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ORIGINAL ARTICLE

Exploring the fish biodiversity, its morphometric measurements, and biological diversity indices at Shizaka streams, Tehsil Shewa, North Waziristan, Pakistan

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Abstract
Biodiversity has a crucial role in maintaining a stable ecosystem. It is associated with biotic and abiotic factors that vary in a geographic region. The fish were collected using different fishing equipment, including simple fishing rods, simple hooks, scoop nets, and drag nets. The species identification was made by studying meristic and morphometric characters. During this study, 12 fish species were collected and identified. These were *Cyprinion watsoni, Tor macrolepis, Naziritor zhobensis, Barilius pakistanicus, B. bendelisis, Crossocheilus diplocheilus, Garra gotyla, Botia birdi, Glyptothorax sufii, G. punjabensis, G. stocki* and *G. naziri*. The reported species belong to two orders; Cypriniformes and Siluriformes and three families; Cyprinidae, Sisoridae, and Cobitidae. Cyprinidae was the richest family represented by seven species whereas Sisoridae was embodied by four species and Cobitidae by a single species. *B. birdi* had not been previously reported from other water bodies in North Waziristan. *T. macrolepis* was also highly abundant and served as a primary food source in this region. It is recommended to impose a complete ban on illegal fishing and implement proper stocking in these streams, as this could play a key role in improving nutrition and boosting the local economy.

Keywords: Ichthyofauna, River Kurram, *Tor macrolepis*, Aquaculture, Cyprinidae

INTRODUCTION

The variety of species in an ecosystem or biosphere is known as Biodiversity (Ullah et al. 2018) which plays a key role in the maintenance of the ecosystem (Ibrahim et al. 2020). Ichthyodiversity is the study of fish biodiversity, which includes the variety of fish species found in specific regions (Shahzad et al. 2021). Fish represent the most diverse group of vertebrates, with 33,554 reported species as of 2017 (Nolte 2020). Approximately 56.6% of fish species are marine, 42.7% are freshwater, and the remaining 0.7% are diadromous (Shahzad et al. 2021).

Fish studies are highly significant in various aspects of animal research such as ecological significance, biomedical research, nutritional importance, and evolutionary and behavioral studies (Khan & Hasan 2011). In aquatic ecosystems, fish are a critical component and contribute substantially to a nation's economy, as they are the dietary staple for many populations (Akhtar et al. 2015). Regarding nutritional and medicinal value, fish remains one of the most essential food sources (Ullah & Ahmad 2014). Fish is a unique food source, rich in important minerals such as zinc, potassium, phosphorous, iron, and iodine as well as vitamins A and D and all necessary amino acids. It also contains a small amount of carbohydrates and polyunsaturated fatty acids which significantly prevent heart diseases (Sanderson et al. 2002) and have antiarrhythmic properties (Givens et al. 2006). Fish fat is more energetic than other animal fats (Brasky et al. 2010). Medicinally, fish oil prevents miscarriage (Khawaja et al. 2012), and high blood pressure during pregnancy (Dunstan et al. 2008). Millions of people worldwide are also employed in the fisheries sector (Ullah et al. 2018). Biodiversity plays a crucial role in how living systems adapt to environmental changes, support ecosystem functions, and deliver the goods and services essential for human well-being. Additionally, biodiversity holds cultural significance as it is intricately connected to the cultural identity of human societies (Hiddink et al. 2008).

Morphological traits are generally used for fish identification (Seçer et al. 2020). The pattern of

