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Research Article

First report and morpho-meristic characterization of *Heteropneustes fossilis* (Bloch,1794) from the river Kabul at its Pakistani gateway: shelman valley, Khyber Pakhtunkhwa

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ABSTRACT

This study is the first comprehensive Morpho-meristic study of *Heteropneustes fossilis* from two distinct locations along the length of river Kabul; Shalman valley and Michini. For this purpose, a total of 20 fish specimens were collected from April to July 2025. Various fishing equipment were employed for catching the fish. The collected fish specimens were identified their meristic characters and morphometric measurements were recorded and finally preserved in ethanol. Fin rays were observed using a magnifying glass and stereo microscope. Body weight (BW) and morphometric measurements were recorded with a digital balance and caliper, with an accuracy of 0.01 g and 0.01 cm, respectively. The specimens showed a moderate variation in total length (15.0-18.2 cm) and body weight (37.3-42.0 g). Statistical analysis of the observed characters, including assessment of length-weight relationships (LWRs) and length-length relationships (LLRs) were done utilizing the software Prism. The fin formula observed for *H. fossilis* was: D. 5-7, P. 1/6-7, V. 6, A. 64-69, C. 18-22. LWRs between BW and most length parameters were significant ($p < 0.001$; $r^2 = 0.94$), except for Post dorsal length ($p > 0.05$). The growth pattern exhibited a negative allometric growth ($b < 3$) potentially due to restricted food supply, environmental stress and reproductive activity. LLRs were statistically significant ($p < 0.001$; $r^2 = 0.98$). These findings report the species for the first time from Shalman valley and provide key baseline data for species identification, which might be helpful in the conservation of *H. fossilis* within the River Kabul ecosystem.

Keywords: Fish; *Heteropneustes fossilis*; river kabul; identification; morpho-meristic; shalman valley; length-weight relationship.

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INTRODUCTION

Morphometric and meristic traits are widely used in the identification and classification of fish (Bagenal, 1978; Hossain et al., 2016; Jayaram, 1999). Morphological study plays a key role in fisheries research as it helps in the comparison of morphological and biological properties of fish's population in different geographical localities and is used not only as a vital tool but is cost effective as well (Hossain et al.,2013; Khatun et al., 2019; Parvin et al., 2018, Siddik et al., 2016). Such studies are helpful in differentiating among fish populations (Siddik et al., 2015). Numerous studies revealed that *H. fossilis* is a carnivorous fish that mainly feed upon aquatic invertebrates such as crustaceans, worms, insects and animal debris (Narejo et al., 2016). *H. fossilis*, the Asian stinging cat fish possess a sharp and tough spine at the anterior edge of the pectoral fin. At the base of this spine there is a venomous gland made of specialized cells that produce the venom. The venom has a complex biochemical composition containing hemolytic, dermonecrotic, edema-inducing and vasospastic factors. A sting affected individual may experience severe pain, swelling, redness, numbness at the site and dizziness (Satora et al., 2008). The fish species is well-known to inhabit the freshwater habitat of mainland Indochinese peninsula (Devi and Raghunathan, 1999; Talwar and Jhingran, 1991), in southeastern Asian countries while in the Indian sub-continent *H. fossilis* is native to countries like Pakistan, Afghanistan, India, Bangladesh, Nepal, Thailand, Loas Myanmar and Sri Lanka (Talwar and Jhingran, 1991). *H. fossilis* has been introduced to countries like Iraq and Iran where they inhabit freshwater ecosystem (Coad, 1996). *H. fossilis* primarily inhabits swamps, ponds, marshlands, turbid waters and ditches (HumpHries et al., 2023).

The body of *H. fossilis* is elongated and compressed with a short dorsal fin, long pelvic fin and serrated pectoral spine linked to the venom gland. The fish has four distinct pairs of barbels. Additionally, a pair of elongated tubular air sac is present which helps to survive in hypoxic conditions (Berra, 2001).

There are six species in the genus *Heteropneustes*: *H. fossilis, H. kemratensis, H. fuscus, H. longipectoralis, H. microps* and *H.nani* (Fowler, 1937; Urmi et al., 2024; Plamoottil, 2022; Subba et al., 2024). *H. fossilis* and *H. nani* are present in Bangladesh while Pakistan only has *H. fossilis* (Hossain et al., 2013).

H. fossilis is commonly known by a name "singhee". It is a commercially significant freshwater fish known for its substantial nutritional value and market demand. Its meat offers substantial quantities of protein and vital minerals; including iron, calcium, and phosphorus, while maintaining a low fat content. On average, 100 g of *H. fossilis* meat has 23 g of protein, 0.5 g of fat, 0.67 g of calcium, and 0.65 g of phosphorus. This make it a recommended dietary component for kids who are in growth and recovery stages (Hossain et al., 2013; Samad and Bhuiyan, 2017; Siddiqui and Choudhury, 1996).

H. fossilis has been previously reported from various region in Pakistan, such as Tunsa barrage (Indus river), Kenjar lake, Manchar lake, River Kabul at the michini site and downstream region of Warsak Dam (A Abro et al., 2020; Altaf et al., 2015; Muhammad et al., 2017; Rauf et al., 2015; Suleman et al., 2017; Narejoet al., 2016).This study aims to provide a comprehensive morpho-meristic assessment and confirm the presence of *H. fossilis* from michini area (District Mohmand) and upstream at Shelman valley (District Khyber) extending the range to the area where river Kabul enters Pakistan from Nangarhar, Afghanistan.

