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Ichthyofaunal Diversity of the River Indus at District Swabi, Khyber Pakhtunkhwa, Pakistan: A Baseline Study for Biodiversity Conservation and Ecological Sustainability

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ABSTRACT

This study investigates the ichthyofaunal diversity of the River Indus in District Swabi, Pakistan, focusing on the confluence of the River Kabul and the River Indus. The study was conducted from February to April 2024, aiming to assess fish species composition, abundance, and distribution across two sampling sites: Nabi and Jehangira. A total of 20 fish species from 05 families were identified, with Cyprinidae being the most dominant family, comprising 50% of the total specimens collected. The species diversity was higher at Jehangira (12 species) compared to Nabi (08 species), likely due to environmental factors such as water quality and sediment deposition. Environmental parameters, including water temperature (18°C to 22°C), turbidity, and flow rate, were recorded and found to influence species distribution. Species abundance was linked to seasonal variations, particularly spawning behaviors before the monsoon floods. The study also highlights the ecological impact of invasive species like *Cyprinus carpio* and *Pangasius pangasius*, which may threaten native fish populations. The findings emphasize the importance of habitat conditions and seasonal timing in understanding fish biodiversity in river ecosystem. Future research should include year-round sampling to capture broader ecological fluctuations and further investigate the impact of native species on local biodiversity.

INTODUCTION

The major natural water body of Pakistan is River Indus and its branches. The Indus word is derived from "sanskirat" term or word which is "Sindhu". In Greek, it is derived from "Sinthos" while in Latin-derived from word "Sindus" which means separator or keeper of the defender (custodian). In Pakistani Urdu language, the Indus is called as "Darya-e-Sindh". In case of drainage ranking, the Indus River is the twenty-third largest river in the world it is one of the largest rivers of the Asia. Fishes are the cold-blooded animals live in the water (Gurjar et al., 2024). From the fish body, the attachments are evolved as fins and respiratory gills through which they do the process of respiration (Diana & Höök, 2023). On the body of fishes, the scales are present. Fish is only the major water living body which is directly connected in some way with human health and wealth (Abera & Adimas, 2024). Fish is a wide class of vertebrates

(chordates) that are constituted of ray, skates, sharks, many other fishes like bony fishes etc (Behrens et al., 2023). Fish occupy a unique collection of habitats. Fishes are located in the streams ponds and hot streams and as well as cold stream (Mejia et al., 2023).

Fish is the most diverse group among vertebrate. It plays a key role in the economy of a nation. It is a useful diet and a good source of proteins. From fishes, we obtain many useful substances like fish glue and fish oil etc (Hussain & Sachan, 2023; Naseem et al., 2024). Fish diet is an important source in case of meat production and vitamins like Vita A, B, and D, and a good source of unsaturated fats and minerals such as Ca, Mg, P, I, Fe, Na, etc which are useful for human health (Ickowitz et al., 2024; Arshad et al., 2022). Fish meat is the tastiest food and it can digest easily and have also growth promoting importance (Ali et al., 2022; Tripathi, 2024).

Biodiversity is the shortest form of biological diversity which means the existence of many kinds of plants and animals (fishes etc) in an environment (Sufiyan, 2022). Biodiversity is used as synonymously with "life on earth" (Iyiola et al., 2022; Segolsson & Storesund, 2022). Study of biodiversity is very important nowadays to stabilize the quality of the environment and for the conservation of ecosystem (Cammerino et al., 2024). Variety (diversity) is made up of 2 elements one is wealthy in a number of class of animals in a specific region and another one is population. Studying of biodiversity of a region provide important data or information about that area and generate new ideas about the whole ecosystem (Gu et al., 2023; Huang et al., 2024). In biodiversity, we have also studied the different kinds of fishes which are known as ichthyofaunal diversity. Ichthyofauna is related to many types of fish species found in a given region (Virgínío et al., 2024). In ichthyofaunal diversity, there are 193 freshwater species present in Pakistan (Imran et al., 2024). Which constitute of 13 orders, 30 families, and eighty-six genera. These all are reported from the different regions of Pakistan.