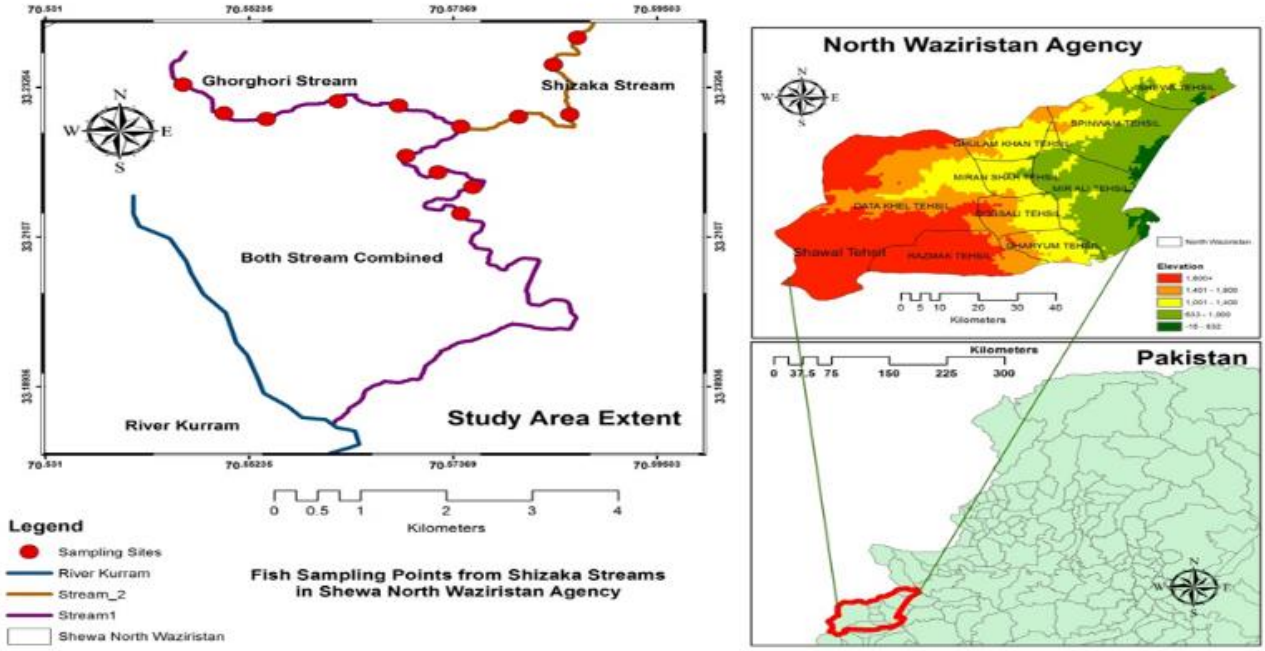

Fig.1. Map showing study area and Shizaka streams (Shizaka stream and Ghorghori stream) as tributaries of River Kurram.

relationship of various morphometric measurements among each other changes with age. The constant ratios of morphometric measurements are useful in identification while variable ratios are not helpful. Environmental issues can also change different parts of the body (Ullah et al. 2014; Rahman et al. 2021; Mouludi-Saleh et al. 2020). The well-being and health status of individuals and differences between their separate unit stocks within the same species can be accessed through these studies. Moreover, the length-to-length ratios can also be used for comparative growth studies of fishes (Hossain 2010).

Various studies have been conducted on fish diversity throughout the world. In Pakistan, researchers have made significant contributions to the Ichthyofauna (Ibrahim et al. 2020, Shahzad et al. 2021; Rahman et al. 2021). However, no research has yet been conducted on the Ichthyofauna of Shizaka streams, Tehsil Shewa, North Waziristan, Pakistan. Therefore, the present study aims to explore the Ichthyofauna diversity of Shizaka streams and document the species found in this remote and unexplored area, contributing to the checklist of fish species in Pakistan.

MATERIALS AND METHODS

Sampling area: According to Ahmad and Hasan (2020), North Waziristan (NW) is bordered to the North by District Hangu, Afghanistan and Kurram Agency; to the East by Frontier Regions of Bannu, adjoining the districts of Karak and Bannu; and to the South and West by South Waziristan and Afghanistan respectively. NW covers an area of 4,707 square kilometers. Latitude and Longitude of NW are 33.0000°North and 70.0000° east, respectively. Tehsil Shewa is located along the Eastern boundary of NW, with coordinates of 33.253310° North and 70.494160° east, respectively. The research area, Shizaka (part of tehsil Shewa), is located at 33.252627° North and 70.623229° East. The Shizaka streams are tributaries of River Kurram, joining it at Zarwam in Sub-Division Wazir Bannu (SDW Bannu) with coordinates of 33.184413° North and 70.562125° East (Fig. 1).

Fish sampling: The fish collection was carried out once a month (between the 15th -20th of every month) from both Shizaka stream and Ghorghori stream of Tehsil Shewa by using different types of fishing equipment including simple fishing rods, simple hooks, scoop nets, drag nets, etc. A total of 296 fish specimens were collected in this study (Table 3).

