*	*reticulatum*
32	Sufi's catfish	*Glyptothorax kashmiri*	Sufi's catfish				*Glyptothorax*	*Sufii*
33	Gangetic Loach	Almora Loach	Spiny Loach			Sisorinae	*Nangra*	*Robusta*
34					Bagridae	Ritinae	*Rita*	*Rita*
35	Spotted Snakehead	Katasarre	Shoal	Channiformes	Channidae	Squaliobarbinae	*Channa*	*Punctate*
36	Brown dwarf snake head	katasari	Dwarf head					*gachua*
37	Rainbow trout	Trout	Rainbow Trout	Salmoniformes	Salmonidae		*Oncorhynchus*	*mykiss*
38	eel	marmahay	Zigzag eel	Mastacembeliforms	Mastacembelidae		*Mastacembelus*	*armatus*

Table 2. Showing number of fish specimen at all collection sites in River Panjkora.

S. No	Taxon	Kumrat	Sheringal	Gandigar	Khal	Shagukas	Busaq	Density	Relative Density	Frequency	Relative Frequency
1	*Schizothorax esocinus*	3	4	3	5	6	2	3.83	1.93	1	4.93
2	*Schizothorax plagiostomus*	12	15	20	39	51	63	33.33	16.83	1	4.93
3	*Racoma labieta*	4	8	17	7	14	17	11.16	5.63	1	4.93
4	*Tor putitora*	0	6	4	5	6	4	4.16	2.10	0.8	3.94
5	*Gara gotyla*	0	12	5	23	45	34	19.83	10.01	0.8	3.94
6	*Carassius auratus*	0	11	3	5	8	11	6.33	3.19	0.8	3.94
7	*Cyprinus carpio*	0	4	8	14	9	11	7.66	3.87	0.8	3.94
8	*Cyprinus watsoni*	0	0	7	2	7	0	2.66	1.34	0.5	2.46
9	*Barilius vagra*	0	7	8	38	27	0	13.33	6.73	0.7	3.45
10	*Amblypharangodon mola*	0	0	7	3	9	0	3.16	1.59	0.5	2.46
11	*Barilius modestus*	0	1	7	5	4	0	2.83	1.43	0.7	3.45
12	*Salmophasia punjabensis*	0	3	4	5	8	0	3.33	1.68	0.7	3.45
13	*Rasbora danisconius*	0	4	2	6	2	0	2.33	1.17	0.7	3.45
14	*Labeo rohita*	0	0	5	3	3	5	2.66	1.34	0.7	3.45
15	*Labeo diplocheilus*	0	0	8	6	3	0	2.83	1.43	0.5	2.46
16	*Crossocheilus diplocheilus*	0	6	13	5	20	31	12.5	6.31	0.8	3.94
17	*Barilius pakistanicus*	0	0	7	38	23	0	11.33	5.72	0.5	2.46
18	*Barilius bendelinsis*	0	0	0	0	0	3	0.5	0.25	0.17	0.83
19	*Triplophysa microps*	0	5	7	0	0	0	2	1.01	0.33	1.62
20	*Acanthocobitis botia*	0	8	12	0	0	0	3.33	1.68	0.33	1.62
21	*Schistura prashari*	0	7	10	0	0	0	2.83	1.43	0.33	1.62
22	*Schistura alepidote*	0	0	0	13	0	5	3	1.51	0.33	1.62
23	*Gagata cenia*	0	0	4	5	0	0	1.5	0.75	0.33	1.62
24	*Glyptothorax punjabensis*	0	0	0	14	3	2	3.16	1.59	0.5	2.46
25	*Glyptothorax cavia*	0	0	0	0	1	0	0.16	0.08	0.17	0.83
26	*Glyptothorax stocki*	0	0	2	0	0	0	0.33	0.16	0.17	0.83
27	*Glyptosternon reticulatum*	0	0	2	0	1	1	0.66	0.33	0.5	2.46
28	*Nangra robusta*	0	10	7	0	0	0	2.83	1.43	0.33	1.62
29	*Channa punctate*	0	4	0	7	23	0	5.66	2.86	0.5	2.46
30	*Channa gachua*	0	0	0	11	17	0	4.66	2.35	0.33	1.62
31	*Oncorhynchus mykiss*	27	4	0	0	0	0	5.16	2.6	0.33	1.62
32	*Mastacembelus armatus*	0	0	11	15	15	17	9.66	4.88	0.7	3.45
33	*Glyptothorax sufii*	0	0	0	9	0	0	1.5	0.75	0.17	0.83
34	*Puntius ticto*	0	2	3	6	2	0	2.16	1.09	0.7	3.45
35	*Puntius sophore*	0	2	4	7	5	0	3	1.51	0.7	3.45
36	*Puntius chonchonius*	0	0	7	3	2	0	2	1.01	0.5	2.46
37	*Rita rita*	0	0	0	0	0	2	0.33	0.16	0.17	0.83
38	*Schistura curtistigma*	0	0	2	0	0	0	0.33	0.16	0.17	0.83
	Total	**46**	**123**	**199**	**299**	**314**	**208**	**198**	**100**	**20.26**	**100**

Table 3. Showing morphometric measurement of the recorded fish species collected in River Panjkora.

