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Fish Biodiversity of the Indus River and Monthly Variations of Physico-chemical Parameters at Ghazi Ghat, Dera Ghazi Khan, Pakistan

Muhammad Hadi[1], Muhammad Luqman Tauhidi[1]*, Aqsa Khan[1], Saveera Basheer[1], Rabia Noureen[1], Innayat Ullah Malik[1], Ayesha Zahid[2], Meraj Younis[3]

[1] Department of Zoology, Ghazi University, Dera Ghazi Khan, Pakistan
[2] Institute of Zoology, University of the Punjab, Lahore, Pakistan
[3] Department of Zoology, GCU, Faisalabad
*Corresponding author: luqmantauhidi@gmail.com

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Abstract

Fish communities are highly sensitive to fluctuations in aquatic environmental conditions; consequently, variations in physico-chemical parameters directly influence local fish diversity and abundance. The present study was conducted in natural lentic water bodies adjacent to the Indus River at Ghazi Ghat (30°3′48″ N, 70°48′51″ E), Dera Ghazi Khan, Pakistan. Physico-chemical parameters and fish diversity, including IUCN conservation status, were assessed monthly from March 2024 to February 2025 (excluding the closed season of June–August). A total of 23 fish species belonging to 18 genera and 11 families were recorded. Dominant species included *Gudusia chapra* (14.18 %), *Oreochromis mossambicus* (10.78 %), *Labeo rohita* (10.39 %), *Securicula gora* (10.11 %) and *Catla catla* (8.83 %). Family Cyprinidae contributed the largest share of species richness. Measured parameters (water temperature, light penetration, TDS, pH, dissolved oxygen, free CO_2, carbonate, bicarbonate, total alkalinity, total hardness, electrical conductivity, Ca^{2+}, Mg^{2+}, Na^+ and Cl^-) generally remained within ranges suitable for freshwater fish. Shannon–Wiener diversity ($H' = 2.73$) and Margalef's richness ($d = 2.49$) indicated moderate diversity. The findings confirm that the wetland habitats at Ghazi Ghat continue to support a commercially and ecologically important fish assemblage and underscore the need for continued monitoring and sustainable management.

Keywords: Ichthyofauna; Physico-Chemical Parameters; Indus River; Ghazi Ghat; Seasonal Variation; Diversity Indices; Pakistan.

Introduction

Ichthyofaunal diversity encompasses the variety of fish species, ranging from genetic diversity within populations to species assemblages across aquatic ecosystems (Burton, 2020). Biodiversity underpins ecosystem resilience, nutrient cycling and the provision of essential services, including clean water and protein sources for human populations (Costanza et al., 1997; Hooper et al., 2005; Díaz et al., 2006).

Freshwater fishes constitute a substantial fraction of global vertebrate diversity. Of the approximately 32 500 described fish species, nearly half inhabit freshwater habitats despite these environments representing less than 0.3 % of Earth's water resources (Nelson, 2006; Ormerod, 2003; Froese & Pauly, 2010). The rate of description of new freshwater species remains high (≈305 species yr^{-1} since 1976; Reid et al., 2023). Fishes exhibit remarkable morphological, behavioural

and physiological adaptations that enable them to occupy springs, ponds, lakes, rivers and reservoirs (Moyle & Cech, 1996).

Fisheries make important contributions to national economies and food security, particularly in developing countries, which account for approximately 94 % of global freshwater capture fisheries (FAO, 2007, 2012). Fish protein supplies more than 6 % of the animal protein consumed by humans worldwide and reaches 40–50 % in several Asian nations (Briones et al., 2004; FAO, 2010).

As key components of aquatic food webs, fishes regulate energy flow, nutrient cycling and community structure (Nelson, 2006). Their sensitivity to physico-chemical change, disease, parasites and pollutants renders them valuable bio-indicators of ecosystem health (Moyle & Leidy, 1992; Holmlund & Hammer, 1999). Alterations in water temperature, dissolved oxygen, suspended solids, chloride, calcium, sodium and other constituents can markedly affect species composition and relative abundance (Grizzle, 1981; Laffaille et al., 2005; Sarkar et al., 2008). Consequently, freshwater fishes rank among the most threatened vertebrate groups globally (Darwall & Vié, 2005).

The Indus River system is central to Pakistan's agriculture, fisheries and biodiversity. Previous investigations at Ghazi Ghat recorded 22 fish species dominated by Cyprinidae (Hussain et al., 2016). More recent surveys along other stretches of the Indus have documented varying richness and highlighted emerging threats from pollution and habitat alteration (Abro et al., 2020; Zainab et al., 2022; Ali et al., 2024). The present study provides an updated assessment of fish diversity and monthly physico-chemical conditions in the lentic wetlands of Ghazi Ghat, thereby contributing baseline data for conservation and management.

