Research Article

Length-Weight Relationship, Growth Pattern and Condition Factor of *Hypophthalmichthys nobilis* from the Farming System of Bahawalnagar, Pakistan

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Abstract |Length-weight relationships (LWRs) and condition factor play a crucial role in fisheries assessment, offering valuable insights into information on fish overall fitness, health status and growth pattern. Hence, this study investigates the LWR, condition factor (K) and growth pattern of farm-reared *Hypophthalmichthys nobilis* from Bahawalnagar, Pakistan. A total of 28 fish specimens of *H. nobilis* with different body size were collected from a fish farm located at Bahawalnagar, Pakistan. Body weight (BW), total length (TL) and Fulton's Condition Factor (K) of the collected *H. nobilis* was ranged 360.27-850.35 g, 29.90-40.40 cm and 1.16-1.53, respectively. LWR of the fish was determined using the equation $W = a\ TL^b$, where W represents the weight (g) and TL denotes the total length (cm), and calculated as $W=-1.6587\ TL^{2.85}$ (r^2 =0.938). Length-weight relationship presented strong positive correlation ($p<0.001$). The *b*-values of LWR of the farmed *H. nobilis* was found as 2.85. The results revealed that the cultured species exhibited a negative allometric growth pattern, indicating a tendency toward a slimmer body profile. The study is valuable for monitoring system and establishing a management of the fish in farming system.

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Keywords | *Hypophthalmichthys nobilis*, Fish biometrics, LWR, Growth pattern, Condition factor, Farming system.

Introduction

In fishery biology, morphometric data plays a crucial role in identifying trends in fish life histories (Ferdaushy and Alam, 2015). For fishery biologists and taxonomists, statistical correlations between fish morphometric measures are also crucial (Mustafa and Brooks, 2008; Simon *et al.*, 2010; Hossain *et al.*, 2016).

In fisheries management, length-weight relationships (LWRs) are the most popular and extensively utilised methods for estimating biomass (Hossain *et al*., 2008; Adarsh and James, 2016). By developing a precise mathematical equation between length and weight, the link between fish length and weight is a frequently used tool in the field of fisheries to assess the biomass of stock from known lengths within the group (Le Cren, 1951; Gupta and Banerjee, 2015; Hossain *et al*., 2016). Additionally, this relationship allows for the association of fish life histories across regions, considering variation among species and populations, as well as a measure of the health of the fish population (Safran, 1992; Bayhan *et al*., 2008). The length-weight data shows how human activity affects aquatic ecosystems in a mirror image and offers a crucial hint about changes in the climate and environment (Sarkar *et al*., 2013). Studies on condition factor and length-weight relationships provide valuable knowledge to farmed fish producers because these indices are useful in measuring overall fish biomass production, onset of fish maturity, population densities, metamorphosis and fish growth (Hossain *et al*., 2006; Araneda *et al*., 2008; Ferdaushy and Alam, 2015; Abedin *et al*., 2024).

In the field of fisheries science, determining the growth quality is typically the first step, with the target species' weight-length relationship serving as the foundation (Demirel and Dalkara, 2012). Length-weight connection is employed in morphometric intra- and inter-specific population comparisons to determine the index of well-being of the fish population (Omoniyi *et al*., 2010; Laboni *et al*., 2024). Growth is a crucial life-history characteristic that determines a fish species' maximum size and age, maturity stage and mortality (Asadujjaman *et al*., 2024). It also plays a role in stock assessment models, which are frequently employed in the management or conservation of fisheries (Eido *et al*., 2024). The majority of morphometric research focuses on the size and shape of an organism's body (Webster, 2006; Kalhoro *et al*., 2015). Determining the age structure and growth pattern, or whether it is allometric or isometric, is also a necessary first step in understanding various elements of fish population dynamics (Le Cren, 1951; Quist *et al*., 2012).