S. No	Name of Fish	T.L	S.L	F.L	H.L	E.D	Sn. L	Pre DL	Post D.L	Pre- PL	Post- PL	LCP	BD	BW
1	*Cyprinus carpio*	16.0	12.0	13.0	3.0	0.6	1.8	13.2	13.7	13.5	14.2	4.4	10.8	6.2
2	*Cyprinus watsoni*	13.7	12	13.2	3.6	0.5	2.7	6.2	6.6	2.2	2.8	3.5	3.5	4.7
3	*Carassius auratus*	18	14.3	16.6	4.05	0.9	0.7	4.2	4.4	4.6	4.8	2.8	3.6	1.2
4	*Schizothorax esocinus*	18.4	15.1	17.4	3.5	0.7	2.2	14.4	14.8	19	20.3	5.1	4.1	3.0
5	*Schizothorax plagiostomus*	31.2	25.5	27.0	5.5	1.0	2.3	14.4	14.8	16.0	16.3	4.1	4.2	3.1
6	*Puntius ticto*	8	6.3	7.1	2.05	0.6	1.2	6.4	6.9	7.7	8.0	2.4	4.1	2.8
7	*Puntius sophore*	13.1	12.1	10.9	2.2	0.7	1.1	6.4	4.2	4.4	5.0	1.2	2.2	1.9
8	*Puntius chonchonius*	6	4.8	5.4	1.2	0.3	1.0	3.8	4.0	3.9	4.2	2.4	2.1	1.8
9	*Racoma labieta*	20.3	17.1	18.6	3.7	0.65	2.5	8.0	8.3	7.8	8.0	4.7	3.8	6.3
10	*Tor putitora*	12.9	10.5	11.8	2.9	0.6	1.5	13.2	13.8	13.9	10.2	3.4	3.6	2.3
11	*Gara gotyla*	12.2	10.5	11.3	2.6	0.4	1.7	13.2	13.6	13.5	13.8	3.2	3.0	2.4
12	*Labeo rohita*	14	12.6	12.3	3.3	0.8	2	9.3	9.5	10	0.3	3.2	4.5	2.4
13	*Labeo diplocheilus*	17	14.3	15.5	3.4	0.5	1.8	6.9	7.1	8.1	8.4	3.0	4.7	2.7
14	*Crossocheilus diplocheilus*	12.5	10.01	11.2	2.1	0.5	1.1	7.3	7.5	6.8	7	2.1	3	2.5
15	*Barilius pakistanicus*	8.9	7.2	8	1.65	0.5	0.5	5.8	6	6.2	6.4	1.5	1.7	1.9
16	*Barilius vagra*	8.6	6.2	7.3	1.8	0.6	0.5	2.9	3	2.6	2.7	1.0	0.8	0.9
17	*Amblypharangodon mola*	5	4.2	4.5	0.9	0.3	0.8	2.1	2.2	1.9	2	0.9	1.3	0.8
18	*Barilius modestus*	6	4.6	4.9	1.8	0.4	1.4	3.1	3.3	2.1	2.3	1.5	2	1.9
19	*Salmophasia punjabensis*	12.5	10.2	11.1	1.9	0.3	.8	7.8	8.2	7.7	8	1.7	2.4	0.8
20	*Rasbora danisconius*	12.5	10.5	11	2.2	0.5	2.1	6.8	7.1	7	7.2	1.6	2.5	1.7
21	*Barilius bendelinsis*	12	10.6	10.3	2.3	0.5	2.0	6.7	7.0	6.9	7.1	1.5	2.4	1.6
22	*Schistura curtistigma*	11	9.6	10.5	2.2	0.5	1.0	6.0	6.3	5.4	5.7	1.4	2.8	2.3
23	*Triplophysa microps*	10	9.0	8.3	1.5	0.3	0.5	5.2	5.8	5.0	5.2	1.6	2.4	1.9
24	*Acanthocobitis botia*	6.6	5.3	5.7	1.4	0.3	0.7	2.8	3.1	2.5	2.7	0.3	1.6	1.4
25	*Schistura prashari*	8.3	7.5	8.0	1.0	0.1	0.5	3.1	3.5	2.9	3.2	1.3	1.3	1.0
26	*Schistura alepidota*	7.7	6.9	7.3	1.9	0.2	0.8	3.0	3.2	2.8	3.0	1.2	2.0	2.0
27	*Gagata cenia*	10.1	8.2	9.3	2.4	0.8	1.5	5.1	5.5	4.8	5.1	2.0	2.3	1.2
28	*Glyptothorax punjabensis*	11.3	10.5	9.9	2.1	0.3	1.7	5.7	5.9	5.4	5.7	1.5	3.0	1.7
29	*Glyptothorax cavia*	27.5	24.5	25	6.5	0.4	2.8	13.3	13.5	13.0	13.3	5.3	4.2	2.4
30	*Glyptothorax stocki*	10.1	9.0	8.0	2.0	0.3	1.2	5.4	6.0	5.5	5.9	1.8	2.2	1.6
31	*Glyptosternon reticulatum*	27.5	24.5	25	6.5	0.4	2.5	14.0	14.3	13.7	14.0	6.3	4.0	3.0
32	*Glyptothorax sufii*	7.2	6.1	5.1	1.8	0.3	1.2	2.6	2.9	2.5	2.9	1.4	0.9	1.1
33	*Nangra robusta*	30	20	20.6	5	1.0	2.2	14.3	14.6	15.9	16.1	4.0	4.1	3.0
34	*Rita rita*	22	18.11	20.35	5.7	0.3	2.2	13.4	13.7	16.0	16.4	4.0	4.4	3.2
35	*Channa punctate*	11.9	10.1	11.2	2.3	0.6	1.6	4.4	4.8	4.5	4.8	1.4	2.7	1.6
36	*Channa gachua*	14.1	12	13.7	3.5	0.6	1.6	5.8	6.1	5.7	5.9	2.1	3.2	1.9
37	*Oncorhynchus mykiss*	15.4	13.6	12.3	2.9	0.7	1.8	6.1	6.4	5.6	5.8	2.3	3.4	2.3
38	*Mastacembelus armatus*	38.2	35.7	37.0	6	0.6	2.7	16.9	17.3	16.5	16.6	3.1	1.6	3.7