Materials and Methods

Study Area

Sampling was conducted in natural lentic water bodies (locally termed dhunds) situated 2–5 km from the main channel of the Indus River at Ghazi Ghat (30°3′48″ N, 70°48′51″ E), Dera Ghazi Khan District, Punjab, Pakistan (Figure 1). These wetlands are periodically inundated by river water during the monsoon and support important natural and commercial fisheries. Water depth and surface area vary seasonally.

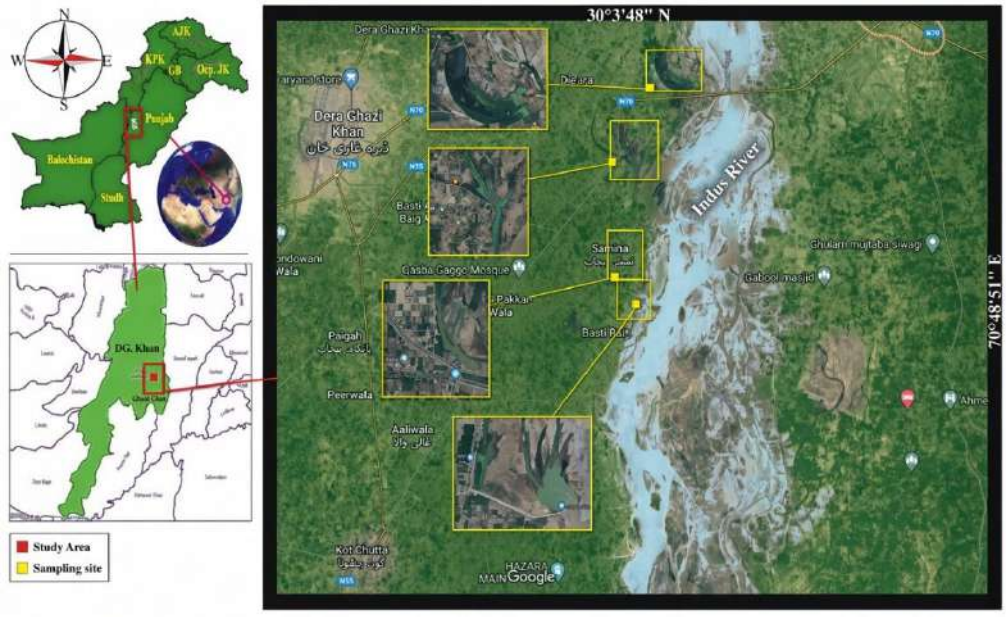

Figure 1. Location of the study area and sampling sites at Ghazi Ghat, Indus River, Dera Ghazi Khan, Pakistan.

Fish Sampling

Fishes were collected monthly from March 2024 to February 2025, excluding June–August when fishing is prohibited by the Punjab Fisheries Department. Cast and drag nets (mesh size 2 cm²) were operated with the assistance of local fishermen. Two independent catches were taken each sampling month. Specimens were sorted by species, counted and preserved on ice for laboratory identification using the standard taxonomic key of Mirza & Sharif (1996). Relative abundance (RA, %) was calculated as:

$RA\ (\%) = (n_i / N) \times 100$

where n_i is the number of individuals of species i and N is the total number of individuals of all species. Frequency of occurrence and diversity indices (Shannon–Wiener H′ and Margalef's d) were also computed.

For seasonal analysis, November–February were designated winter, March–April spring, May summer, and September–October post-monsoon.

Physico-Chemical Analysis

Water samples were collected monthly from March 2024 to February 2025. In-situ measurements of water temperature, pH, total dissolved solids (TDS), electrical conductivity (EC) and dissolved oxygen (DO) were obtained with calibrated portable meters. Additional parameters (free CO_2, CO_3^{2-}, HCO_3^-, total alkalinity, total hardness, Ca^{2+}, Mg^{2+}, Na^+ and Cl^-) were analysed at the Soil and Water Laboratory, Agriculture Department, Government of Punjab, following standard methods.

Statistical Analysis

Relative abundance was calculated in Microsoft Excel. Shannon–Wiener diversity (H′) and Margalef's richness (d) were computed according to Shannon & Weaver (1963) and Margalef (1968), respectively.