MATERIALS AND METHODS

Collection, preservation and identification

This study was conducted at two distinct localities along the river Kabul; Shelman valley (34.2103°N, 71.1944°; and Michini (34.213054°N, 71.49609°E; from April to July 2025. A total of 20 specimens of *H. fossilis* were collected as pooled sample across both localities using cast nets, mesh nets, hand nets and hooks. The collected samples were cleaned, washed thoroughly with distilled water, photographed and finally preserved in 70% alcohol before shifting to fisheries and aquaculture lab at the Institute of Zoological Sciences, University of Peshawar. The specimens were identified based on the available dichotomous taxonomic keys. All the meristic counts and morphometric measurements in triplicate were carefully recorded using magnifying glass and stereomicroscope where required. The mean value of triplicate was taken for statistical analysis (Talwar & Jhingran, 1991; Sandhu, 2017). To summarize, a total of 33 morphometric characteristics were recorded for *H. fossilis* using a digital caliper (0.01 cm accuracy), a measuring board, and an electronic balance (0.01 g precision) to obtain precise measurements (See Table 6, Results section).

Data analysis

Length weight relationships (LWRs) were calculated using the formula: W = a × Lb, where W represents body weight and L denotes lengths in centimeters. The parameters (a) and (b) were determined using log-log linear regression analyses: ln (W) = ln (a) + b ln (L). Furthermore, a 95% confidence limit (CL) for (a) and (b), as well as the coefficient of determination (r^2) was calculated following (Froese, 2006) by omitting extreme outliers from the regression analysis. The Length-length relationships (LLRs) were found through simple linear regression between Total Length (TL) and selected morphometric measurements such as; Standard Length, Pre-dorsal Length, Post-pectoral Length, Post-ventral Length, Pre-anal Length, and Post-Dorsal Length by applying the formula: Y= a+bX, where (Y) and (X) represent different morphometric variables while (a) and (b) signify intercept and the regression slope (Hossain et al., 2006). The most effective model for both LWRs and LLRs was chosen based on the highest coefficient of determination, r^2. Graph Pad Prism 8.0 software was used for the analysis.

RESULTS AND DISCUSSION

Meristic study

H. fossilis, is with an elongated mouth having four pairs of barbells. The fish is yellow or dark purplish brown on the dorsal side while lighter in color on the ventral side. Pectoral spine is attached to the rays via a membrane. *H. fossilis* has 3-4 anteriorly orientated serrations along the inner margin of the pectoral spine and a prominent notch on the anal and caudal fins both of which help in the identification of species.

Table 1. Meristic count of *H. fossilis* (n=20) collected from river Kabul.

Meristic Data	Numbers
Dorsal fin rays	5-7
Pectoral fin rays	6-7
Pelvic fin rays	6
Anal fin rays	64-69
Caudal fin rays	18-22

Morphological relationships

Descriptive statistics for the morphometric measurements of the collected 20 *H. fossilis* specimens are presented in (Table 2). Total length (TL) varied from 15.0 to 18.2 cm, with a mean of 16.42 ± 0.81 cm, whereas standard length (SL) ranged from 14.0 to 16.5 cm, average 15.36 ± 0.78 cm. Body weight (BW) ranged from 37.3 to 42.0 g, with a mean of 39.57 ± 1.00 g. Some of the morphometric characteristics such as pre-dorsal length (PrDL), post-pectoral length (PoPL), post-ventral length (PoVL), pre-anal length (PrAL), and post-dorsal length (PoDL) demonstrated minimal variability, as can be seen in (Table 2), indicating relative homogeneity within the sampled population.

Table 2. Descriptive statistics of morphometric characters of *H. fossilis.*

Morphometric character	Min	Max	Mean	SD	SE	95% CI Lower	95% CI Upper
Total Length (TL)	15.0	18.2	16.42	0.8126	0.1817	16.03	16.8
Standard Length (SL)	14.0	16.5	15.36	0.7764	0.1736	15.0	15.72
Pre-dorsal Length (PrDL)	4.5	5.7	5.08	0.3473	0.0777	4.917	5.243
Post-pectoral Length (PoPL)	10.0	12.7	10.77	0.6779	0.1516	10.45	11.09
Post-ventral Length (PoVL)	8.7	10.3	9.315	0.4793	0.1072	9.091	9.539
Pre-anal Length (PrAL)	5.6	7.2	6.28	0.4099	0.0917	6.088	6.472
Post-dorsal Length (PoDL)	8.2	9.3	8.69	0.2751	0.0615	8.561	8.819
Body Weight (BW)	37.3	42.0	39.57	1.004	0.2244	39.1	40.03

Table 3. Log-Log LWRs results of selected morphometric counts of *H. fossilis*

Relationship	Slope (b)	Intercept (a)	R^2	95% CI b (low)	95% CI b (high)	p-value	Significance
TL vs BW	0.3874	2.594	0.5737	0.222	0.5527	0.0001	Significant
SL vs BW	0.3244	2.792	0.4251	0.1376	0.5112	0.0018	Significant
PrDL vs BW	0.2618	3.253	0.5055	0.1336	0.3901	0.0004	Significant
PoPL vs BW	0.3244	2.907	0.6116	0.1964	0.4524	0.0001	Significant
PoVL vs BW	0.3604	2.874	0.5207	0.1892	0.5316	0.0003	Significant
PrAL vs BW	0.2918	3.142	0.5669	0.1655	0.4181	0.0001	Significant
PoDL vs BW	0.3414	2.94	0.1797	0.01977	0.7026	0.0625	Non-significant

Table 3 presents the length-weight relationships (LWRs) between body weight and morphometric characteristics. Notable regressions were identified for TL-BW ($r^2 = 0.574$, $p = 0.0001$), SL-BW ($r^2 = 0.425$, $p = 0.0018$), PrDL-BW ($r^2 = 0.506$, $p = 0.0004$), PoPL-BW ($r^2 = 0.612$, $p < 0.0001$), PoVL-BW ($r^2 = 0.521$, $p = 0.0003$), and PrAL-BW ($r^2 = 0.567$, $p = 0.0001$). The slopes (b values) of regressions varied from 0.26 to 0.39, showing negative allometric growth patterns.

