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COMPARATIVE MORPHOBIOLOGICAL ASSESSMENT AND LENGTH–WEIGHT RELATIONSHIPS OF GRASS CARP (Ctenopharyngodon idella VALENCIENNES, 1844) BROODSTOCK FROM THREE POND FARMS IN THE TASHKENT REGION

Khudayberganova Kh[1]
Assistant Lecturer
Email: Zarazayka.1995.18@gmail.com

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ABSTRACT

This study compared the morphobiological characteristics and length–weight relationships of grass carp (Ctenopharyngodon idella Valenciennes, 1844) broodstock maintained at three pond farms in the Tashkent region. Ninety-three mature fish were sampled in October 2025, with 31 individuals obtained from each farm. Total length, standard length, body weight, and Fulton's condition factor were determined. Pearson correlations, the regression model $W = aL^b$, and one-way analysis of variance were used. Khorrot Fish LLC recorded the highest mean total length (66.55 ± 1.16 cm), standard length (57.15 ± 1.13 cm), and body weight (3.88 ± 0.18 kg). Farm differences were significant for total length, standard length, and body weight, whereas Fulton's condition factor did not differ significantly. Total length was strongly correlated with body weight in all farms. The farm-specific allometric coefficients ranged from 1.866 to 2.209, and the pooled coefficient was 2.252, indicating negative allometric growth. The findings support the use of morphometric monitoring in broodstock assessment and selection, while causal interpretations of farm differences require controlled studies of feed, water quality, age, sex, and management.

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Keywords: *grass carp; Ctenopharyngodon idella; broodstock; pond aquaculture; morphometry; length–weight relationship; Fulton's condition factor; selective breeding.*

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INTRODUCTION

Aquaculture is an increasingly important component of the global food system and contributes substantially to the supply of high-quality animal protein. The continued expansion of aquaculture increases the need for efficient production systems, reliable biological monitoring, and scientifically informed broodstock management (Food and Agriculture Organization of the United Nations [FAO], 2024). In Uzbekistan, the development of pond aquaculture and selective breeding is particularly relevant to food security and the sustainable growth of the fisheries sector.

Grass carp (*Ctenopharyngodon idella* Valenciennes, 1844) is widely cultured because of its rapid growth, effective utilization of plant biomass, ecological adaptability, and economic importance. The interpretation of fish condition and growth commonly relies on morphometric measurements, Fulton's condition factor, and length–weight models (Le Cren, 1951; Froese, 2006; Froese et al., 2011). Pond

productivity is influenced by the interaction of water quality, feeding, and husbandry practices (Boyd & Tucker, 1998). Studies of grass carp have further demonstrated that feeding rate, diet composition, and production system affect growth, feed efficiency, body composition, muscle quality, and survival (Du et al., 2006; Mahmood et al., 2018; Zhao et al., 2018; Kristan et al., 2019; Gharti et al., 2023).

Morphometric traits also provide useful information for broodstock selection. Quantitative-genetic and genomic investigations have identified exploitable variation in growth and body-shape traits in grass carp (Fu et al., 2016; Jiang et al., 2022; Guo et al., 2022; Chen et al., 2025). Regional research from the Tudakul Reservoir confirms the relevance of morphometric and length–weight analyses for grass carp in Uzbekistan (Sobirov et al., 2019). However, comparative evidence for broodstock maintained under different farm conditions in the Tashkent region remains limited. Therefore, this study aimed to compare total length, standard length, body weight, Fulton's condition factor, and length–weight relationships in grass carp broodstock from three pond farms and to assess the practical value of these indicators for broodstock monitoring and selection.

MATERIALS AND METHODS

Study design and sampling. The study was conducted during 2023–2025 at three pond fish farms in the Tashkent region: Khorrot Fish LLC, ZAFARASAD Farm, and Imkon Baliq Fayz LLC. Biometric sampling was performed in October 2025. A total of 93 sexually mature and apparently healthy grass carp were selected by random sampling, with 31 fish obtained from each farm. Fish showing visible deformities, mechanical injury, or clinical signs of disease were excluded.

Rearing and feeding conditions. Fish were maintained under intensive pond-culture conditions supported by the natural food base and commercial compound feeds. Khorrot Fish LLC used an Iranian common-carp feed containing approximately 32–35% protein; ZAFARASAD Farm used Aller Aqua feed containing approximately 30–35% protein; and Imkon Baliq Fayz LLC used Shench Jou feed produced through Chinese–Uzbek cooperation. The reported daily feeding rate was approximately 2% of body weight. Water temperature, dissolved oxygen, pH, and transparency were monitored by the farms, and routine fish-health and veterinary-preventive measures were implemented according to current production practices.

Morphometric measurements. Total length (TL, cm), standard length (SL, cm), and body weight (W, kg) were measured for each fish. Lengths were recorded to the nearest millimetre with an ichthyological measuring board. Total length was measured from the tip of the snout to the most posterior point of the caudal fin, whereas standard length was measured from the tip of the snout to the base of the caudal fin. Body weight was measured to the nearest gram using an electronic balance. Each measurement was repeated three times, and the mean value was used in the analysis.