Table 1. Total reported fish species from Shizaka streams.

S. No.	Order	Family	Species	Local Names
1	Cypriniformes	Cyprinidae	*Cyprinion watsoni*	Sabzug
2			*Tor macrolepis*	Speen patakhy Mahasher
3			*Naziritor zhobensis*	Zhobi Mahasher
4			*Barilius pakistanicus*	Pepal
5			*Barilius bendelisis*	Pepal
6			*Crossocheilus diplocheilus*	Butten
7			*Garra gotyla*	Kanesatt
8		Cobitidae	*Botia birdi*	Loaches
9	Siluriformes	Sisoridae	*Glyptothorax sufii*	Sulamani
10			*Glyptothorax punjabensis*	Sulamani
11			*Glyptothorax stocki*	Sulamani
12			*Glytothorax naziri*	Sulamani

After capturing, the fish were killed by hitting their heads with a blunt rod. The small fish specimens were preserved in 10% formalin. In the case of larger specimens, preservation was done after intraperitoneal injection of 5% formalin.

Labelling: The specimens were kept in bottles and labelled. The collected specimens were labelled with various information like the original locality of collection, date of collection, name of the collector, etc.

Laboratory work: The laboratory work was performed in the Department of Zoology, University of Peshawar Khyber Pakhtunkhwa, Pakistan. Using forceps, the specimens were carefully taken out of the bottles and placed in petri dishes. Before identification, the fish specimens were thoroughly washed. Surgical gloves were worn while handling the fish in the laboratory. The specimens were measured for their meristic and morphometric characteristics, and identification was conducted up to the species level. Various tools were employed, including forceps, counting needles, petri dishes, a magnifying glass, a dissection microscope, and a ruler. The magnifying glass and dissection microscope were used to count lateral line scales and fin rays, while morphometric measurements were taken using a ruler (Table 3). Several standard keys and research papers were used for the identification like fishes of the Punjab, Pakistan (Mirza & Sandhu 2007), Freshwater fishes of the India (Jayaram 1999), and (Omer 2017).

Data analysis: For the calculation of the Shannon diversity index (H′) and Simpson diversity index (D), the data on the abundance and occurrence of various species was used (Magurran 2013). Statistical analysis was performed using Microsoft Excel 2010 and GraphPad Prism 8.0.

RESULTS

Total reported species: In the current study, the total collected specimens comprised 12 species (Table 1): *Cyprinion watsoni*, *Tor macrolepis*. *Naziritor zhobensis*, *Barilius pakistanicus*, *B. bendelisis*, *Crossocheilus diplocheilus*, *Garra gotyla*, *Botia birdi*, *Glyptothorax sufii*, *G. punjabensis*, *G. stocki* and *G. naziri.* All the recorded species belonged to two orders (Cypriniformes and Siluriformes), three families (Cyprinidae, Cobitidae, and Sisoridae), and seven genera. Morphometric measurements of each fish species are given in Table 2.

Cyprinion watsoni was the most abundant species represented by 132 specimens (44.745%) while *Naziritor zhobensis* was the poorest with one specimen only (0.33%) as shown in Table 3.

Biological diversity indices: The order Cypriniformes was numerically the most dominant, comprising 66.66% of the total collected species while Siluriformes accounted for 33.33%. Among the families, Cyprinidae represented 58.33%, Cobitidae 8.33%, and Sisoridae 33.33% of the total species collected. Based on the fish collection, May was the richest month, contributing 30.16% (89 specimens), followed by October with 21.35% (63 specimens),

Table 2. Morphometric measurements (cm) of reported species from Shizaka streams.