In contrast, the PoDL-BW regression was non-significant ($r^2 = 0.180$, $p = 0.0625$), indicating a limited predictive capacity of this indicator for body weight. (See figure 2) for corresponding graph of the data.

Table 4. LLRs result of selected morphometric counts of *H. fossilis.*

Relationship	Slope (b)	95% CI (b)	Intercept (a)	R²	p-value	Significance
TL vs SL	0.8636	0.6612-1.066	1.182	0.817	<0.0001	Significant
TL vs PrDL	0.4142	0.3619-0.4665	-1.719	0.9389	<0.0001	Significant
TL vs PoPL	0.7584	0.5863-0.9305	-1.678	0.8265	<0.0001	Significant
TL vs PoVL	0.552	0.4491-0.6550	0.2534	0.8758	<0.0001	Significant
TL vs PrAL	0.4827	0.4103-0.5552	-1.644	0.9158	<0.0001	Significant
TL vs PoDL	0.1692	0.0240-0.3144	5.912	0.2498	0.0248	Significant

Table 4 summarizes the length-length relation (LLRs) between total length (TL) and other morphometric characteristics. Robust linear correlations were identified for TL-SL ($r^2 = 0.817$, $p < 0.0001$), TL-PrDL ($r^2 = 0.939$, $p < 0.0001$), TL-PoPL ($r^2 = 0.827$, $p < 0.0001$), TL-PoVL ($r^2 = 0.876$, $p < 0.0001$), and TL-PrAL ($r^2 = 0.916$, $p < 0.0001$). The TL-PoDL regression demonstrated a moderate correlation ($r^2 = 0.250$, $p = 0.0248$), signifying less reliability in predicting this parameter based on TL. The results validate significant morphometric correlations within the species. The date is graphically presented in figure (3).

Table 5. Correlation results of selected morphometric counts.

Comparison	Pearson r	95% CI	R²	P-value	Significance
SL vs MXBL	0.8875	0.7327-0.9550	0.7876	<0.0001	Significant
SL vs TL	0.9039	0.7689-0.9617	0.817	<0.0001	Significant
SL vs BW	0.6566	0.3018-0.8517	0.4311	0.0017	Significant
SL vs POVL	0.7916	0.5374-0.9140	0.6267	<0.0001	Significant
SL vs BD	0.8867	0.7310-0.9546	0.7862	<0.0001	Significant
SL vs HW	0.5299	0.1142-0.7877	0.2808	0.0162	Significant
SL vsPrDL	0.9032	0.7674-0.9614	0.8158	<0.0001	Significant
SL vs POL	0.7293	0.4235-0.8859	0.5319	0.0003	Significant
SL vsPrVL	0.6812	0.3417-0.8634	0.464	0.0009	Significant
SL vs NBL	0.5953	0.2074-0.8214	0.3543	0.0056	Significant

Table 5 the morphometric analysis shows significant positive relationships between standard length (SL) and other morphometric features in *H. fossilis*. Among the studied parameters, SL exhibited the strongest association with total length (TL; $r = 0.9039$, $R^2 = 0.8170$, $p < 0.0001$) while pre-dorsal length (PrDL; $r = 0.9032$, $R^2 = 0.8158$, $p < 0.0001$), show a strong linear relationship. Moderate relationships were identified with body weight (BW; $r = 0.6566$, $R^2 = 0.4311$, $p = 0.0017$) and head width (HW; $r = 0.5299$, $R^2 = 0.2808$, $p = 0.0162$). All relationships were statistically significant ($p < 0.05$), indicating that SL is a dependable predictor of morphometric characteristics in this species. The data is graphically presented in figure (1).

This work presents the first comprehensive analysis of the meristic and morphometric traits of *H. fossilis* from shelman area of the River Kabul, Pakistan, a previously unexplored area of its distribution. This study is intended to serve as a baseline study for the identification of the species and hints towards the overall health of its population. The finding and analysis verify the species unique physical characters and reveals a growth pattern which might be largely shaped by environmental conditions of the habitat.

The different meristic counts recorded here are in agreement with studies and earlier descriptions of the species from various regions; as for example the number of pectoral fin rays (1/6-7), dorsal fin rays (5-7), pelvic fin rays (6), caudal fin rays (18-22) and the anal fin rays (64-69) (Rahman, 1989; Rahman et al., 2019; Shafi and Quddus, 2001). The uniformity of fin ray, a character that is a genetically controlled is a strong taxonomic character that can be utilized throughout its geographic range (Bagenal, 1978; Jayaram, 1999). On the other hand, certain small variations in meristic counts such as the range in anal fin rays, are widespread and are linked to phenotypic plasticity (Hossain et al., 2013; Lindsey, 1988). Other factors like water temperature, salinity, availability of food might have an effect on somitogenesis and may cause some population-specific variations in the meristic features (Parvinet al., 2018). The persistent count of eight barbels in all collected specimens was in agreement and acted as one of the most dependable diagnostic characteristic for *H. fossilis* (Talwar and Jhingran, 1991).