Condition and growth calculations. Body proportions were evaluated using the SL/TL ratio. Fulton's condition factor was calculated as $K = 100W/L^3$, where W is body weight in grams and L is total length in centimetres. The length–weight relationship was estimated using $W = aL^b$, where a is the regression constant and b is the allometric coefficient (Le Cren, 1951; Froese, 2006). Growth was interpreted as isometric when $b = 3$, positively allometric when $b > 3$, and negatively allometric when $b < 3$.

Statistical analysis. Data were processed in Microsoft Excel 2021 and IBM SPSS Statistics. Descriptive statistics included the number of observations, mean, standard deviation, standard error, range, coefficient of variation, and 95% confidence interval. Associations among morphometric variables were assessed using Pearson's correlation coefficient. Length–weight parameters were estimated by least-squares regression, and model fit was summarized with the coefficient of determination (R^2). Differences among farms were evaluated using one-way analysis of variance. Statistical significance was set at $p < 0.05$.

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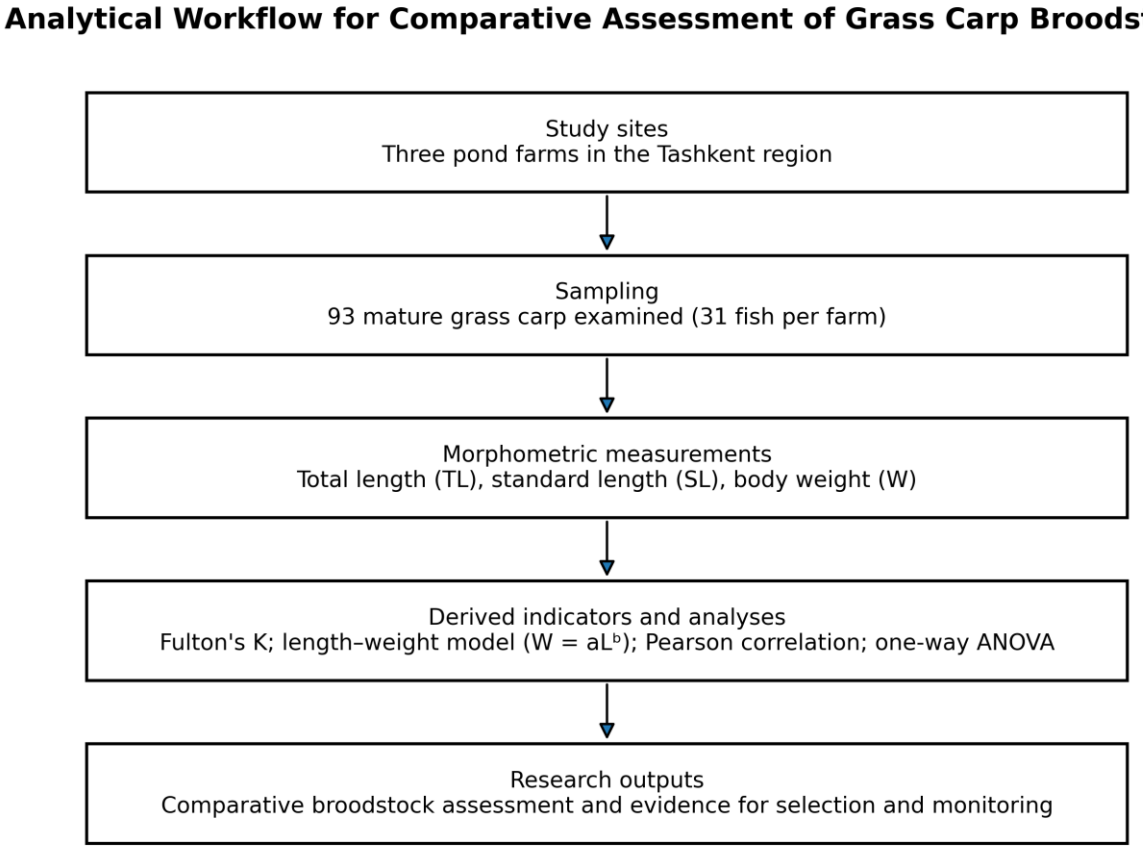


Figure 1. Analytical workflow for the comparative assessment of grass carp broodstock in the Tashkent region.

RESULTS

The three farms differed in broodstock size characteristics (Table 1). Khorrot Fish LLC had the highest mean total length (66.55 ± 1.16 cm), standard length (57.15 ± 1.13 cm), and body weight (3.88 ± 0.18 kg). ZAFARASAD Farm ranked second for these measurements, with a mean total length of 63.19 ± 0.94 cm, standard length of 53.90 ± 1.01 cm, and body weight of 3.38 ± 0.11 kg. Imkon Baliq Fayz LLC had the lowest means: 61.13 ± 0.81 cm for total length, 50.66 ± 0.80 cm for standard length, and 2.92 ± 0.10 kg for body weight. Fulton's condition factor ranged from 1.28 ± 0.03 to 1.35 ± 0.04.