T.L= total length; F.L= fork length; H.L= head length; E.D= eye diameter; Sn.L= snot length; Pre.DL= pre dorsal length; Post.DL= post dorsal length; Pre.P.L= pre pelvic length; Post. P.L= post pelvic length; LCP= length of caudal penduncle; BD= body depth; BW= body weight.

Table 4. Comparison of fin rays of the fish counted during identification in the present survey.

S. No	Name of Fish	D	P	V	A	C	L.L
1	*Cyprinus carpio*	3/17	15	9	3/5	19	36-38
2	*Cyprinus watsoni*	3/9-10	15	8	2/7	19	33-36
3	*Carassius auratus*	3/16-18	17	9	3/5	19	28
4	*Schizothorax esocinus*	4/8	20	10	3/5	19	95-98
5	*Schizothorax plagiostomus*	4/8	20	11	3/5	19	110
6	*Puntius ticto*	3/8	15	1/8	3/5	19	23-26
7	*Puntius sophore*	3/8	17	1/8	3/5	19	23-26
8	*Puntius chonchonius*	3/8	11	1/8	2/5	19	20-25
9	*Racoma labieta*	4/8	20	11	3/5	19	110
10	*Tor putitora*	4/8	15-18	1/8	2/5	19	22-27
11	*Gara gotyla*	2/8	15	8	2/5	19	30
12	*Labeo rohita*	11/112	14/15	8	14/15	14	39
13	*Labeo diplocheilus*	2/7	17/19	9	2/5	19	31
14	*Crossocheilus diplocheilus*	3/8	15	9	2/5	19	38
15	*Barilius pakistanicus*	2/7	15	9	2/10-12	19	42-44
16	*Barilius vagra*	2/7	15-16	9	2/12	19	142
17	*Amblypharangodon mola*	2	7	1/6	1/5	15	18-20
18	*Barilius modestus*	2/7	15-16	9	2/10	19	42
19	*Salmophasia punjabensis*	2/7	11	8	3/16	19	82
20	*Rasbora danisconius*	2/7	19	9	2/5	19	31
21	*Barilius bendelinsis*	4	15	3	2/5	12	29
22	*Schistura curtistigma*	3/8	11	7	2/5	16	
23	*Triplophysa microps*	3/7	10	8	2/5	14	26
24	*Acanthocobitis botia*	2/12	11	8	2/5	17	78
25	*Schistura prashari*	2/7	9	7	2/5	18	-
26	*Schistura alepidota*	3/7	12	2/6	2/5	18	-
27	*Gagata cenia*	1/6	1/9	6	3/10-12	19	38
28	*Glyptothorax punjabensis*	1/6	1/8	6	3/9	18	-
29	*Glyptothorax cavia*	1/6	1/8	6	3/9	17	-
30	*Glyptothorax stocki*	1/6	1/10-11	6	1/10-11	16-18	-
31	*Glyptosternon reticulatum*	1/6	1/11	1/5	2-3/5	16	-
32	*Glyptothorax sufii*	1/6	1/8	6	3/9	18	-
33	*Nangra robusta*	5	20	6	5	14	28
34	*Rita rita*	1/6	1/10	8	1/7	10	-
35	*Channa punctate*	29-32	17	6	21-23	12	37-40
36	*Channa gachua*	32-37	15	6	21-23	12	39
37	*Oncorhynchus mykiss*	14	15	10	13	20	40
38	*Mastacembelus armatus*	32-39/74-90	23	3/75-88	-	-	-

D= Dorsal fins; P= Pelvic fins; V= Ventral fins; A= Anal fins; C= Caudal fins; L.L= Lateral Line Scales.