Condition factor in fish indicates the physiological status of the fish with respect to its welfare (Le Cren, 1951). It can be used to assess well-being, fatness and fish condition, based on the straightforward premise that larger fish of a given length are in better condition (Froese, 2006; Jisr *et al*., 2018). The condition factor plays a crucial role in comprehending the life cycle of fish species and aids in their proper management, helping to preserve the ecosystem's equilibrium (Imam *et al*., 2010; Parvin *et al*., 2024).

Hypophthalmichthys nobilis (Cypriniformes, Xenocyprididae) commonly employed in aquaculture, is the fifth largest contributor to world aquaculture production, primarily coming from China (FAO, 2020). This species was first found in Asia and has since introduced to numerous countries and has achieved a near global distribution. *H. nobilis* (Bighead carp) is highly commercial and marketed as fresh and frozen form (Froese and Pauly, 2025).

The aim of the study was to provide information on the length-weight relationships, growth pattern and condition factor of farmed *H. nobilis* from Bahawalnagar, Pakistan.

Materials and Methods

A total of 28 specimens of *Hypophthalmichthys nobilis* (Bighead Carp) with different body size were collected from a local fish farm (latitude 30.055° and longitude 73.382°) of Bahawalnagar, Pakistan. Fish samples were caught by using drag nets during October, 2022. Collected fish samples were carried to Aquaculture and Fisheries Lab, The Islamia University of Bahawalpur, Bahawalnagar Campus, Bahawalnagar, Pakistan, for further analysis. The collected fish specimens were carefully cleaned with blotting paper and identified according to the systematic characters described by Froese and Pauly (2025).

Fish specimens were weighed to the nearest 0.01 g (body weight, BW) and measured to the nearest 0.1 cm (total length, TL). Fishes with broken caudal fin were not considered for the analyses. The LW relationship ($W = a\ TL^b$) was transformed into its logarithmic form: $ln\ W = ln\ a + b\ ln\ TL$. The regression parameters a (intercept) and b (slope) were determined through least-squares regression, along with the calculation of r^2 (coefficient of determination). Furthermore, the constants (a and b) of LWR were assessed using 95 % CI (confidence interval).

To classify the growth type as either isometric or allometric, the b-value of LWR was compared against

the isometric value (b = 3.0) (Gonzalez-Acosta *et al.*, 2004; Zar, 2014). Fulton's condition factor was calculated using formula, $K = 100^{*}W/TL^{3}$, where W denotes body weight and TL represents total length of the *H. nobilis*.

Results

Mean values of total length (TL), body weight (BW) and condition factor (K) were found 34.78±0.60 cm, 556.45±28.24 g and 1.30±0.02, respectively, for the collected specimens of farmed *H. nobilis* (Table 1).

Table 1: *Descriptive statistics of total length (cm), body weight (g) and condition factor for bighead carp (H. nobilis) collected from the farming system of Bahawalnagar, Pakistan.*

Parameter	Mean ±SE	Range
Total length	34.78±0.60	29.90-40.40
Body weight	556.45±28.24	360.27-850.35
Condition factor	1.30±0.02	1.16-1.53