Table 1. Descriptive statistics by farm (mean ± SE)

Farm	n	TL (cm)	SL (cm)	W (kg)	Fulton's K
Khorrot Fish LLC	31	66.55±1.16	57.15±1.13	3.88±0.18	1.31±0.03
ZAFARASAD Farm	31	63.19±0.94	53.90±1.01	3.38±0.11	1.35±0.04
Imkon Baliq Fayz LLC	31	61.13±0.81	50.66±0.80	2.92±0.10	**1.28±0.03**

Table 2. Variability of total length and body weight by farm

Farm	TL SD	TL CV (%)	W SD	W CV (%)
Khorrot Fish LLC	6.45	9.70	1.01	25.93
ZAFARASAD Farm	5.22	8.27	0.63	18.62
Imkon Baliq Fayz LLC	4.50	7.36	0.54	18.57

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Table 3. Pearson correlation coefficients among morphometric variables			
Farm	**TL–SL**	**TL–W**	**SL–W**
Khorrot Fish LLC	0.953	0.855	0.838
ZAFARASAD Farm	0.935	0.789	0.695
Imkon Baliq Fayz LLC	0.954	0.853	0.770

Table 4. Length–weight regression models			
Farm	**Regression equation**	**b**	**R^2**
Khorrot Fish LLC	$W = 0.000369 \times TL^{2.201}$	2.201	0.779
ZAFARASAD Farm	$W = 0.001460 \times TL^{1.866}$	1.866	0.631
Imkon Baliq Fayz LLC	$W = 0.000328 \times TL^{2.209}$	2.209	0.706
Overall (n = 93)	$W = 0.000289 \times TL^{2.252}$	2.252	0.748

Table 5. One-way analysis of variance comparing farms		
Indicator	**F**	**p**
TL	7.800	0.00075
SL	10.913	0.00006
W	12.603	0.000015
Fulton K	1.117	0.332

DISCUSSION

Body-weight variability was highest at Khorrot Fish LLC (CV = 25.93%), whereas ZAFARASAD Farm and Imkon Baliq Fayz LLC showed similar coefficients of variation (18.62% and 18.57%, respectively; Table 2). This pattern indicates greater heterogeneity in the Khorrot Fish broodstock and may provide a broader phenotypic range for selection, although age and sex composition were not available for direct evaluation. Total length and standard length were very strongly correlated in all farms (r = 0.935–0.954), and total length was strongly associated with body weight (r = 0.789–0.855; Table 3). These relationships support the use of routine length measurements as practical indicators of broodstock size.

The length–weight models explained 63.1–77.9% of the within-farm variation in body weight (Table 4). The farm-specific b coefficients ranged from 1.866 to 2.209, and the pooled value was 2.252. Because every estimate was below 3, the broodstock exhibited negative allometric growth: weight increased with length, but less rapidly than expected under isometric growth. This interpretation is consistent with established recommendations for fish length–weight analysis (Le Cren, 1951; Froese, 2006; Froese et al., 2011).

One-way ANOVA identified significant farm differences in total length ($F = 7.800$, $p = 0.00075$), standard length ($F = 10.913$, $p = 0.00006$), and body weight ($F = 12.603$, $p = 0.000015$), whereas Fulton's condition factor did not differ significantly ($F = 1.117$, $p = 0.332$; Table 5). Thus, the farms differed in broodstock size but not in the measured condition index. The higher mean size at Khorrot Fish LLC and ZAFARASAD Farm may be associated with feeding regime, environmental conditions, stock structure, or broodstock-selection practices. However, because farms were not randomly assigned to treatments and feed type, water-quality measurements, age, and sex were not analysed as covariates, the present observational design cannot establish which factor caused the differences.

The biological plausibility of the observed farm variation is supported by research showing that water quality, feeding rate, diet composition, and culture system influence grass carp growth and performance (Boyd & Tucker, 1998; Du et al., 2006; Mahmood et al., 2018; Zhao et al., 2018; Kristan et al., 2019; Gharti et al., 2023). Furthermore, quantitative-genetic and genomic studies indicate that growth and body-shape measurements can contribute to broodstock improvement (Fu et al., 2016; Jiang et al., 2022; Guo et al., 2022; Chen et al., 2025). The present results are also broadly comparable with regional morphometric research on grass carp in Uzbekistan (Sobirov et al., 2019). Future work should use repeated seasonal sampling, record age and sex, report farm-level water-quality and feed-intake data, and apply multivariable or mixed-effects models to distinguish management effects from biological differences among stocks.

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CONCLUSION

Grass carp broodstock from the three pond farms differed significantly in total length, standard length, and body weight, with Khorrot Fish LLC recording the highest mean values and Imkon Baliq Fayz LLC the lowest. Fulton's condition factor did not differ significantly among farms. Strong positive correlations among length and weight variables confirmed the practical value of morphometric monitoring, while all farm-specific and pooled b coefficients indicated negative allometric growth. These results can support routine broodstock assessment and the preliminary identification of large, phenotypically promising individuals. Nevertheless, selection decisions should combine morphometric evidence with reproductive performance, age, sex, health, genetic background, feed intake, and water-quality data. Controlled and longitudinal studies are required before farm differences can be attributed to specific feeding or management technologies.

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