S. No.	Species	TL	FL	SL	SnL	HL	ED	CPL	BD
1	*C. watsoni*	12.9	11.8	10.6	0.9	2.0	0.5	1.6	3.0
2	*T. macrolepis*	17.4	15.0	13.5	1.3	3.0	0.7	2.3	3.6
3	*N. zhobensis*	15.0	13.4	11.6	1.0	2.4	0.5	1.8	2.8
4	*B. pakistanicus*	8.5	7.4	6.5	0.4	1.1	0.4	1.6	1.4
5	*B. bendelisis*	5.4	4.9	4.3	0.3	0.9	0.4	1.7	0.8
6	*C. diplocheilus*	12.4	10.9	9.7	0.9	1.8	0.4	2.1	2.3
7	*G. gotyla*	17.2	15.6	14.2	1.7	3.2	0.5	2.8	2.9
8	*B.birdi*	15.5	13.5	12.5	2.0	3.2	0.3	1.7	3.2
9	*G. sufii*	8.7	7.5	6.9	0.9	1.8	0.2	1.4	1.3
10	*G. punjabensis*	9.3	8.3	7.2	0.9	2.0	0.2	1.5	1.5
11	*G. stocki*	9.9	8.9	8.7	1.0	2.1	0.2	1.7	1.8
12	*G. naziri*	9.3	8.3	7.5	0.9	1.8	0.2	1.4	1.7

TL= Total length, SL= Standard length, FL= Forked length, SnL= Snout length, HL= Head length, ED= Eye diameter, CL= Caudal peduncle length, BD= Body depth.

Table 3. Total number of collected fish specimens from Shizaka streams.

S. No.	Fish species	February	March	April	May	October	Total	Percentage
1	*C.watsoni*	24	20	33	41	15	133	44.745
2	*T. macrolepis*	0	10	21	29	08	68	22.372
3	*N. zhobensis*	0	0	0	0	01	01	0.338
4	*B. pakistanicus*	03	07	0	11	02	23	7.796
5	*B. bendelisis*	05	01	08	05	0	19	6.440
6	*C. diplocheilus*	0	0	0	0	12	12	4.067
7	*G. gotyla*	0	0	0	0	06	06	2.033
8	*B. birdi*	0	0	0	0	01	01	0.338
9	*G. sufii*	0	0	0	0	04	04	2.033
10	*G. punjabensis*	0	0	0	0	08	08	2.711
11	*G. stocki*	0	0	0	0	14	14	4.745
12	*G. naziri*	0	0	0	0	07	07	2.372
	Total	41	36	62	80	76	296	99.99

April with 21.01% (62 specimens), March with 13.89% (41 specimens) and February with 13.55% (40 specimens) of the total catch. In terms of relative abundance for all collected specimens, the order-wise relative abundance was 88.13% (260 specimens) and 11.86% (35 specimens) for Cypriniformes and Siluriformes respectively. Family-wise relative abundance was 87.79% (259 specimens), 11.86% (35 specimens), and 0.33% (one specimen) for Cyprinidae, Sisoridae, and Cobitidae, respectively. Genus-wise relative abundance was 44.74% (132 specimens), 22.71% (67 specimens), 14.23% (42 specimens), 11.86% (35 specimens), 4.06% (12 specimens), 2.03% (six specimens), and 0.33% (one specimen) for *Cyprinion*, *Tor, Barilius*, *Glyptothorax*, *Crossocheilus*, *Garra* and *Botia*, respectively. Taxonomically, the most dominant family was

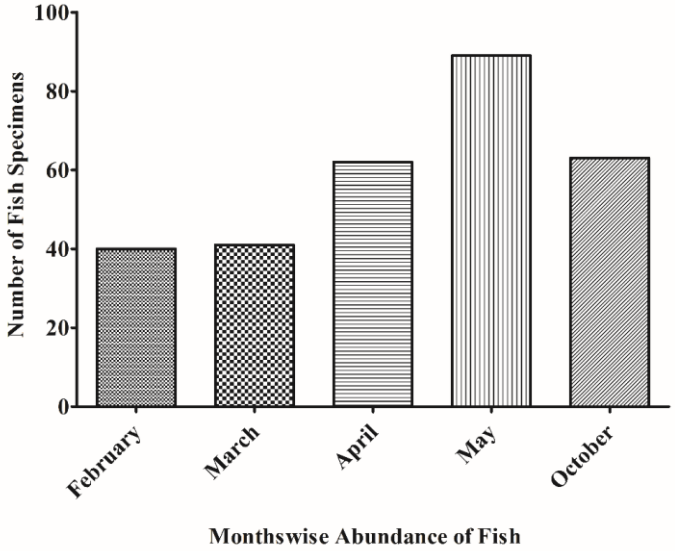

Fig. 2. Monthwise collection of the total fish specimens from Shizaka streams.