Results

Fish Diversity and Relative Abundance

A total of 23 fish species belonging to 18 genera and 11 families were recorded (Table 1). Family Cyprinidae was the most species-rich, accounting for approximately two-thirds of the assemblage; the remaining families (Cichlidae, Clupeidae, Notopteridae, Bagridae, Siluridae, Channidae, Heteropneustidae, Osphronemidae, Ambassidae, Mastacembelidae and Schilbeidae) contributed the balance. *Gudusia chapra* was the most abundant species (14.18 %), followed by *Oreochromis mossambicus* (10.78 %), *Labeo rohita* (10.39 %), *Securicula gora* (10.11 %) and *Catla catla* (8.83 %) (Figure 2). Shannon–Wiener diversity (H′ = 2.73) and Margalef's index (d = 2.49) indicated moderate diversity.

Table 1. Relative abundance, distributional status, IUCN category and commercial importance of fish species recorded at Ghazi Ghat, Indus River

Scientific name	Common name	n	RA (%)	Status	IUCN	Commercial
Labeo rohita	Rohu	697	10.39	Indigenous	NE	Very High
Catla catla	Thaila	592	8.83	Indigenous	LC	Very High

Cirrhinus mrigala	Mori	451	6.72	Indigenous	NE	Very High
Cyprinus carpio	Common carp	201	2.99	Exotic	VU	High
Securicula gora	Chalwa	678	10.11	Indigenous	LC	—
Labeo calbasu	Calbasu	100	1.49	Indigenous	LC	High
Puntius sophore	Spotfin swamp barb	349	5.20	Indigenous	LC	—
Puntius ticto	Ticto barb	100	1.49	Indigenous	LC	—
Notopterus notopterus	Bronze featherback	336	5.01	Indigenous	LC	High
Rita rita	Rita	38	0.05	Indigenous	LC	Very High
Aorichthys aor	Long-whiskered catfish	32	0.04	Indigenous	LC	Very High
Channa marulius	Great snakehead	95	1.41	Indigenous	LC	Very High
Channa punctata	Spotted snakehead	136	2.02	Indigenous	LC	—
Heteropneustes fossilis	Stinging catfish	62	0.09	Endemic	LC	—
Colisa fasciata	Banded gourami	73	1.08	Endemic	LC	—
Colisa lalia	Dwarf gourami	92	1.37	Indigenous	LC	—
Ambassis ranga	Indian glassy fish	309	4.61	Indigenous	LC	—
Mastacembelus armatus	Zig-zag eel	137	2.04	Indigenous	LC	High
Wallago attu	Freshwater shark	41	0.06	Indigenous	NT	Very High
Eutropiichthys vacha	Batchwa vacha	71	1.05	Indigenous	LC	Very High
Oreochromis mossambicus	Mozambique tilapia	—	10.78	Exotic	LC	High
Oreochromis aureus	Blue tilapia	—	6.53	Exotic	LC	High
Gudusia chapra	Indian river shad	—	14.18	Indigenous	LC	—

Notes: n = number of individuals; RA = relative abundance; NE = Not Evaluated; LC = Least Concern; NT = Near Threatened; VU = Vulnerable. IUCN status follows global assessments (IUCN Red List). Commercial status adapted from Rafique & Khan (2012).

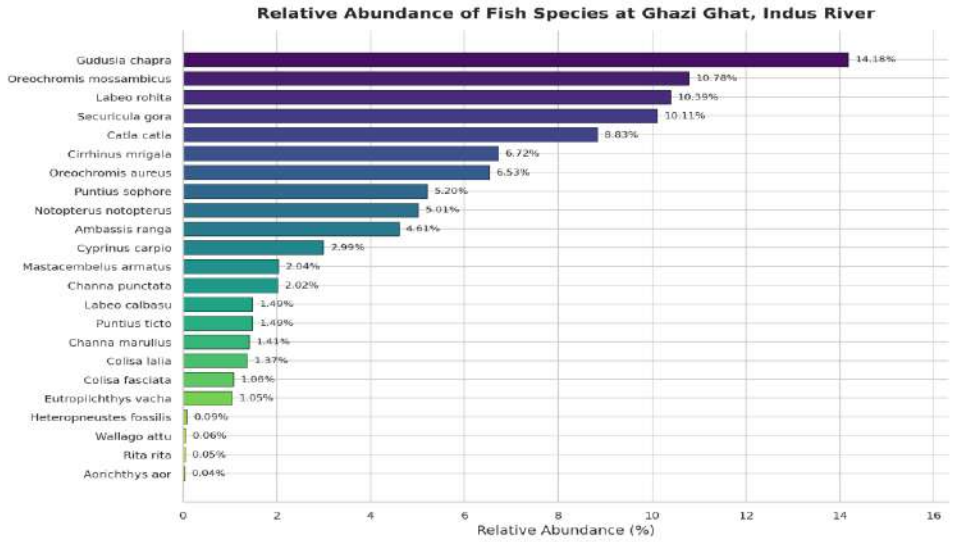

Figure 2. Relative abundance (%) of fish species recorded at Ghazi Ghat, Indus River.