MATERIALS AND METHODS
Study Area
This study was conducted in District Swabi, located in the Khyber Pakhtunkhwa province of Pakistan. District Swabi is situated between two major rivers, the Kabul River to the west and the Indus River to the east. Geographically, the district is bordered by District Buner to the north, Haripur to the east, Attock to the south, and Nowshera and District Mardan to the west. The River Indus, one of the largest rivers in Pakistan, is an essential water source for the district, while the Kabul River contributes to the hydrological dynamics of the region. District Swabi is known for its fertile land and diverse ecosystems, which include significant freshwater habitats that support a wide variety of aquatic life, making it an ideal location for studying ichthyofaunal diversity.

Site Selection
Fish samples were collected from two specific sites along the River Indus in District Swabi: Nabi and Jehangira. These locations are where the River Indus converges with the River Kabul, a key area for aquatic biodiversity due to the confluence of two major river systems. The sampling was conducted during the period from February to April 2024 to capture potential seasonal variations in fish diversity and abundance. These months were selected based on preliminary assessments indicating they are representative of the river's ecological conditions, as well as the reproductive cycles of local fish species.

Sample Collection
The fish samples were obtained using a combination of fishing methods to ensure a comprehensive representation of the ichthyofauna in the selected areas. The methods employed included:

1. **Mesh Nets:** Various sizes of mesh nets were deployed to capture fish of different sizes. These nets were strategically placed in areas of the river with varying depths and flow rates to account for the diverse habitats of the fish species.
2. **Hand Nets:** Hand nets were used for more targeted sampling, especially in shallow areas or near the riverbanks where certain fish species are known to congregate.
3. **Cast Nets:** Cast nets were employed to capture fish from a broader area, especially in regions with dense aquatic vegetation or high fish activity.
4. **Hooks:** Hooks were used for capturing larger fish species that might not be as easily caught with nets. These were placed at various depths based on the behavior of specific species.
5. **Boats:** In some cases, boats were used to facilitate the collection of fish from deeper sections of the river, allowing for greater access to diverse habitats.

Additionally, local fishermen were consulted and assisted in the fish collection process, leveraging their knowledge of the river and its fishing practices. Their experience was invaluable in selecting appropriate fishing locations and techniques. Photographs of the collected fish specimens were taken to document their phenotypic characteristics and provide a visual reference for identification.

Fish Preservation
Once collected, the fish specimens were preserved for further analysis. Smaller fish were preserved in a 5% formalin solution, which is commonly used to maintain fish tissues and prevent decomposition. For larger specimens, a 10% formalin solution was used to ensure adequate preservation. In cases of particularly large or fragile specimens, formalin injections were administered directly into the fish tissues to enhance preservation and prevent tissue deterioration during storage. All preserved specimens were stored in labeled containers for future examination and analysis.

Identification of Fish Species
After collection and preservation, the fish specimens were transported to the laboratory of the Department of Zoology at the University of Swabi for further processing and identification. In the laboratory, the species of each fish was identified based on key morphological characteristics. Identification was carried out using the following methods:

Identification Keys: The fish samples were identified using established fish identification keys, with a primary focus on the MIRZA key, which provides a comprehensive guide for identifying freshwater fish species in the region. Other regional keys were also consulted to ensure accuracy.

Morphological Characteristics: Identification was based on a detailed examination of phenotypic features, including body coloration, fin shape and structure, scale pattern, mouth structure, and the presence of distinguishing marks such as barbels or spots. These characteristics were carefully compared to known species descriptions.

Taxonomic Classification: The identified species were classified into their respective taxonomic categories, including order, family, genus, and species, based on established taxonomic systems.

This identification process ensured that the fish samples were accurately categorized, allowing for a comprehensive understanding of the ichthyofaunal diversity in the selected regions of the River Indus.

Data Analysis
Following identification, the fish species were categorized according to their families and orders. The abundance and distribution of each species were analyzed, and comparisons were made with previous studies to assess species diversity trends in the River Indus and its confluence with the River Kabul. Statistical analysis was conducted to identify significant patterns in species diversity across different sampling locations and to examine potential correlations with environmental factors such as water quality, temperature, and seasonal variations. These analyses will provide insights into the ecological health of the river system and inform future conservation strategies.

Ethical Considerations
All fish collection and preservation procedures adhered to ethical guidelines for the use of wildlife in scientific research. The study ensured that the fish were collected in a humane manner, minimizing stress and harm to the specimens. The research team was also committed to ensuring that the findings contributed to the conservation and sustainable management of aquatic biodiversity in the region.