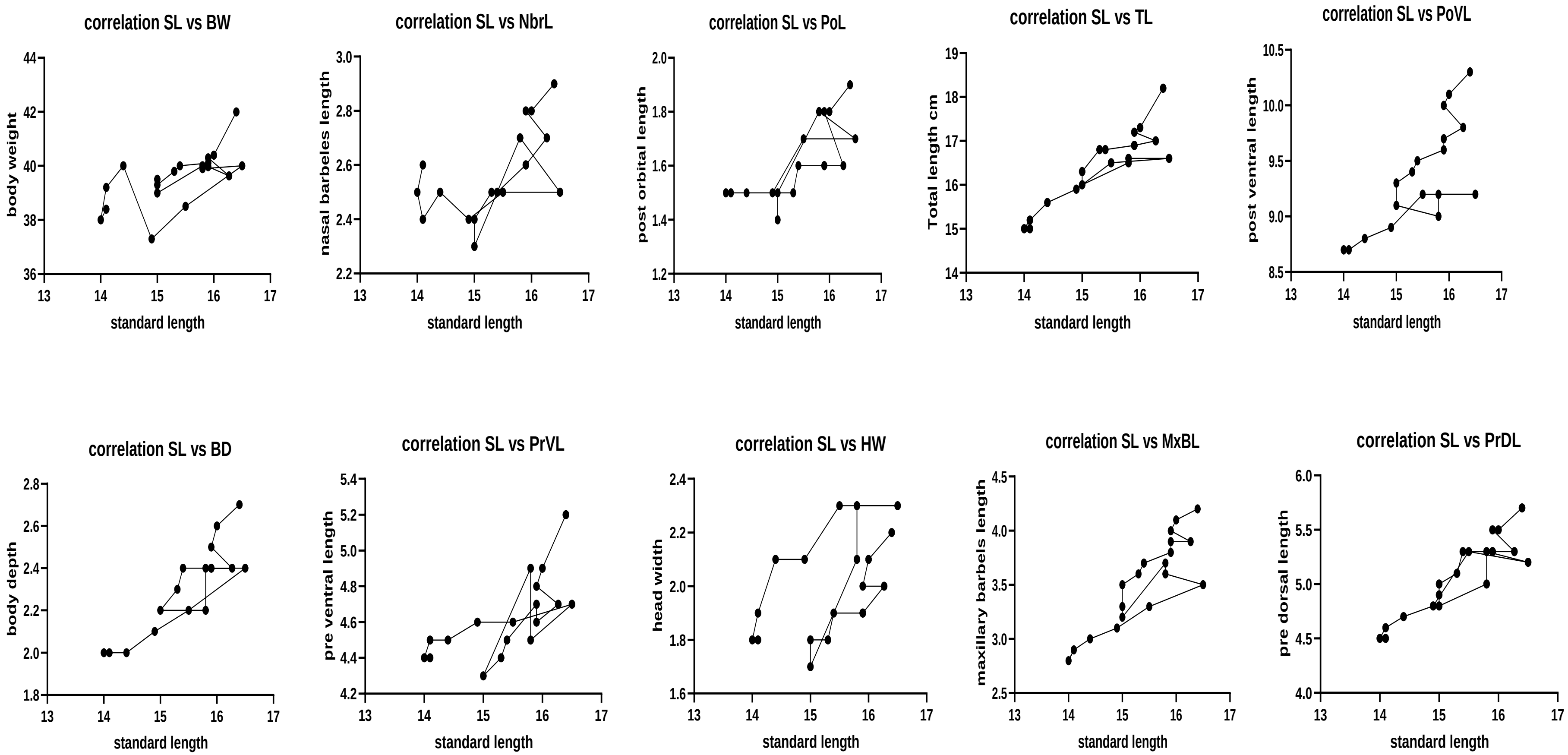

Figure1. This figure (representing table 5) is depicting correlation of body weight, nasal barbel length, postorbital length, total length, post-ventral length, body depth, pre-ventral length, head width, maxillary barbell length and pre-dorsal length with standard length of *H. fossilis.*

The morphometric study with the size and weight ranges (TL: 15.0 - 18.2 cm; BW: 37.3 - 42.0 g) is in fact a limitation of this study which restricts the study to convenient available sampling. However, when compared to other such studies the longest overall length recorded in this study was less than that reported from Bangladesh at 26.8 cm (Rahman et al., 2019) and 31.0 cm from the Ganga River in India (Khan et al., 2012). This suggests the collected samples primarily were composed of younger individuals, hints towards the sampling bias or may be towards the minimal expansion as a result of environmental pressures and