SE=Standard error

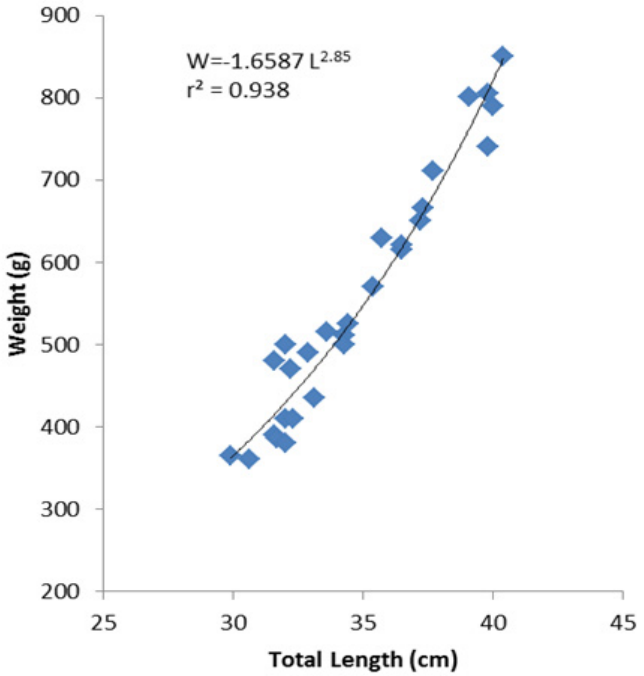

Figure 1: *Length-weight relationship of farmed H. nobilis from Bahawalnagar, Pakistan.*

Figure 1 shows the relationship between the fish length and wet weight of farm cultured *H. nobilis*. While, the parameters of LW relationships of logarithm-transformed data, calculated for farmed *H. nobilis*, are presented in Table 2. Length-weight relationship (LWR) represented strong positive correlation ($p<0.001$, r^2=0.938). Whereas TL and BW showed non-significant correlations ($p>0.05$) with the condition factor of farm-raised *H. nobilis* (Table 2).

The 95% confidence interval (CI) for b was determined to assess whether the hypothetical isometric value (b=3.0) fell within the interval. Slope value of LW relationship (b=2.85), being less than 3.0, indicated negative allometric pattern of growth in farmed *H. nobilis* (Table 2).

Discussion

The LWR and the condition factor are vital in fisheries assessments, providing valuable insights into fish growth, overall health, and fitness. Although, the sample size in the present study was relatively small, several considerations justify its adequacy for analyzing the length-weight relationship (LWR) of the studied fish species. In fisheries science, the coefficient of determination (r^2) and statistical significance of the regression model are often more critical indicators of model reliability than the absolute number of samples (Froese, 2006). The LWR of the studied fish species, *Hypophthalmichthys nobilis*, demonstrated a significant, positive, and strong correlation, indicating a consistent growth pattern where weight increases proportionally with length. These findings align with previous studies (Javaid *et al.*, 1992; Salam *et al.*, 2005; Naeem *et al.*, 2010; Hossain et al., 2016; Ishtiaq and Naeem, 2016; Khalid *et al.*, 2020; Ishtiaq *et al.*, 2021; Thomas *et al.*, 2025), highlighting reliability of LWR as a robust tool for understanding fish growth and resource management. Moreover, numerous peer-reviewed studies have demonstrated that valid and statistically meaningful LWR estimates can be derived from small sample

Table 2: *Statistics of regression parameters of farmed H. nobilis collected from Bahawalnagar, Pakistan.*

Equation	a	b	95% CI of a	95% CI of b	r^2
Log W = a + b Log TL	-1.6587	2.85	-2.1126 to -1.2049	2.56–3.15	0.938
Log K = a + b Log TL	0.3413	-0.15	-0.1126 to 0.7951	-0.44–0.15	0.040
Log K = a + b Log BW	0.0773	0.01	-0.2016 to 0.3562	-0.09–0.11	0.002

sizes, particularly when data quality is high and when length and weight are measured with precision (Petrakis and Stergiou, 1995; Binohlan and Pauly, 1998). It is also noteworthy that in our study, the sampled individuals of *H. nobilis* ranged between 360.27-850.35 g, which adequately represents the common size spectrum of the population and reduces the potential for bias introduced by extremely small or large individuals. Therefore, while a larger sample size is generally desirable, the range and quality of the data collected, combined with statistically robust results, support the scientific validity of the findings presented here.

To compare the length-weight relationship (LWR) estimates for *H. nobilis* obtained in this study with those of other species within the same family and various other species, a plot of log *a* versus *b* (Froese, 2006) from the global encyclopedia about fish, FishBase (Froese and Pauly, 2025) was utilized. The results revealed that the current estimate (represented by the black dot) closely aligns with the existing LWR data for *H. noilis* available in FishBase (red dot) and other species within the same family (green dots) (Figure 2). Comparison of slope (*b* value) in LW relationships of wild and farmed carps from different localities is also illustrated as Table 3.