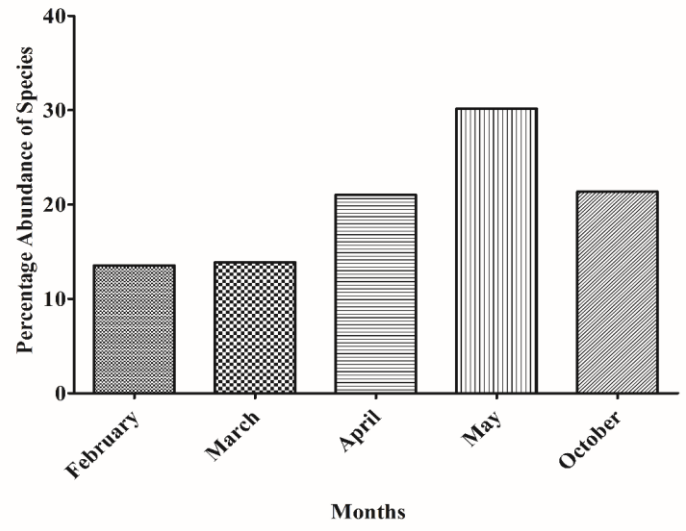

Fig.3. Monthwise percentage abundance of total reported fish species from Shizaka streams.

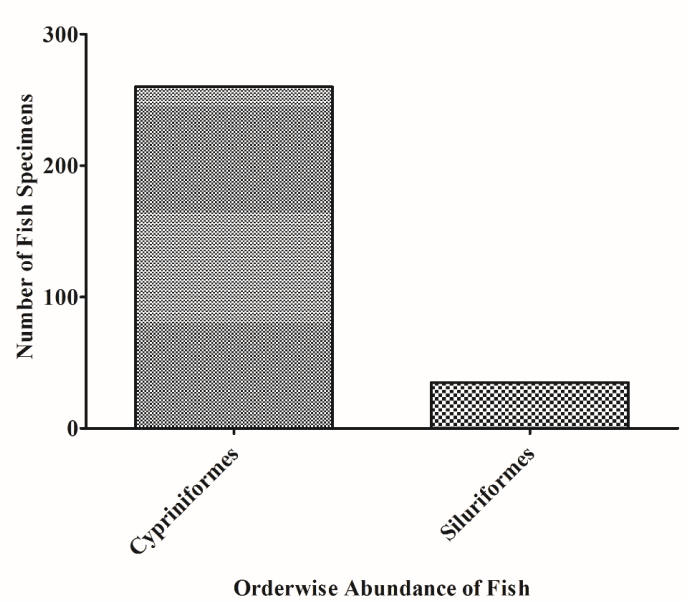

Fig.4. Orderwise diversity of the total collected fish specimens.

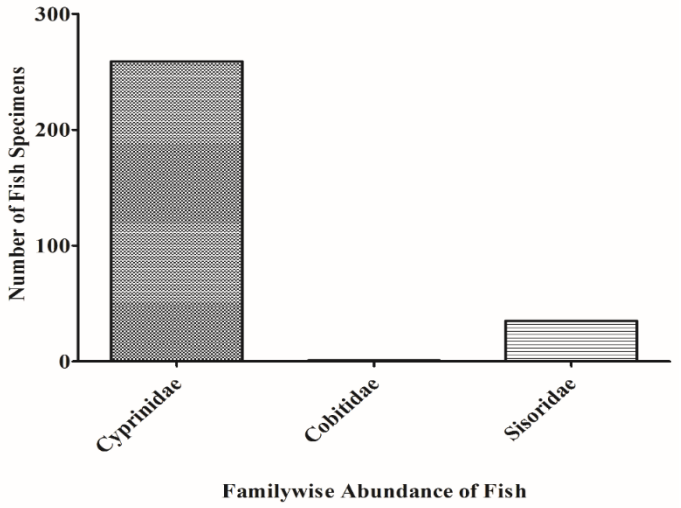

Fig.5. Familywise diversity of the total collected fish specimens.