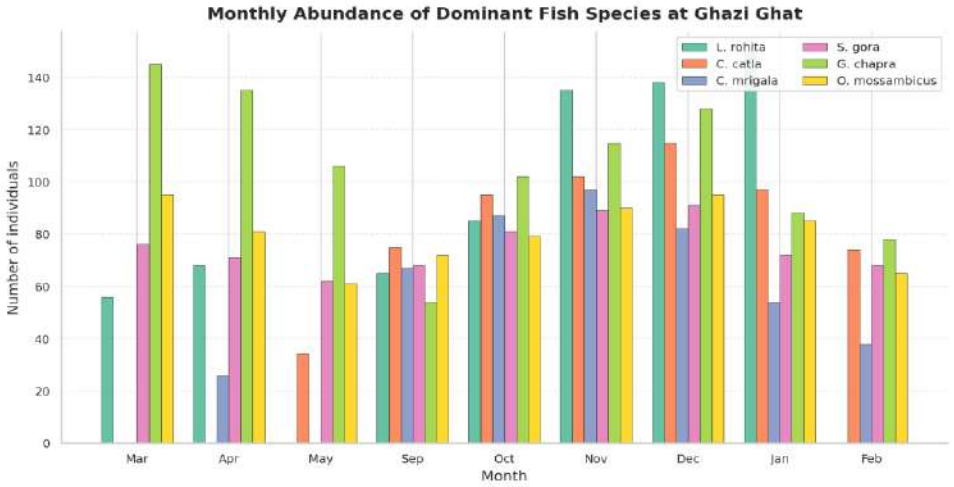

Figure 3. Monthly abundance of dominant fish species at Ghazi Ghat (sampling excluded June–August).

Physico-Chemical Parameters

Monthly mean values (± SD) of physico-chemical parameters are presented in Table 2 and illustrated in Figure 4. Water temperature ranged from 10.5 °C (January) to 31.5 °C (July). Dissolved oxygen was highest in winter (9.8 mg L^{-1} in February) and lowest in mid-summer (6.3 mg L^{-1} in July). pH remained slightly alkaline (7.5–8.1). TDS, electrical conductivity, total alkalinity and hardness exhibited moderate seasonal variation, generally peaking during the warmer months. Overall, values remained within ranges considered suitable for freshwater fish culture and survival.

Table 2. Monthly mean values of selected physico-chemical parameters at Ghazi Ghat

Month	WT (°C)	DO (mg/L)	pH	TDS (mg/L)	TA (mg/L)	TH (mg/L)	EC (µS/cm)	CO_2 (mg/L)
January	10.5	9.2	7.6	850	68.6	25.5	382	6.6
February	12.7	9.8	7.8	950	78.7	29.7	390	6.8

March	15.3	9.2	7.9	970	82.4	30.5	405	7.2
April	22.5	8.9	7.7	995	84.1	32.5	415	7.5
May	28.2	7.8	7.5	1020	88.9	29.7	426	8.5
June	30.2	7.5	7.8	1070	95.4	30.5	436	9.4
July	31.5	6.3	7.5	1120	101.2	31.6	460	10.5
August	30.6	6.8	7.8	1190	98.5	29.5	445	8.9
September	28.1	7.2	8.1	941	90.3	27.8	428	7.9
October	25.9	7.6	7.9	1040	81.5	28.2	412	7.3
November	23.4	8.5	7.7	980	76.1	25.6	380	7.1
December	18.5	9.5	7.9	930	74.5	26.5	395	6.9
Mean	**23.11**	**8.19**	**7.76**	**1004.7**	**85.0**	**29.0**	**414.5**	**7.88**
SD	**7.29**	**1.14**	**0.17**	**91.4**	**10.1**	**2.3**	**25.4**	**1.20**

WT = water temperature; DO = dissolved oxygen; TDS = total dissolved solids; TA = total alkalinity; TH = total hardness; EC = electrical conductivity. Full dataset including light penetration, carbonate, bicarbonate, Ca, Mg, Na and Cl is available upon request.