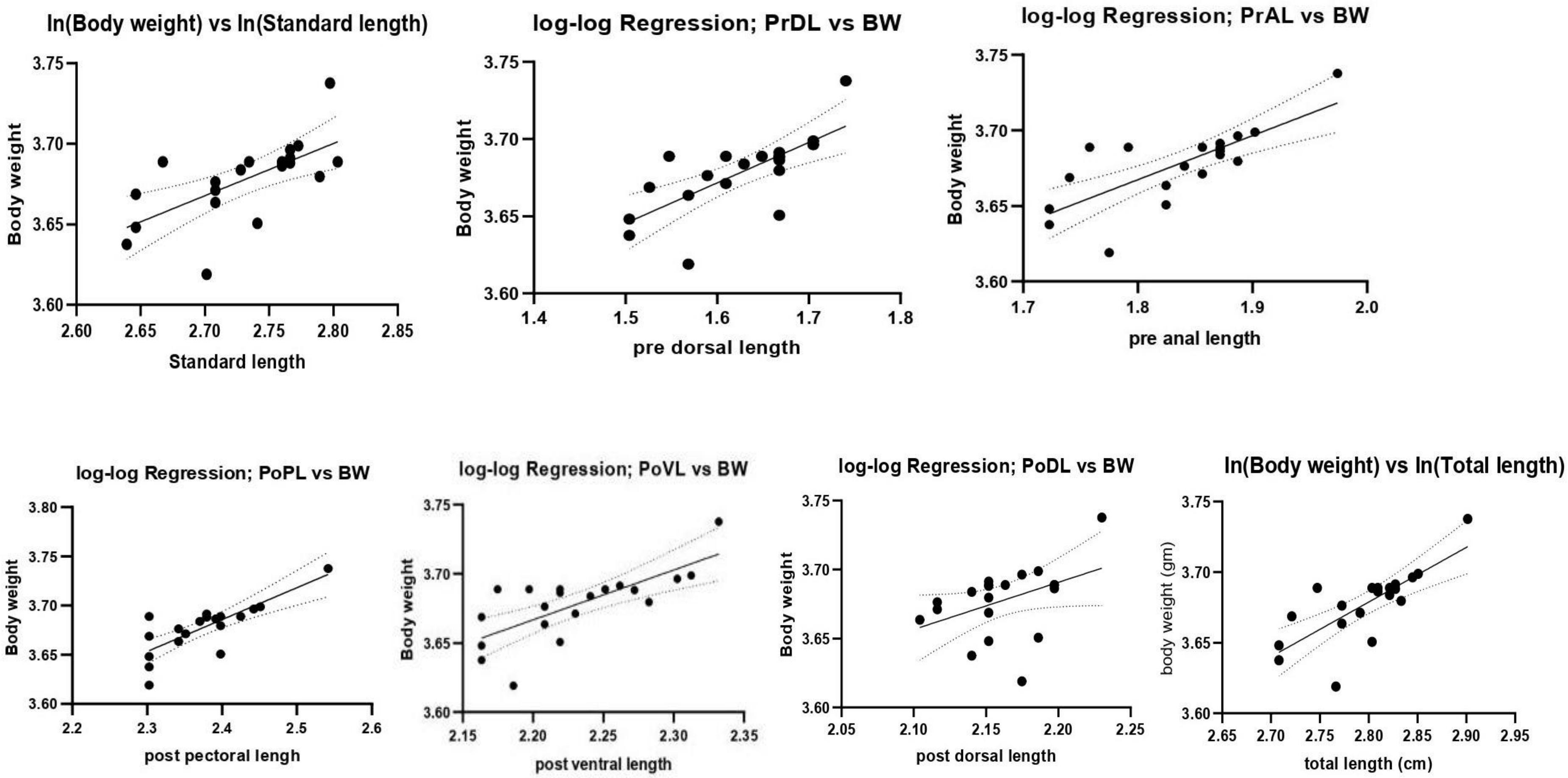

Figure 2. Log-log length-weight relationships for *H. fossilis* from River Kabul. The graph represents table (30 and is depicting relationship of body weight with different lengths such as; Standard length, Pre-dorsal length, preanal length, post-pectoral length, postventral length, postdorsal length and total length of *H. fossilis*.

habitat quality of the River Kabul. The Length-Length Relationships (LLRs) for various body parts in relation to Total Length (TL) have substantial coefficients of determination ($r^2 > 0.81$ for TL-SL, TL-PrDL, TL-PoPL, TL-PoVL, TL-PrAL), indicating a robust positive allometry.

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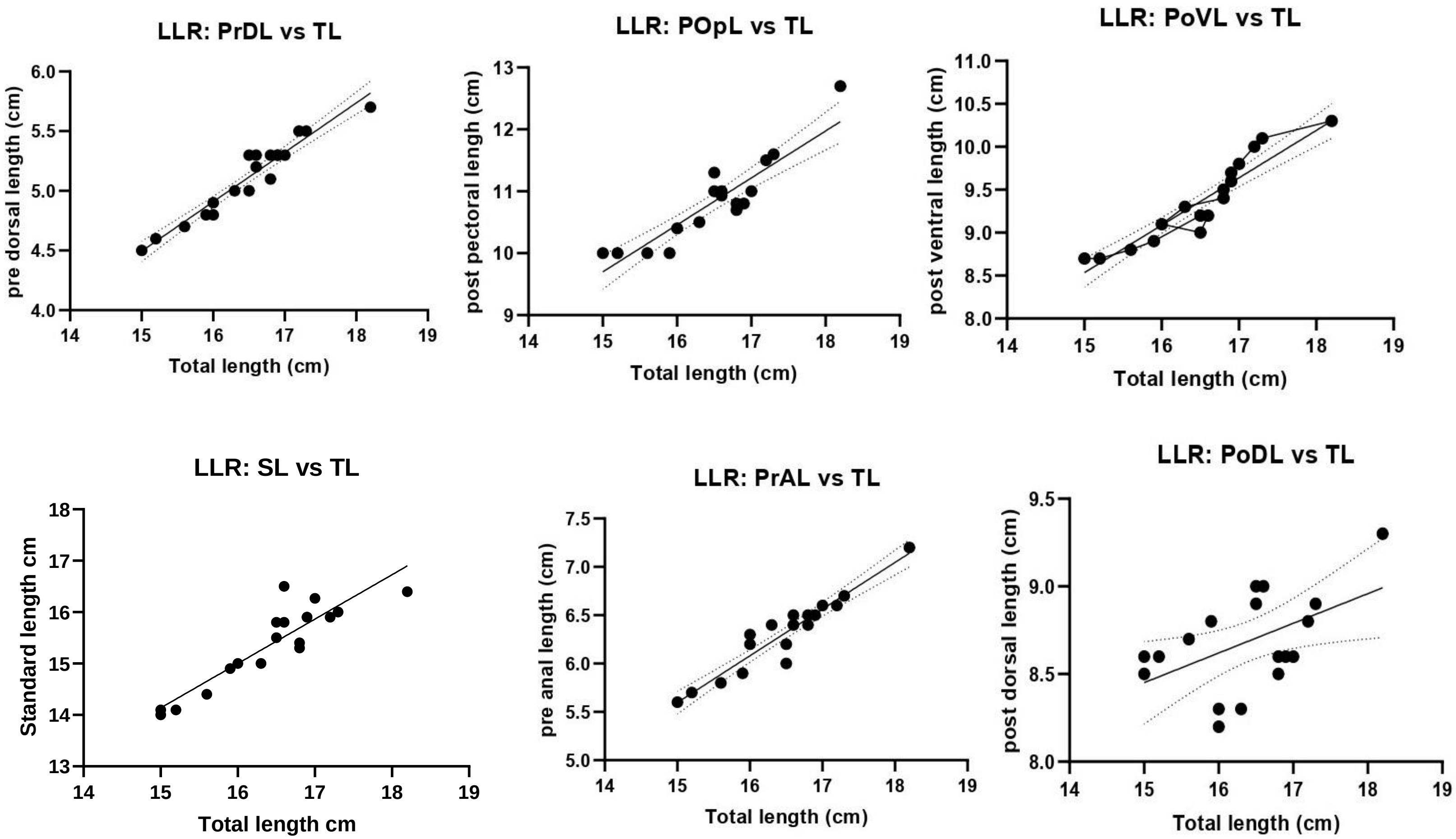