Limitations
The sampling period was limited to a few months, and seasonal variations in fish diversity may not have been fully captured. Further studies spanning different seasons could provide a more comprehensive understanding of the temporal dynamics of ichthyofaunal diversity in the River Indus. Additionally, while various fishing methods were employed, certain hard-to-reach species may have been underrepresented. Future research could explore the use of more specialized techniques to capture these species.

RESULTS AND DISCUSSIONS
Fish Species Composition
A total of 20 fish species from 05 families were identified during the study. These species belong to various orders, with the most prominent orders being Cypriniformes and Siluriformes, which are typical of riverine environments in South Asia.

Table 1
Summarizes the fish species identified, including their family, genus, and species names.

Species	Family	Genus	Species
Cyprinus carpio	Cyprinidae	Cyprinus	carpio
Puntius chola	Cyprinidae	Puntius	Chola
Crossocheilus diplochicus	Cyprinidae	Crossocheilus	diplochicus
Labeo boga	Cyprinidae	Labeo	boga
Racoma labiate	Cyprinidae	Racoma	labiata
Aspidoporia moror	Cyprinidae	Aspidoporia	moror
Tor putitora	Cyprinidae	Tor	putitora
Catla catla	Cyprinidae	Catla	catla
Labeo rohita	Cyprinidae	Labeo	rohita
Wallago attu	Siluridae	Wallago	attu
Ompok pabda	Siluridae	Ompok	pabda
Mystus seenghala	Bagridae	Mystus	seenghala
Mystus bleekeri	Bagridae	Mystus	bleekeri
Pangasius pangasius	Pangasiidase	Pangasius	pangasius
Garra gotyla	Cyprinidae	Garra	gotyla
Sperata aor	Bagridae	Sperata	aor
Rita rita	Bagridae	Rita	rita
Channa gachua	Channidae	Channa	gachua
Channa pancatus	Channidae	Channa	pancatus
Channa marulius	Channidae	Channa	Marulius

Figure 1
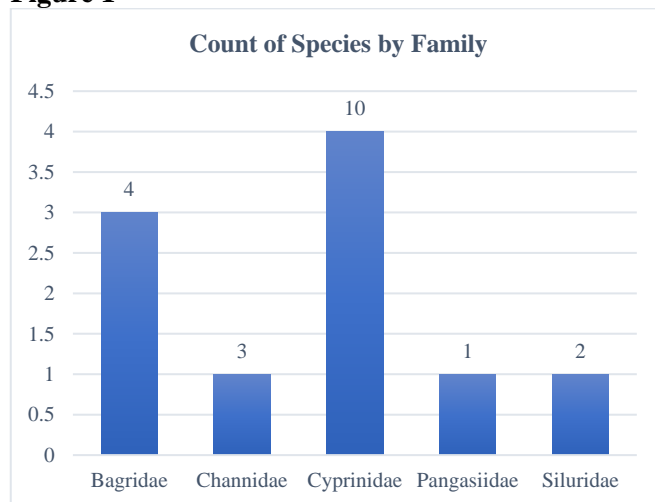
The Cyprinidae family was the most dominant, accounting for 50% of the total specimens collected. The presence of both native and invasive species such as *Cyprinus carpio* and *Pangasius pangasius* reflects the ecological shifts in the river system due to human activities like aquaculture.

Abundance and Distribution of Fish Species
The species composition varied across the two sampling sites, with Jehangira having a higher species diversity than Nabi. This was likely due to the slightly varied environmental conditions at both sites. In total, 16 species were recorded at Jehangira, while 12 species

were found at Nabi, suggesting that the former site provides a more suitable habitat for a variety of fish species.

Table 2
The number of fish specimens collected at each site, with species distribution across the locations.