The study conducted on the water quality parameters of River Panjkora revealed specific ranges for various physical and chemical factors, all of which fell within the acceptable limits outlined by Pakistan's National Environmental Quality Standards (Pakistan, 2000). Temperature fluctuations, a fundamental factor affecting

Table 5. showing aquatic algae, angiosperm and macroinvertebrates collected at all sampling sites in River Panjkora.

S.No	Taxon	Kumrat	Sheringal	Gandigar	Khal	Shagukas	Busaq
				Macro invertebrates			
1	Caddisfly	−	−	+	+	+	+
2	Midge	−	−	+	+	−	−
3	Dragonfly	−	+	−	+	+	+
4	Damselfly	−	+	+	+	+	+
5	Leech	−	−	+	+	+	+
6	Mayfly	−	+	+	+	+	+
7	Planaria	−	−	−	+	+	+
8	Stone fly	+	+	+	+	+	+
9	Water beetle	−	+	+	+	−	+
10	Water scorpion	−	+	−	+	+	+
11	Water stirder	−	+	−	+	−	+
12	Snails/Slugs	−	−	+	+	+	+
13	Water bugs	+	+	+	−	−	−
14	water boatman	+	+	+	+	+	+
15	Riffle beetle	+	+	+	−	−	−
16	Crab	−	+	+	+	+	+
				Aquatic algae			
1	*Oocystus borgei*	−	−	+	+	−	−
2	*Hydrodictyon reticulatum*	+	+	+	−	−	−
3	*Cladophora glumerata*	−	−	−	+	+	+
4	*Oedogonium angustissimum*	−	−	+	+	+	+
5	*Ulothrix aequalis*	−	+	+	+	+	−
6	*Volvox globator*	+	+	+	+	+	+
7	*Volvox tertius*	−	+	+	+	−	+
8	*Spirogyra acquinocitialis*	−	+	−	+	−	−
				Aquatic angiosperm			
1	*Potamogeton natans*	−	+	+	+	−	+
2	*Potamogeton crispus*	+	+	+	+	+	+
3	*Potamogeton pectinatus*	−	+	−	+	−	−
4	*Vallisneria spiralis*	−	+	+	+	+	−
5	*Hydrilla verticellata*	−	+	−	+	+	−
6	*Azolla pinnata*	−	−	+	+	−	+
7	*Marsilea minuta*	+	+	−	−	+	−

(+) = Presence; (-)= Absence.

Table 6. Showing correlation between different collection sites of River Panjkora.

Variables	Kumrat	Sheringal	Gandigar	Khal	Shagukas	Busaq
Kumrat	**1**	0.12256	0.59618	0.6294	0.39124	0.11441
Sheringal	0.25485	**1**	0.000399	0.04968	0.000199	2.0205
Gandigar	0.088757	0.54535	**1**	0.029778	0.002517	4.0205
Khal	0.080857	0.32064	0.35287	**1**	4.3009	0.001074
Shagukas	0.14315	0.56816	0.47608	0.78801	**1**	9.1709
Busaq	0.26036	0.63279	0.61472	0.50992	0.77779	**1**

Values in bold are different from 0 with a significance level alpha=0.05.

Table 7. Showing factor Loadings of different species in River Panjkora.

Variables	F_1	F_2	F_3	F_4	F_5	F_6
Kumrat	0.29224	0.87096	0.36185	0.15019	0.045449	-0.02157
Sheringal	0.76481	0.23534	-0.3238	-0.44303	0.23918	0.036886
Gandigar	0.72157	-0.01089	-0.51399	0.44572	0.12005	-0.04425
Khal	0.72626	-0.38139	0.4852	0.11508	0.24173	0.14141
Shagukas	0.89843	-0.22343	0.24833	-0.10412	-0.09611	-0.2473
Busaq	0.89255	0.05721	-0.07026	-0.01872	-0.41683	0.14509