Growth pattern of *H. nobilis* was evaluated on the basis of constant *b* value, as the growth pattern identifies as $b < 3$ for negative allometric growth, *b* value more than 3 for positive allometric growth, and $b = 3$ for the isometric growth pattern. In present study the estimated value of parameter *b* for LW relationship remained within the expected range of 2.5-3.5. Value of *b* remained less than 3 revealed negative allometric type of growth pattern for *H. nobilis*.

Table 3: *Comparison of slope (b value) in LWRs of wild and farmed carps.*

Fish species	Catchment	b value	Reference
Aristichthys nobilis	Farmed	2.80	Salam *et al.* (1993)
Aristichthys nobilis	Farmed	3.32	Naeem and Salam (2005)
Catla catla	Farmed	3.04	Ishtiaq and Naeem (2016)
Catla catla	Farmed	3.23	Khalid *et al.* (2020)
Cyprinus carpio	Wild	3.02	Khan *et al.* (2020)
Labeo boga	Wild	2.37	Khalid *et al.* (2023)
Hypophthalmichthys nobilis	Wild	2.77	Vilchez *et al.* (2024)
Ctenopharyn. idella	Wild	2.28	
H. molitrix	Wild	3.10	

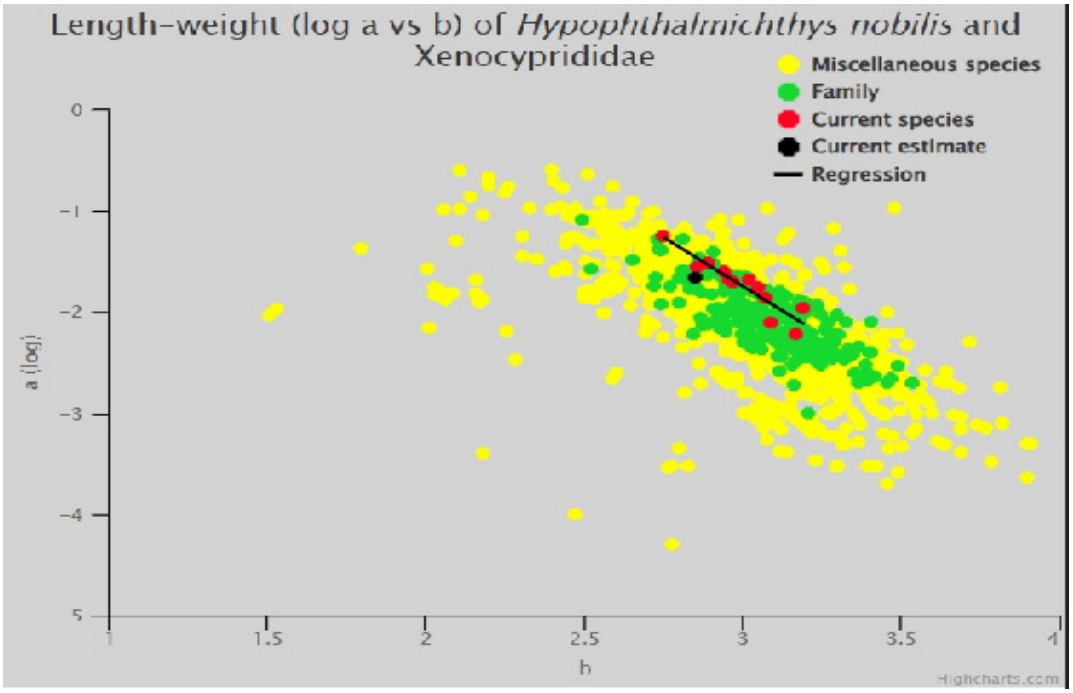

Figure 2: *Comparative LWR plot between logarithm of a and b-value of the studied fish species in this study (Hypophthalmichthys nobilis), with the data available on fishbase for the same fish species and other fishes.*