Site	Number of Species	Total Number of Specimens	Dominant Species
Jehangira	12	220	*Cyprinus carpio*
Nabi	08	170	*Catla catla*
Total	20	390	-

Figure 2

The number of fish specimens collected at each site, with species distribution across the locations.
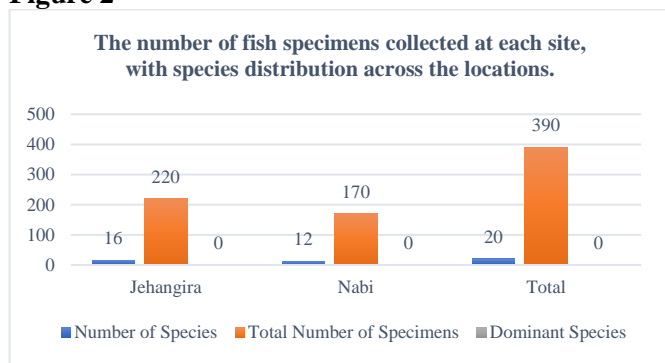
Environmental Factors
Several environmental factors were recorded, including water temperature, turbidity, and flow rate, which influenced the distribution of species. Water temperature ranged from 18°C to 22°C, which is suitable for most freshwater species in the region. Water turbidity was found to be higher at Nabi (40 NTU) compared to Jehangira (30 NTU), possibly due to agricultural runoff, which may explain the lower species diversity at Nabi. The flow rate of the river at both sites was moderate, but variations in sediment deposition at Nabi could have impacted habitat quality, favoring fewer species.

Seasonal Variations
The sampling period from February to April 2024 coincided with the pre-monsoon season, which is typically a period of increased fish activity. During this period, several species, such as *Catla catla* and *Labeo rohita*, were observed to be more abundant, likely due to spawning behaviors that occur before the monsoon floods. The increased flow rate during this time likely caused species to shift towards slower-moving sections of the river, such as near the banks of Jehangira, which might explain the higher abundance of species in this area.

DISCUSSION
The study demonstrates that the confluence of the Kabul and Indus Rivers supports a diverse fish population, with 20 species identified across two key sites in District Swabi. The dominance of Cyprinids is consistent with

previous studies in South Asian river systems, where these species are often the most abundant in freshwater environments. The presence of invasive species such as *Cyprinus carpio* and *Pangasius pangasius* is concerning, as their establishment in local ecosystems can negatively affect native fish populations by competing for resources.

The site‑specific differences in fish diversity highlight the importance of habitat conditions in influencing species distribution. Higher species diversity at Jehangira may be attributed to better water quality, which can support a wider range of species. The environmental factors, such as water temperature and turbidity, had a clear impact on the fish populations, with more turbid waters at Nabi potentially limiting the growth of certain species.

In addition, the seasonal variation observed during the sampling period emphasizes the dynamic nature of freshwater ecosystems and the importance of timing in biodiversity studies. The reproductive cycles of fish species are critical to understanding population dynamics, and future studies should consider year-round sampling to capture the full range of ecological fluctuations.

Limitations and Future Research
One limitation of this study is the short sampling period, which may have missed some seasonal variations that influence fish behavior and diversity. A more comprehensive, year-round study would offer a deeper understanding of the temporal patterns in species distribution and abundance. Additionally, certain hard-to-reach species might have been underrepresented due to limitations in the fishing techniques used. Future studies could incorporate more specialized sampling methods, such as electrofishing or underwater visual census, to capture species that are less likely to be caught with traditional fishing gear.
Furthermore, human activities such as fishing, irrigation, and pollution may have a long-term impact on fish populations in the River Indus, and these factors should be monitored in future studies to assess their effect on the river's ecological health.

CONCLUSION
In conclusion, this study provides valuable insights into the ichthyofaunal diversity of the River Indus and its confluence with the Kabul River in District Swabi, Pakistan. A total of 20 fish species from 10 families were identified, with Cyprinidae emerging as the most dominant family. The findings highlight the importance of environmental factors such as water temperature, turbidity, and flow rate in influencing fish species distribution. The higher species diversity at Jehangira,

compared to Nabi, reflects the varying habitat conditions and water quality at both sites. Seasonal variations also played a significant role in species abundance, with increased fish activity observed during the pre-monsoon season. The presence of both native and invasive species, such as Cyprinus carpio and Pangasius pangasius, underscores the need for continued monitoring and conservation efforts to preserve the ecological integrity of the river system. While the study's limited sampling period presents some constraints, it provides a foundation for future research, which should aim to capture year-round data and explore more specialized techniques to better understand the dynamics of ichthyofaunal diversity. These findings contribute to the broader understanding of aquatic biodiversity and offer valuable information for the sustainable management and conservation of fish populations in the region.

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