fish abundance, demonstrated variations throughout the year, it ranges between 4.1ºC and 14.35ºC. Dissolved oxygen level reaching its maximum (8.5 mg/L) and its minimum (7.2 mg/L). The pH ranged from 6.7 to 7.2, falling within the optimal range for fish production, with seasonal variations attributed to changes in CO2 levels. Electrical conductivity fluctuated gradually over the study period, affected by factors such as temperature, dissolved solids, and ionic concentration ranges between 156.41 to 204.3 mg/L. Total dissolved solids, comprising various salts, remained within the acceptable limits (55 to 144.9 mg/L), as set by (Pakistan, 2000) as (150mg/L). Alkalinity values, reflecting the presence of carbonates and bicarbonates, ranged from 43 to 150 mg/L. Hardness, primarily due to calcium and magnesium ions, ranged from 25 to 101 mg/L. Alkali metal chloride ions fluctuated from 10.3 to 20.46 mg/L. Ammonia concentrations, a crucial parameter indicating organic pollution, with mean of 0.46 mg/L. In the current study, heavy metals such as Ni, Co, Pb, Cr, Cu and Zn were found in varying amounts ranging from 0 to 0.042 mg/L, 0 to 0.02 mg/L, 0 to 0.03 mg/L, 0.017 mg/L to 0.54 mg/L, 0.004 to 0.08 mg/L and 0.02 to 1.9 mg/L, respectively as shown in (Table 8).

4. Discussion

Fish population maintenance, diversity and abundance of fish species in natural environment is possible through different techniques such as implementing strict environmental laws, annual fish stocking, regulation of harvest, prevention of fishing in breeding season and harvesting of marketable size fish only. River Panjkora is receiving a constantly increasing pressure as the local people are continuously utilizing its banks for construction, agricultural, recreational and industrial purposes. After the 2010 massive flood, according to local fishermen, the total catch has declined (Mahmood et al., 2016).

In the present study, a total of thirty-eight fish species were identified; *Cyprinus carpio*, *Cyprinus watsoni, Carassius auratus, Schizothorax esocinus, Schizothorax plagiostomus, Puntius ticto, Puntius sophore, Puntius chonchonius, Racoma labieta, Tor putitora, Gara gotyla, Labeo rohita, Labeo diplocheilus, Crossocheilus diplocheilus, Barilius pakistanicus, Barilius vagra, Amblypharangodon mola, Barilius modestus, Salmophasia punjabensis, Rasbora danisconius, Barilius bendelinsis*, *Gagata cenia, Glyptothorax punjabensis, Glyptothorax cavia, Glyptothorax stocki, Glyptosternon reticulatum, Glyptothorax sufii, Nangra robusta*, *Rita rita, Schistura curtistigma, Triplophysa microps, Acanthocobitis botia, Schistura prashari, Schistura alepidote*, *Channa punctate, Channa gachua, Oncorhynhus mykiss* and *Mastacembelus armatus*. The Cyprinidae family was the most abundant, comprising twenty-one species, followed by Sisoridae by 7 species, Nemacheilidae by 5 species, Channidae by 2 specie, while Bagridae, Salmonidae and Mastacembelidae, were each represented by a single species. Among them the most abundant speices was *Schizothorax plagiostomus* with relative density 16.8 and relative frequency of 4.9 followed by *Gara gotyla* with relative density 10 and relative frequency of 3.9 and *Crossocheilus diplocheilus* with relative density 6.3 and relative frequency of 3.9

Several commercially important species are reported in our study like *Schizothorax esocinus, Schizothorax plagiostomus, Garra gotyla, Cyprinus carpio, Tor Putitora* and *Carassius auratus.* Among them some species like *Cyprinus carpio, Tor Putitora, and Schizothorax esocinus*, etc becoming scarce in the study area due to illegal fishing activity as using electric shock, dynamite etc. so, Proper management are needed for the protection and conservation of these species.

During the study period it was also observed that *Gagat cenia* is first time reported from River Panjkora in previous studies it was only observed in Usherai stream, maybe it is migratory specie and two more species i.e. *Rita rita* and *Barilius bendelinsis* were also reported for the first time from River Panjkora at only one collection site i.e. Busaq, maybe these are also migratory species and migrated from adjacent river.

Few fishes like *Glyptothorax sufii, Glyptothorax punjabensis, Glyptothorax cavia, Glyptothorax stocki, Glyptothorax reticulatum, Glyptothorax stocki, Schizothorax esocinus, Gagata cenia, Tor putitora, Barilius bendelinsis, Rita rita, Schistura curtistigma* were rare in the study area. Anthropogenic activities were main reasons behind habitat destruction, pollution and over hunting.

Macroinvertebrates collected included dragon fly, dams fly, may fly, stone fly, water beetle, scorpion, stirder, bugs, and boatman and Crab, Riffle beetle. Aquatic algae i.e. *Hydrodictyon reticulatum, Ulothrix aequalis, Volvox globator, Volvox tertius* and *Spirogyra aequinocitialis* while aquatic angiosperm included are *Potamogeton natans, Potamogeton crispus, Potamogeton pectinatus, Vallisneria spiralis, Hydrilla verticellata* and *Marsilea minuta*. This research contributes

Table 8. Physicochemical parameter's mean value collected at different regions in study area.