Figure3. Length-length relationships of total length with other selected lengths for H. fossilis. The figure is depicting table 4 for linear regression between total length and predorsal length, postpectoral length, postventral length, standard length, preanal length and post dorsal length.

This signifies that when H. fossilis matures, its body proportions scale in a coherent and systematic way. The robust correlation between TL and PrDL (r^2 = 0.94) shows a conserved body plan. This body plan is potentially essential for sustaining hydrodynamics and the burrowing efficiency. This study's most

Table 6. Morphometric measurements and meristic counts of *H. fossilis* collected from Kabul river.

Character	Sample 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TL	18.2	17.3	17.2	17	16.9	16.9	16.8	16.8	16.3	16	16	16.5	16.6	16.6	16.5	15.9	15.6	15.2	15	15
SL	16.4	16	15.9	16.27	15.9	15.9	15.4	15.3	15	15	15	15.8	15.8	16.5	15.5	14.9	14.4	14.1	14	14.1
HL	2.9	2.7	2.5	2.5	2.4	2.5	2.4	2.4	2.4	2.2	2.1	3	2.9	3	3	2.9	2.8	2.8	2.9	2.8
HW	2.2	2.1	2	2	1.9	1.9	1.9	1.8	1.8	1.7	1.7	2.1	2.3	2.3	2.3	2.1	2.1	1.9	1.8	1.8
HD	1.2	1.2	1.2	1.1	1.1	1.2	1.2	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.3	1.1	1	1.2	1.2	1.2
ULL	1	1	1	1	0.9	0.9	0.9	0.8	0.7	0.6	0.6	1	0.9	0.9	0.9	0.8	0.7	0.6	0.6	0.7
LLL	0.8	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.9	0.8	0.9	0.9	0.9	0.9	0.8	0.8	0.7	0.6	0.6	0.6
MH	0.8	0.6	0.6	0.6	0.5	0.6	0.6	0.7	0.6	0.5	0.6	0.7	0.6	0.6	0.6	0.6	0.7	0.5	0.5	0.4
HrMW	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
ED	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.4	0.3	0.4	0.4	0.3	0.4	0.4	0.4	0.3
IOL	1	1	1	0.9	0.9	0.9	0.9	0.8	0.7	0.6	0.8	1	0.9	1	1	0.9	0.9	0.9	0.9	1
POL	1.9	1.8	1.8	1.6	1.6	1.6	1.6	1.5	1.5	1.4	1.5	1.8	1.8	1.7	1.7	1.5	1.5	1.5	1.5	1.5
AFL	1.5	1.4	1.3	1.3	1.4	1.3	1.2	1.1	1.2	1.2	1.2	1.4	1.4	1.4	1.4	1.3	1.3	1.4	1.4	1.4
AFB	10	9.7	9.7	9	8.9	8.9	9	8.7	8.6	8.5	8.4	9.4	9.8	9.5	9.4	9.2	9.1	9	9	8.9
PFL	1.9	1.7	1.6	1.5	1.4	1.5	1.4	1.3	1.2	1.2	1.1	1.6	1.5	1.5	1.4	1.3	1.3	1.2	1.1	1
PrPL	2.6	2.5	2.5	2.4	2.4	2.3	2.3	2.2	2.1	2	2	2.3	2.2	2.3	2.3	2.1	2.1	2.1	2	2
PoPL	12.7	11.6	11.5	11	10.8	10.8	10.8	10.7	10.5	10.4	10.4	11.3	10.93	11	11	10	10	10	10	10
PrAL	7.2	6.7	6.6	6.6	6.5	6.5	6.4	6.5	6.4	6.3	6.2	6	6.5	6.4	6.2	5.9	5.8	5.7	5.6	5.6
VFL	1.7	1.5	1.5	1.4	1.4	1.4	1.4	1.3	1.2	1.2	1.1	1.5	1.5	1.4	1.3	1.3	1.2	1.2	1.1	1.1
PrVL	5.2	4.9	4.8	4.7	4.6	4.7	4.5	4.4	4.3	4.3	4.3	4.9	4.5	4.7	4.6	4.6	4.5	4.5	4.4	4.4
PoVL	10.3	10.1	10	9.8	9.7	9.6	9.5	9.4	9.3	9.1	9.1	9	9.2	9.2	9.2	8.9	8.8	8.7	8.7	8.7
BD	2.7	2.6	2.5	2.4	2.4	2.4	2.4	2.3	2.2	2.2	2.2	2.2	2.4	2.4	2.2	2.1	2	2	2	2
CFL	0.9	0.8	0.8	0.7	0.7	0.6	0.5	0.5	0.5	0.4	0.4	0.7	0.7	0.6	0.6	0.5	0.6	0.5	0.5	0.6
DFL	1.6	1.5	1.5	1.4	1.3	1.4	1.3	1.2	1.2	1.2	1.3	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3
DFB	0.7	0.6	0.6	0.6	0.6	0.6	0.5	0.4	0.3	0.2	0.2	0.6	0.5	0.6	0.6	0.5	0.5	0.6	0.6	0.6
PrDL	5.7	5.5	5.5	5.3	5.3	5.3	5.3	5.1	5	4.9	4.8	5	5.3	5.2	5.3	4.8	4.7	4.6	4.5	4.5
PoDL	9.3	8.9	8.8	8.6	8.6	8.6	8.6	8.5	8.3	8.3	8.2	9	9	9	8.9	8.8	8.7	8.6	8.5	8.6
Barbles	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
MxBL	4.2	4.1	4	3.9	3.9	3.8	3.7	3.6	3.5	3.3	3.2	3.7	3.6	3.5	3.3	3.1	3	2.9	2.8	2.9
NBL	2.9	2.8	2.8	2.7	2.6	2.6	2.5	2.5	2.4	2.3	2.3	2.7	2.7	2.5	2.5	2.4	2.5	2.4	2.5	2.6
OMBL	3	3	2.9	2.9	2.9	2.8	2.7	2.6	2.4	2.5	2.4	3	3	3	2.7	2.6	2.5	2.4	2.4	2.5
IMBL	2.7	2.6	2.5	2.4	2.4	2.3	2.3	2.3	2.3	2.4	2.4	2.5	2.5	2.5	2.6	2.5	2.4	2.3	2.3	2.3
BW	42	40.4	40.3	39.63	39.97	40.1	40	39.8	39.3	39.5	39	40	39.9	40	38.5	37.3	40	39.2	38	38.4