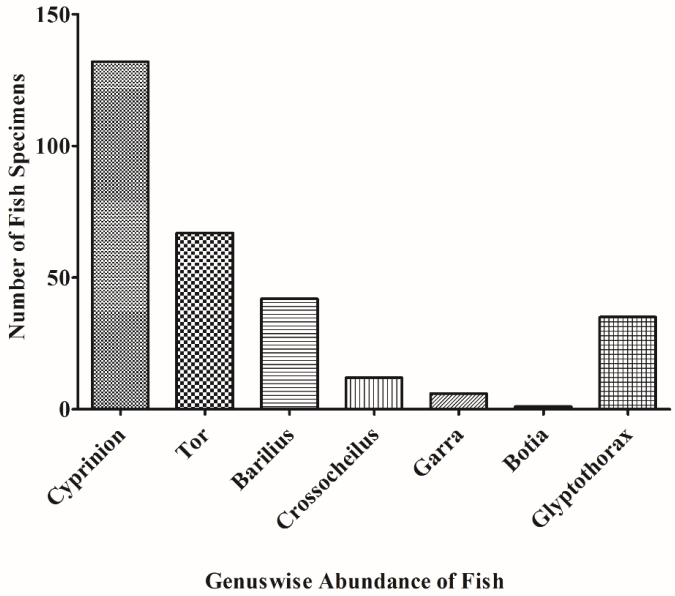

Fig.6. Genuswise diversity of the total collected fish specimens.

Cyprinidae, which included five genera and seven species. This was followed by Sisoridae, represented by one genus and four species, and Cobitidae, by one genus and one species (Figs. 2-7).

DISCUSSION AND CONCLUSION

Biological diversity plays a crucial role in maintaining ecosystems (Elmqvist et al. 2003). The fish fauna of the Shizaka streams was not highly diverse, with a Shannon's Index of 0.645, but it was evenly distributed, as indicated by a Simpson Evenness value of 3.70. The species richness of the reported species varied significantly among them. Shahjehan & Khan (1997) reported 17 species from the River Kurram in District Bannu, the primary river in the region, while Shahjehan & Khan (1998) recorded 26 species from Baran Dam, also located in District Bannu and fed by the River Kurram. Similarly, Mirza et al. (2008) documented 51 species from the River Kurram in the same district. When compared with these previous studies, it is evident that the River Kurram has much richer fish fauna than the Shizaka streams in the same

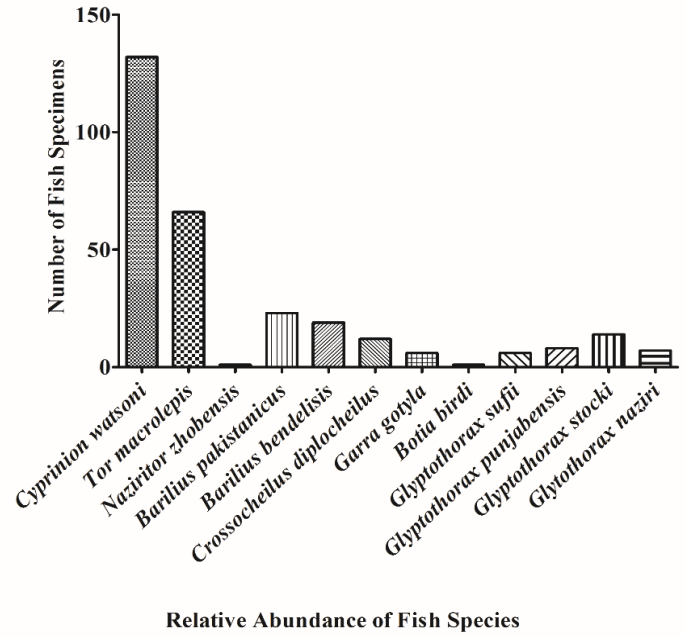

Fig.7. Relative abundance of the total reported fish species from Shizaka streams.