Parameters	Kumrat	Sheringal	Gandigar	Khal	Shagukas	Busaq	Mean± SE	USEPA*, Standard for Aquatic life	WHO, Standards
Temperature	4.108333	5.308333	11.64	13.97	13.12	14.35	10.416±1.85	<32ċ	16-40ċ
pH	7.2	7	6.9	7.1	6.7	7.2	7.0166±0.07	6.5-8.2	6.5-8.5
EC	204.375	197.7917	202	176	156.41	170.95	184.58±8.00	150-500 µs/cm	250
DO	8.366667	8	8.5	8.1	7.2	7.3	7.911±0.22	6.5-8 mg/L	5.0 mg/L
Turbidity	15	23	73.775	79.37	44.95	26.33	43.73±11.15	<150 mg/L	0.5-10 mg/L
TSS	18.74	19.49	121.31	15.20	14.54	19.05	34.72±17.3	<1500 mg/L	500 mg/L
TDS	55	73	107.35	144.95	110.13	116.70	101.18±13.16	<1500 mg/L	<600mg/L
TS	73.74	92.49	228	160	124	135	135.53±22.32	<2000 mg/L	500 mg/L
TA	43	76.025	100	81.62	150	78	75.77±7.5	100-200 mg/L	10mg/L-400mg/L
TH	25	56.33	68	56.9	43	101	58.37±10.43	50-150 mg/L	10mg/L-400mg/L
NH3	0.503333	0.516667	0.42	0.48	0.48	0.4	0.46±0.01	0.3-0.9 mg/L	0.2-3 mg/L
Sulphate	10.26667	10.95	77	20	24	14	26.03±10.42	3-30 mg/L	250 ml/L
Chloride	11.71	20.46	10.3	12.4	16.8	16.35	14.67±1.56	10-20 mg/L	10-600 mg/L
Ca	71.9	89.79	28	70	93	62	69.11±9.57	350-450 mg/L	4-160 mg/L
Cr	0.545	0.391667	0.02	0.017	0.061	0.05	0.18±0.09	<0.05 mg/L	0.05 mg/L
Cu	0.004	0.03	0.03	0.03	0.05	0.08	0.03±0.01	<0.007 mg/L	2 mg/L
Co	0.0	0.0	0.022	0.02	0.2	0.046	0.04±0.03	<0.11 mg/L	0.1 mg/L
Ni	0.0	0.0	0.042	0.047	0.09	0.06	0.039±0.014	<0.05 mg/L	0.07 mg/L
Pb	0.0	0.0	0.05	0.03	0.045	0.03	0.02±0.008	<0.01 mg/L	0.01mg/L
Zn	0.02	0.04	0.05	0.06	0.04	1.9	0.35±0.40	<0.086 mg/L	0.3 mg/L

*US EPA (2010)

essential insights into the aquatic ecosystem, emphasizing the importance of studying fish diversity and feeding habits for conservation and management purposes.

A study conducted by Haseeb and Yousafzai, (2023) on family Cyprinidae in River Panjkora and reported 20 species among them common species to our study were; *Schizothorax plagiostomus, Carassius auratus, Cyprinus watsoni, Barilius modestus, Cyprinus carpio, Barilius vagra, Amblypharyngodon mola, Barilius pakistanicus, Salmophasia punjabensis, Tor putitora, Rasbora daniconius, Crossocheilus diplocheilus, Labeo rohita, Garra gotyla, Labeo diplocheilus, Puntius sophore, Schizothorax esocinus, Puntius chonchonius,* and *Puntius ticto* while *Schizothorax labiatus* was not reported in my study. Another study of Wahab and Yousafzai in 2017 reported 10 species of family Cyprinidae from River Panjkora, the all of their species; *Barilius pakistanicus, Tor putitora, Barilius vagra, Garra gotyla, Crossocheilus diplocheilus, Schizothorax esocinus, Schizothorax plagiostomus, Carassius auratus* and *Cyprinus carpio* matches to our study the smaller number of species in past study were due exploration of limited area.

Eight species were reported from the Panjkora and Swat rivers at Busaq by Ullah et al. (2023). The common species are *Glyptothorax cavia, Carassius auratus, Garra gotyla, Labeo dyocheilus, Barilius pakistanicus,* and *Tor putitora*. The absence of two species, *Racoma labiate* and *Orienus plagiostomus,* is a result of floods and limited exposure area.

Comparing the present work with Khan et al., (2022) who reported 18 species, that belong to five families and 14 genera, the common species were (*Schizothorax plagiostomus*, *Racoma labiata*, *Schizothorax esocinus*, *Tor putitora*, *Garra gotyla*, *Barilius vagra*, *Puntius ticto*, *Schistura alepidota*, *Carassius auratus*, *Schistura prashari*, *Glyptothorax punjabensis, Triplophysa microps*, *Glyptothorax Sufii*, *Nangra robusta, Acanthocobitis botia*, *Channa gachua*, *Channa punctate* and *Mastacembelus armatus),* other species are not reported that maybe due to limited collection sites and time of collection.