Table 7. Morphometric measurements, meristic counts and the abbreviations.

S. No.	Parameter	Abbreviation	S.No.	Parameters	Abbreviations
1	Total length	TL	17	Post-pectoral length	PoPL
2	Standard length	SL	18	Pre-anal length	PrAL
3	Head length	HL	19	Ventral fin length	VFL
4	Head width	HW	20	Pre-ventral length	PrVL
5	Head depth	HD	21	Post-ventral length	POVL
6	Upper lip length	ULL	22	Body depth	BD
7	Lower lip length	LLP	23	Caudal fin length	CFL
8	Mouth height	MH	24	Dorsal fin length	DFL
9	Horizontal mouth width	HMW	25	Dorsal fin base	DFB
10	Eye diameter	ED	26	Pre-dorsal length	PrDL
11	Interorbital length	IOL	27	Post-dorsal length	PoDL
12	Postorbital length	POL	28	Maxillary barbel length	MxBL
13	Anal fin length	AFL	29	Nasal barbel length	NBL
14	Anal fin base	AFB	30	Outer mandibular barbel length	OMBL
15	Pectoral fin length	PFL	31	Inner mandibular barbel length	IMBL
16	Pre-pectoral length	PrPL	32	Body weight	BW

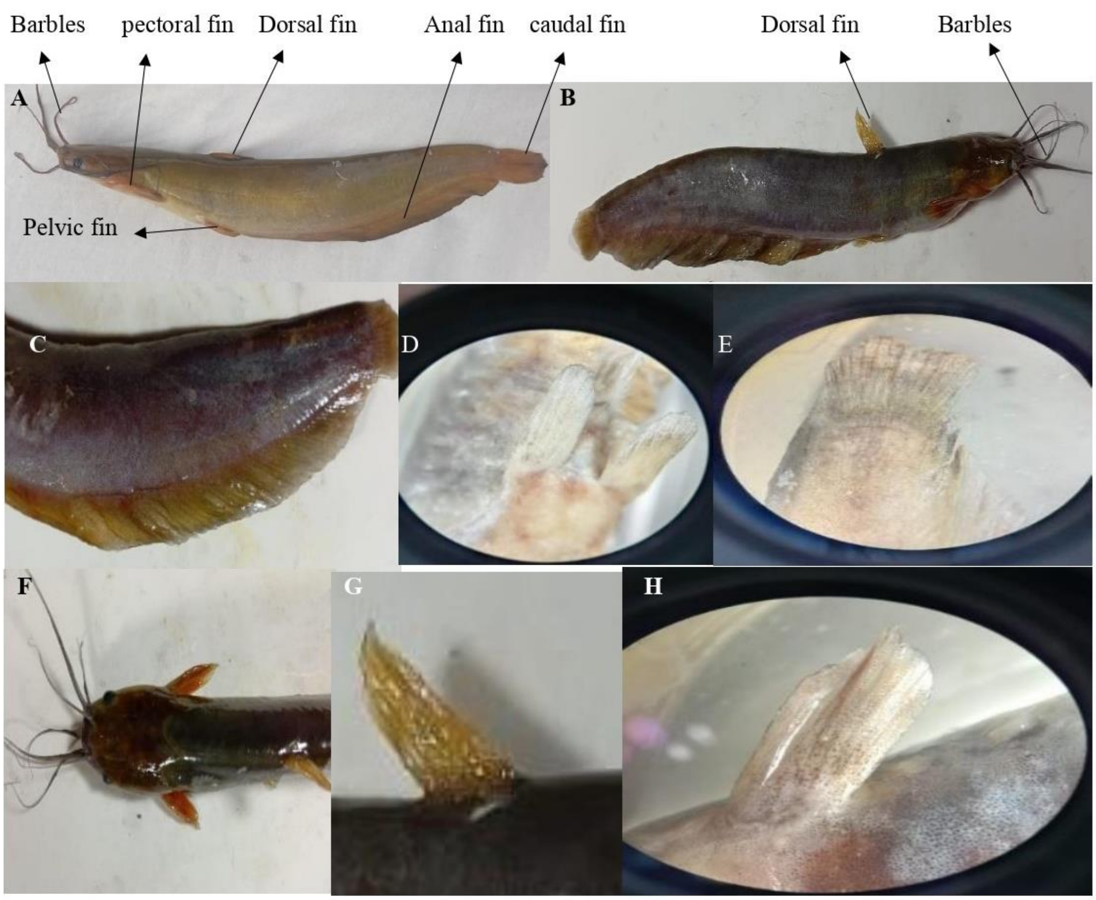

Figure 4. Pictorial representation of *H. fossilis*. In the figure (A)depicts the colour of the fish and its different parts (labeled) at the time of collection, (B) depicts the change in colour after preservation in ethanol, (C) is showing the anal fin, (D) the pelvic fin, (E) the caudal fin (F) is giving the dorsal view of the head and body, (G) is depicting the dorsal fin and (H) is showing the pectoral fin.

ecologically relevant finding is the negative allometric growth pattern (b < 3) identified in all notable Length-Weight Relationships (LWRs) signifying that an increase in body length surpasses the increase in body weight for the collected samples. Despite being statistically significant ($p < 0.01$ for TL, SL, PrDL, PoPL, PoVL, PrAL) the growth coefficient (b) values are markedly lower than the isometric value of 3(0.26 to 0.39). This phenomenon, in which fish show greater thinness and elongation throughout growth, is a thoroughly documented reaction to suboptimal environments (Froese, 2006). Multiple non-exclusive explanations and speculations given below may elucidate this phenomenon within the Kabul River population. A limited, substandard or inadequate food supply to satisfy the metabolic requirements is a primary factor in negative allometry. In such a scenario, individuals may tend to prioritize elongation which in turn can enhance their ability to evade predators and exploit new foraging areas (Hossain et al., 2006).
The River as we know may be experiencing multiple environmental stressors such as; pollution, elevated concentration of ammonia, variable water levels and elevated turbidity. Such factors are known to elevate metabolic expenses which in turn may results in lower biomass accumulation. It may be due to these facts as a plausible explanation that the energy necessary for osmoregulation, detoxification and managing hypoxia, despite their ability to breathe air may redirect resources away from weight gain. The sampling period (April-July) aligns with the mating season of *H. fossilis* in the area, as a matter of fact adults expends considerable effort in gamete production during this period (Rahman et al., 2019; Urmi et al., 2024). This extensive reproductive endeavor may result in a transient decline in physical condition causing the overall (b) value to fall below 3 warranting an all season lengthy survey. The relation (linear weight relationship) between post dorsal length Vs Body weight is not