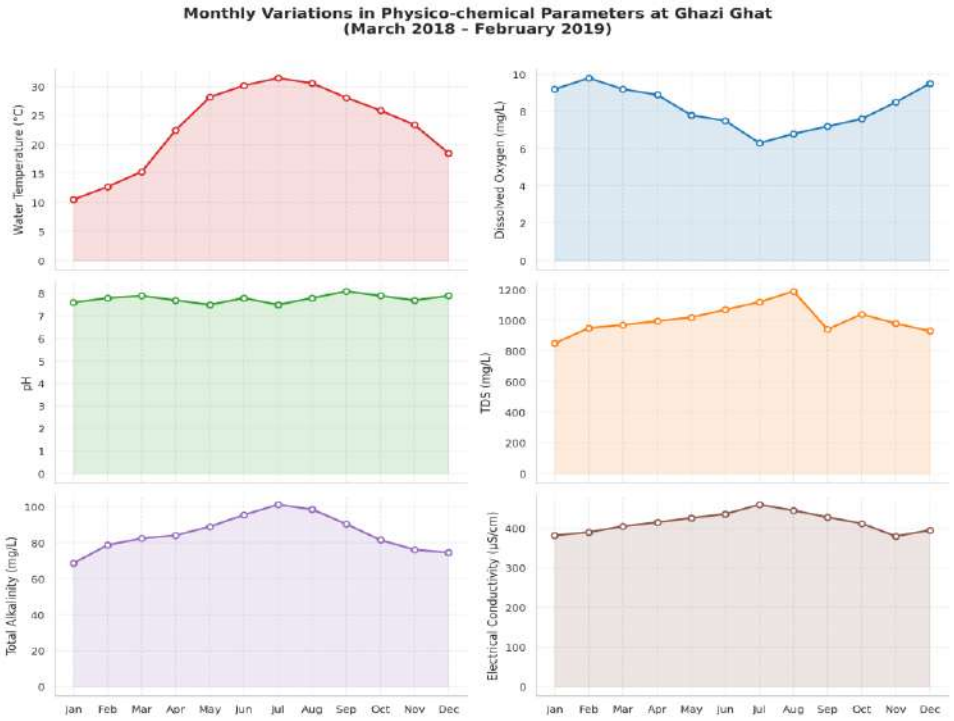

Figure 4. Monthly variations in selected physico-chemical parameters at Ghazi Ghat, Indus River.

Discussion

The 23 species recorded in the present study are consistent with earlier findings of 22 species at the same locality (Hussain et al., 2016) and with broader surveys of the Indus drainage that emphasise the numerical dominance of Cyprinidae (Rafique & Khan, 2012; Abro et al., 2020; Zainab et al., 2022). The high relative abundances of *Gudusia chapra*, *Labeo rohita*, *Securicula gora* and the two tilapia species reflect both the productivity of the wetlands and the influence of

aquaculture introductions. The presence of commercially valuable indigenous carps (*L. rohita*, *C. catla*, *C. mrigala*) underscores the continuing economic importance of these habitats.

Physico-chemical conditions remained within the ranges generally regarded as favourable for warm-water freshwater fishes (pH 6.5–8.5; DO > 5 mg L^{-1}; moderate hardness and alkalinity). Seasonal patterns—higher temperatures and lower DO in summer, higher DO and lower temperatures in winter—are typical of subtropical lentic systems and match patterns reported for other Indus sites (Ali et al., 2024; Abro et al., 2020). Free CO_2 peaked in summer, consistent with elevated rates of organic-matter decomposition at higher temperatures.

Diversity indices ($H' = 2.73$; $d = 2.49$) indicate a moderately diverse assemblage. Similar moderate values have been reported from other Indus wetlands and canals (Hussain et al., 2016; Rasheed et al., 2022). Continued monitoring is warranted, particularly in light of increasing anthropogenic pressures, including agricultural runoff, water abstraction and the spread of exotic tilapias, which can alternative community structure.

Conclusion

The lentic wetlands at Ghazi Ghat support a moderately diverse fish fauna of 23 species, dominated by Cyprinidae and including several commercially important indigenous and exotic taxa. Physico-chemical parameters remained within tolerance limits for aquatic biota throughout the study period, confirming the suitability of these habitats for fish production and, with appropriate treatment, for other water uses. No evidence of parasitic or fungal infection was observed in the examined specimens. Sustained monitoring and the implementation of sustainable fishery-management practices are recommended to safeguard this valuable component of the Indus River biodiversity.

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