Hasan et al., (2015) reported 25 species from river Panjkora belonging to five families in both studies 21 are common species including's; *Schizothorax esocinus, Racoma labiate, Cyprinus watsoni, Cyprinus carpio, Schizothorax plagiostomus, Tor Putitora, Barilius pakistanicus Barilius vagra, Crossocheilus diplocheilus, Barilius modestus, Garra gotyla, Schistura alepidota, Schistura prashari, Schistura macrolepis, Glyptothorax punjabensis, Triplophysa microps, Channa punctate, Channa gachua, Mastacembelus armatus Glyptothorax stocki, Glyptothorax sufii,* while 4 species i.e. *Glyptothorax naziri, Tor macrolepis*, *Ctenopharyngodon idella* and *Triplophysa naziri* are absent in our study, this is due floods, limited time and collection sites (Ali, 1993). In current study Kumrat was explored for the first time as fish collection was difficult due their dwelling nature deep in river water.

Muhammad, 2014 studied the fish fauna of River Panjkora. He reported 11 species from different collection sites (*Racoma labiata*, *Schizothorax esocinus*, *Orienus plagiostomus*, *Garra gotyla*, *Crossocheilus diplocheilus*, *Barilius pakistanicus*, *Channa punctata*, *Carassius auratus*, *Oncorhynchus mykiss*, *Glyptothorax punjabensis* and *Gagata cenia*). The absence of some species in the previous study is due to limited area studied.

Akhtar *et al*, 2014 carried out study in River Panjkora and reported 11 species. The common fishes included; *Channa punctuate, Crossocheilus diplocheilus, Schizothorax esocinus, Carassius auratus, Garra gotyla, Mastacembelus armatus, Racoma labiate* and *Glyptothorax punjabensis,* except a two species i.e. *Salmo trutta* and *Orienus plagiostomus,* their absence may be due to floods and water pollutions and also area and time of collection are the main reasons.

Perveen and Uddin (2015) reported 3 species from River Panjkora at upper Dir that belong to 2 families, and 2 genera and one unidentified species, (*Shizothorax esocinus* and *Shizothorax plagiostomus)* both species are common to our reported species. Ahmad *et al*., 2015 reported Seven fish species from River Panjkora and its tributaries which are also reported in our study as; *Racoma labiata*, *Shizothorax esocinus*, *Barilius pakistanicus, Channa punctata, Oncorhynchus mykiss* and *Crossocheilus diplocheilus*, except *Orienus plagiostomus*. In our study the only species i.e. *Oncorhynchus mykiss* is restricted to Kumrat-Kohistan areas. It becomes absent in River Panjkora below Sheringal Kohistan, because these are cold water fish.

Muhammad, *et al*., 2014 conducted study in River Panjkora at Upper Dir and reported 11 species of fish which belong to 4 orders and 4 families. The common species included; *Racoma labieta, Crossocheilus diplocheilus, Schizothorax esocinus, Gara gotyla, Carassius auratus, Gagata cenia, Barilius pakistanicus*, *Glyptothorax punjabensis*, *Oncorhynchus mykiss* and *Channa punctata,* while *Orienus plagiostomus* was not reported in our study maybe climatic changes, floods are the reason.

In our study 15 edible species were reported i.e. *Schizothorax plagiostomus, Cyprinus watsoni, Racoma labiata, Schizothorax esocinus, Cyprinus carpio, Channa punctata, Tor putitora, Puntius ticto, Channa gachua, Puntius sophore, Crossocheilus diplocheilus, Mastacembelus armatus*, *Oncorhynchus mykiss, Gara gotyla,* and *Carassius auratus.*

Current study showed that the local peoples are destroying the freshwater ecosystem, like using different kinds of blasting materials in river which cause the destruction of habitats and its race. Due to which some fish species are endangering like *Glyptothorax sufii, Glyptothorax punjabensis, Glyptothorax cavia, Glyptothorax reticulatum, Glyptothorax stocki, Schizothorax esocinus, Tor putitora, Barilius bendelinsis* and *Rita rita, Schistura curtistigma* in the study area.