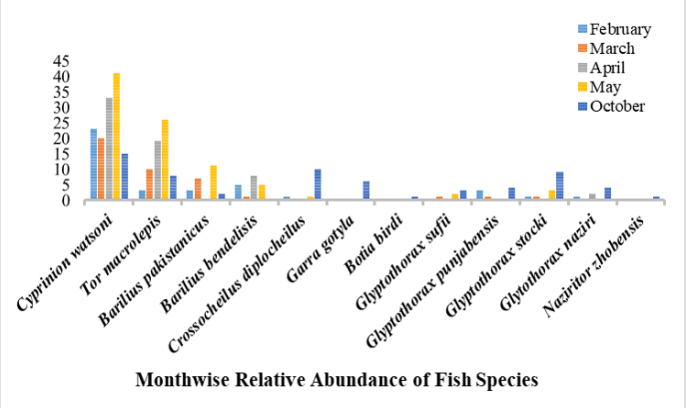

Fig.8. Monthwise relative abundance of all the fish specimens of total reported species from Shizaka streams.

area. In addition, Shizaka streams exhibit significantly lower diversity than the River Kurram.

Fish specimens were collected from different parts of these streams, with higher abundance observed upstream in certain areas. This could be attributed to factors such as reduced disturbance, greater availability of food, suitable breeding sites, favourable topography, water depth, and physico-chemical properties of water. The magnitude, timing, frequency, duration, and rate of change of hydrologic conditions are key factors of natural flow regimes, which significantly influence ecological processes in aquatic environments (Poff et al. 1997). These factors play a crucial role in shaping fish assemblage in aquatic habitats (Church 2002) and can directly affect the availability of food resources in these ecosystems (Lancaster 2000). The increased diversity of aquatic systems can often be correlated with variations in flow regimes, as these variations create opportunities for new species to establish and thrive (Mirza et al. 2011).

Although these streams are tributaries of the River Kurram, the present study reveals little similarity with the findings of Shahjehan & Khan (1997) on the River Kurram in District Bannu. None of the species reported in the present study were recorded in their research except for the genera *Tor* and *Glyptothorax,* which are common to both studies. In addition, the 27-year gap between the studies could have altered the species occurrence pattern over time.

By comparing the current study with that of Shahjehan & Khan (1998) on Baran Dam in District Bannu, both studies show slight resemblance because eleven species of the present study were absent from their report, while all the species in their report, except *Barilius bendelisis,* were not found in our study. Genera such as *Tor, Glyptothorax,* and *Barilius* were common to both studies although the species differed. In contrast, the study by Mirza et al. (2008) on the River Kurram revealed a significant resemblance. Only *Barilius bendelisis* and *Glyptothorax sufii* reported in the present study were absent from their findings, while the remaining ten species were also documented in their study. However, 41 species of their report were missing in our study. Although, all the genera were common in both studies. Shahjehan & Marwat (2001) studied the fish fauna of River Tochi (Gambila), recording 14 species. Only two species, *Glyptothorax punjabensis* and *Tor macrolepis,* were common between their study and the current one. Twelve species from their study were absent in the present study, while ten species from the present study were missing in theirs. In both studies, the genera *Tor*, *Glyptothorax,* and *Barilius* were common. Overall, a comparison of the current study with the previous works by Shahjehan & Khan (1997), Shahjehan & Khan (1998), Shahjehan & Marwat (2001), and Mirza et al. (2008) reveals that the genera *Tor*, *Glyptothorax,*

and *Barilius* are consistently common across all these studies. This indicates that the region provides suitable conditions for the growth and survival of fish belonging to these genera.

In the present study, all the identified species belonged to two orders; Cypriniformes, which was the most abundant (66.66%, Table 3, Fig. 4), followed by Siluriformes. These species were distributed among three families: Cyprinidae, Sisoridae, and Cobitidae. The family Cyprinidae was the most dominant (58.33%, Table 2, Fig. 5), consistent with findings from similar studies by Shahjehan & Khan (1997), Shahjehan & Khan (1998), Shahjehan & Marwat (2001) and Mirza et al. (2008). This was followed by the family Sisoridae, while the family Cobitidae was represented by a single species. *Cyprinion watsoni* was the most abundant species observed in this study. Notably, *Botia birdi* was the only species identified in this study that had not been previously reported from other water bodies in NW, suggesting that this species is successfully expanding its distribution in new aquatic habitats.