significant with a $p= 0.0625$ which can be indicative that the length of the caudal peduncle is not suitable for the estimation of body weight in this species. The morphology of this species is an excellent example for adaptations required for benthic, hypoxic and turbid conditions. The high PrDL and PoVL for *H. fossilis* signify the elongated cylindrical form which in turn is helpful for excavating and navigation, similarly the small eye diameter with respect to head length is a prevalent character among cat fishes residing in turbid waters, Conversely, the four pairs of elongated, chemosensory barbels (with Maxillary Barbels Length exhibiting a high association with Standard Length) constitutes the principal adaptation for foraging in low visibility environments. The strong pectoral and dorsal fin spines showing an increase in size with the body, serves as a vital defense mechanism throughout its lifespan. The negative allometric growth pattern may be viewed as a functional adaptation to shortage, enabling the fish to maintain development in size despite suboptimal conditions for mass accumulation. The limitations of this study include a relatively small sample size (n=20) collected over a single season which might have affected the results so a larger study spanning different seasons, localities and involving analysis of the gastric content and water quality is highly recommended.

CONCLUSION

This study provides the evidence that morphological characters such as meristic counts is an important identification tool for the species *H. fossilis* while other morphological associations such as the negative allometric growth points towards the overall population health and ecology of the habitat. Additional research and surveillance are required to determine the precise impact of certain environmental forces on the species in question. Such studies are highly recommended and of utmost importance for the conservation, management and sustainability of this species amidst the anthropogenic environmental pressure faced by fish species in river Kabul.

AUTHOR'S CONTRIBUTION

All authors agreed for publication for the present work and confirm that all materials, data, and results reported in this study are based on field and lab work followed by manuscript preparation and submission, where all authors made their due contributions; Muhammad Khan conducted the research work and wrote first draft of the manuscript, Muhammad Adnan conceived the idea and supervised the work throughout, Saeed anwar and Muhammad Ishtiyaq helped in collection of specimens, Tanzeela and Sanaullah Khan helped with statistical analysis of the data. All the authors read and approved the final manuscript.

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AVAILABILITY OF DATA AND MATERIAL

The datasets supporting this study are included in the article. Extended methodological details and raw data can be accessed by contacting the corresponding author, subject to ethical and institutional guidelines.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study did not involve human subjects or animal models. In accordance with institutional guidelines, ethical approval and informed consent requirements were formally waived for this research.

CONSENT FOR PUBLICATION

All the authors agree for the publication.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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