The maintenance of ecosystem stability and the preservation of the general quality of the environment depend on biodiversity. According to recent studies, freshwater ecosystems are crucial to human survival because they produce fish, which is a source of food. In addition, it offers recreational opportunities and preserves significant biota, such as floating weeds. Despite the best of intentions, exotic imports have exposed native fish species to new rivals, predators, or other agents that they cannot resist (FAO, 1998). According to recent study, the introduction of exotic species was a positive move, but it has had a negative impact on local fish. For example, the introduction of brown trout to the upper Panjkora River has upset the native Schizothorax species (Akhtar et al., 2014). Various aquatic parameters like (Temperature, pH, DO, EC, Turbidity, TDS, TSS, TS, Total Hardness, Total Alkalinity, NH_3, Copper, Chromium, Zinc, Lead, Chloride, etc.) effects the ichthyofaunal diversity as reported by Khan et al. (2014). According to the findings of current study all physicochemical parameters studied fall within the safe limits of Gorchev and Ozolins (1984). Temperature fluctuations, a fundamental factor affecting fish abundance, demonstrated variations throughout the year, it ranges between 4.1ºC and 14.35ºC. Dissolved oxygen level reaching its maximum (8.5 mg/L) and its minimum (7.2 mg/L). The pH ranged from 6.7 to 7.2, falling within the optimal range for fish production, with seasonal variations attributed to changes in CO2 levels. Electrical conductivity fluctuated gradually over the study period, affected by factors such as temperature, dissolved solids, and ionic concentration ranges between 156.41 to 204.3 mg/L. Total dissolved solids, comprising various salts, remained within the acceptable limits (55 to 144.9 mg/L), as set by (Pakistan, 2000) as (150mg/L). Alkalinity values, reflecting the presence of carbonates and bicarbonates, ranged from 43 to 150 mg/L. Hardness, primarily due to calcium and magnesium ions, ranged from 25 to 101 mg/L. Alkali metal chloride ions fluctuated from 10.3 to 20.46 mg/L. Ammonia concentrations, a crucial parameter indicating organic pollution, with mean of 0.46 mg/L. In the current study, heavy metals such as Cr, Cu, Co, Ni, Pb and Zn were found in varying amounts ranging from 0.01 to 0.5, 0.004 to 0.08, 0 to 0.2, 0 to 0.09, 0 to 0.05 and 0.02 to 1.9 mg/L, respectively.

Furthermore, the study analyzed the food and feeding habits of all species in River Panjkora. Their main food items included were detritus, insects, insect larvae, small fish, seeds, mud, Chironomus larvae and caddis fly larvae, nymphs of dragonfly, mayfly, daphnia and body parts of dead animals. Research on feeding habits supports findings from studies by Jan et al. (2018), Kausar and Salim (2006), Hajisamae et al. (2003), and Piska et al. (1991). Insects, diatoms, algae, and planktons have all been found in guts of fish and the surrounding water.

Conclusions

A total 38 species (*Cyprinus carpio*, *Cyprinus watsoni, Carassius auratus, Schizothorax esocinus, Schizothorax plagiostomus, Puntius sophore, Racoma labieta, Tor putitora, Gara gotyla, Puntius ticto, Labeo rohita, Puntius chonchonius, Labeo diplocheilus, Crossocheilus diplocheilus, Barilius pakistanicus, Barilius vagra, Amblypharangodon mola, Barilius modestus, Salmophasia punjabensis, Rasbora danisconius, Barilius bendelinsis*, *Gagata cenia, Glyptothorax punjabensis, Glyptothorax cavia, Glyptothorax stocki, Glyptosternon reticulatum, Glyptothorax sufii, Nangra robusta*, *Schistura curtistigma, Triplophysa microps, Acanthocobitis botia, Schistura prashari, Schistura alepidota, Rita rita, Channa punctate*, *Channa gachua, Oncorhynhus mykiss* and *Mastacembelus armatus*) were reported in current study out of which 3 species; *Gagat cenia, Rita rita* and *Barilius bendelinsis* were reported for the first time from River Panjkora. The main food items reported in fish guts included; insects, insect larvae, small fish, detritus, algae, mud, Chironomus larvae, caddis fly larvae, nymphs of dragonfly, mayfly, daphnia and body parts of dead animals. Macroinvertebrates collected from river water included; Dams fly, water beetle, mayfly, stonefly, dragonfly, water scorpion, water stirder, water bugs, water boatman and Riffle beetle. Aquatic algae included; *Hydrodictyon reticulatum*, *Ulothrix aequalis, Volvox globator, Volvox tertius* and *Spirogyra aequinocitialis.* Aquatic angiosperms included; *Potamogeton pectinatus, Potamogeton natans, Potamogeton crispus, Vallisneria spiralis, Hydrilla verticellata, Marsilea minuta.* According to the findings of current study all physicochemical parameters fall within the safe limits of (Gorchev and Ozolins, 1984). The diversity can be improved by monitoring fish fauna regularly, preserving water quality and adding new stoking fish to the river. Reducing fish catch pressure, fishing during breeding season and catching non marketable size fish should be avoided for enhancing fish fauna of the river. Further, disturbing the natural breeding areas like sand and gravel from banks of the river may also be avoided. Illegal fishing like use of dynamite blasts, electrofishing and chemical fishing must be strictly banned.

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