The results showed that the diversity of the Shizaka streams was relatively good, but it has been adversely impacted by anthropogenic activities. Further research is needed to fully document the Ichthyodiversity of this area. *Tor macrolepis,* reported as the second most abundant species in the current study, serves as a primary food source in the region. While it was once highly abundant in Pakistan, this species is now considered endangered. According to the local fishermen, it was previously common to catch fish (*Tor macrolepis)* weighing 9-10kg; however, in recent times, catching a fish even 3kg has become rare. The population of this species has declined significantly due to the intense pressure of illegal fishing. In the present research, it has been observed that there are illegal fishing practices including the use of electric shocks, chemicals, dynamite, and even firing through gun. These damaging practices have further intensified the decline in fish populations, particularly affecting species like *Tor macrolepis.*

Naziritor zhobensis was also reported during this study. This species was first reported in the River Zhob, Baluchistan, Pakistan, and is endemic to the country. While it was previously believed to be extinct, this study confirms its continued existence although in very low numbers. The species was identified in the Shizaka streams; a tributary of River Kurram, suggesting a possibility of its presence in the River Kurram due to its migratory nature. The results of this study also highlight the potential of Shizaka streams to contribute significantly to the nutrition and economy of this area if proper stocking measures are implemented. Such efforts could help re-establish fish populations and support defensible livelihood in the region.

In conclusion, twelve fish species were reported in this study, including a novel species, *Botia birdi* which had not been previously reported in the area. Additionally, *Naziritor zhobensis*, a critically endangered and endemic species of Pakistan, was recorded. The decline in key species is primarily attributed to anthropogenic activities and illegal fishing practices. The diversity and richness of these species can be preserved through conservation efforts and induced breeding programs in the future. Strict measures are recommended to mitigate illegal fishing, particularly targeting *Tor macrolepis,* which is crucial for the local ecosystem and livelihoods. Furthermore, focused conservation efforts are necessary to protect *Naziritor zhobensis,* and prevent its extinction.

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مقاله کامل

بررسی تنوع زیستی ماهی، ریخت‌سنجی آن و شاخص‌های تنوع زیستی در نهرهای شیزاکا، تهصیل شوا، وزیرستان شمالی، پاکستان

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چکیده: تنوع زیستی نقش حیاتی در حفظ یک اکوسیستم پایدار دارد. این تنوع با عوامل زیستی و غیرزیستی مرتبط است که در یک منطقه جغرافیایی متفاوت هستند. ماهی‌ها با استفاده از تجهیزات ماهیگیری مختلف، از جمله چوب ماهیگیری ساده، قلاب ساده، ساچوک و تورهای ماهیگیری جمع‌آوری شدند. شناسایی گونه‌ها با مطالعه ویژگی‌های شمارشی و ریخت‌سنجی انجام شد. در طول این مطالعه، ۱۲ گونه ماهی جمع‌آوری و شناسایی شدند. که این گونه‌ها شامل: *Cyprinion watsoni, Tor macrolepis, Naziritor zhobensis, Barilius pakistanicus, B. bendelisis, Crossocheilus diplocheilus, Garra gotyla, Botia birdi, Glyptothorax sufii, G. punjabensis, G. stocki* and *G. naziri*. بودند. گونه‌های گزارش‌شده متعلق به دو راسته Cypriniformes و Siluriformes و سه خانواده Cyprinidae، Sisoridae و Cobitidae هستند. Cyprinidae با هفت گونه، غنی‌ترین خانواده بود، در حالی‌که Sisoridae با چهار گونه و Cobitidae با یک گونه در این خانواده قرار داشتند. *B. birdi* قبلاً از سایر اکوسیستم‌های آبی وزیرستان شمالی گزارش نشده بود. *T. macrolepis* نیز بسیار فراوان بود و به‌عنوان منبع غذایی اصلی در این منطقه مورد استفاده قرار می‌گرفت. توصیه می‌شود ممنوعیت کامل ماهیگیری غیرقانونی اعمال شود و ذخیره‌سازی مناسب در این نهرها اجرا شود، زیرا این امر می‌تواند نقش کلیدی در بهبود تغذیه و تقویت اقتصاد محلی داشته باشد.

کلمات‌کلیدی: فون ماهیان، رودخانه کوروم، *Tor macrolepis*، آبزی‌پروری، کپورماهی‌شکلان