The observed negative allometric pattern of growth in our results indicates that the fish's weight increases at a slower rate than its length, suggesting shape changes as the fish grows. Negative allometric growth pattern has also been reported in studies such as Ishtiaq and Naeem (2016), Rashıd *et al.* (2018), Wani *et al.* (2020) and Thomas *et al.* (2025). Additionally, fish specimens with negative allometric growth, as observed in the present study, are known to undergo body shape changes influenced by their nutritional condition (Ruiz-Campos *et al.*, 2006; Ishtiaq and Naeem, 2016). These findings suggest that nutritional factors may play a significant role in shaping growth patterns of the studied fish population.

On the other hand, *b*-value, in present study, deviates from the findings of Yousaf *et al.* (2009), Pervaiz *et al.* (2012) and Ishtiaq *et al.* (2021), who have reported either isometric or positive allometric type of growth patterns in different fish species. Difference might be due to various factors including sexual maturity (Pervaiz *et al.*, 2012; Barros *et al.*, 2023), size and nutrition (Ruiz-Campos *et al.*, 2006; Ishtiaq and Naeem, 2016). Moreover, Vilchez *et al.* (2024) found that although young female bighead carp were initially smaller than their male counterparts, as they grew older, they became much bigger than male bighead carp. However, Papoulias *et al.* (2006) found no sex differences were in bighead carp. Thus, further investigation is required to explore the potential influence of other variables on the observed growth dynamics.

Fulton's condition factor (*K*) is used to assess the growth condition of fish, with values ≥1 indicating good growth and values <1 indicating poor growth, hence serves as an effective indicator of fish growth rates, age, and feeding intensity (Ndimele *et al.*, 2010; Ragheb, 2023). Fish living and feeding conditions are largely assessed using the condition factor (K) (Mozsar *et al.*, 2015). In present study the value of condition factor (K) found 1.30 which means that the fish (*H. nobilis*) samples were in good physiological condition in farming system. Similar value of condition factor was reported by Hossain *et al.* (2016), Ishtiaq and Naeem (2016) and Chitrakar and Parajuli (2017) in different fish species. In current study the value of condition factor deviate from the findings of Wani *et al.* (2020) and El-Bokhty and Mehanna (2023). This difference in value of condition factor may be due to difference in fish size, feeding intensity (Le Cren, 1951; Thakur, 1975), position of sexual maturity, sex and age of fish (Gomiero, 2005), and environmental conditions (Blackwell *et al.* 2000).

Conclusions and Recommendations

The results obtained for farmed *Hypophthalmichthys nobilis* displayed negative allometric growth pattern. The observed condition factor values further suggested that the fish samples were in good health inside the body of water. The obtained results are valuable for updating length-weight relationship parameters for data-poor fish species from the farming system of the studied area.

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Novelty Statement

This study provides novel insights into the length-weight relationship, growth pattern, and condition factor of *Hypophthalmichthys nobilis* cultured in Bahawalnagar, Pakistan, offering valuable baseline data for aquaculture management and stock assessment in the region. The findings contribute to understanding species-specific growth dynamics in a controlled farming system, aiding sustainable fisheries development.

Author's Contribution

Maria Younas: Data curation, Formal analysis, Investigation, Methodology, Writing original draft.
Rehmat: Formal analysis, Investigation, Methodology
Zara Naeem: Data curation, Methodology, Software, Writing – original draft.
Waheed Ali Anjum: Formal analysis, Investigation, Methodology
Nida Maqsood: Formal analysis, Investigation, Methodology
Mughisa Hashim: Formal analysis, Investigation, Methodology
Tasveer Ishtiaq: Data curation, Methodology, Software, Writing original draft.
Abir Ishtiaq: Conceptualization, Resources, Supervision, Writing review & editing.

Muhamamd Naeem: Supervision, Writing - review and editing.

Generative AI or AI assisted technology statement

No generative AI or AI-assisted technologies were used in the preparation of this work.

Conflict of Interest

The authors have declared that there is no conflict of interest.

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