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Short Communication
Determination of Growth Indicators for *Cyprinus carpio* (Linnaeus, 1758) in Anzali Lagoon, Iran

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Abstract

Background and Objective: Understanding the biology of fish is crucial for ensuring the sustainable management and conservation of their biodiversity. The objective of this study was to observe the condition factors and length-weight relationships of *Cyprinus carpio*, which can provide valuable insights into the ecological and nutritional conditions of aquatic animals. **Materials and Methods:** Condition factor (CF) and length-weight relationship (LWR) for 100 specimens of *C. carpio* collected from the Anzali Lagoon 2016 (April to August) were studied. To determine the size of each fish, the total length using a caliper with a precision of 0.1 mm and the weight using a balance with an accuracy of 0.1 g was measured. Differences were analyzed using ANOVA with the Tukey's *post hoc* test. In order to evaluate the differences in sexes each month, a non-parametric Chi-square test was employed. **Results:** The total length and body weight of *C. carpio* ranged from 9.1-53.8 cm and 110.3-5565.2 g, respectively. It was observed that there is a strong positive correlation between length and weight ($r = 0.96$). The results revealed they had a negative allometry growing rate. In the condition factors, there were no significant differences between male and female specimens ($p>0.05$). The observed sex ratio suggests no significant difference between males and females ($p>0.05$). **Conclusion:** The Anzali Lagoon population of *C. carpio* exhibited allometric growth, as evidenced by a strong correlation between length and weight represented by a high "r" value.

Key words: Length-weight relationship (LWR), condition factor, *Cyprinus carpio*, Anzali Lagoon, growing rate

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Wetlands are considered the most biologically diverse of all ecosystems. However, the Anzali Lagoon also has a special ecotone because the lagoon's water is between freshwater and brackish ecosystems[1]. The Anzali Lagoon is located in an area of 15,000 ha on the Southern Coast of the Caspian Sea. Anzali Lagoon is essential for the spawning period time of fish species[2].

Cyprinus carpio is native to Europe and Asia. This particular fish has been selectively bred for its ornamental qualities and for use in aquaculture. This type of fish can reach biomasses of up to 3144 kg ha^{-1} and densities of 1000 individuals per ha. One of the most commercially important freshwater fish species that is widely farmed[3]. Aquaculture production of common carp increases parallel to the global production of freshwater fishes. Karnai and Szücs[4] reported that common carp production was 4,447,000 tons by 2015.

The condition factor is a commonly used index to measure fish's growth and feeding intensity. As the fish's length increases, this index's value decreases and affects their reproductive cycle. This factor indicates the impact of seasonal and habitat differences on the overall health and robustness of the species[5].

Research on fish biology is necessary for the sustainable preservation and management of fish diversity[6]. Comprehending the length-weight relationships of aquatic organisms like fish is crucial for effective fishery management. This helps to assess the average weight of a particular length and the overall health of the population[7]. Therefore, this study evaluated the condition factor and length-weight relationship (LWR) of *C. carpio* in Anzali Lagoon, Iran.

MATERIALS AND METHODS

Study area: Three localities were used in this study, namely site 1 (GPS coordinates: 37°47'026.42"N and 49°34'307.12"E) and site 2 (GPS coordinates: 37°41'2998.45"N and 49°41'6902.1"E) site 3 (GPS coordinates: 37°44'2998.45"N and 49°44'6902.1"E) in Anzali Lagoon. The study was carried out from April, 2016 to August, 2016.

Specimen sampling: As soon as the samples were gathered (100 specimens), they were carefully stored in iceboxes and taken to the fish biology laboratory for further examination. The pieces were then sorted into male and female groups. To determine their size, the total length of each fish was measured using a caliper (Caliper PRO 300 mm, France) with a precision of 0.1 mm. Additionally, the weight of each fish was measured using a balance (Adam Lbx Bench Portion Scale, UK) with an accuracy of 0.1 g.

Growth pattern (length and weight): The total length of the assessed *C. carpio* individuals was recorded. The fish's length-weight relationship was estimated through linear regression using the following equation[8]:

$$W = aL^b$$

Where, W is weight (g), L is total length (cm), a is intercept (regression constant) and b is slope (regression coefficient).

Condition factor (F): The condition factor (F) indicates the fish's physical health. The F was determined monthly and by gender. The equation used to calculate *C. carpio's* condition factor is[9]:

$$F = \frac{W}{L^3} \times 100$$

Where, F is condition factor, L is length (cm) and W is weight (g).

Sex ratio: The sex ratio of male-to-female fish caught during the sampling period was estimated using Pena-Mendoza *et al.*[10] method:

$$\frac{M}{F}$$

Where, M is number of males and F is number of females.

Statistical analysis: To determine if the data was normal, the Shapiro-Wilk test was used. Differences were analyzed using Analysis of Variance (ANOVA) with the Tukey's *post hoc* test to determine significance ($p<0.05$). A non-parametric (Chi-square) test was used to evaluate the differences in sexes each month. Statistical analyses were conducted using SPSS (version 16) and figures were created using Excel (version 2022).

RESULTS

Length-frequency distribution: The mean weight and length of *C. carpio* were 1757.7±110 g and 48.12±15 cm, respectively (Table 1). The data revealed a significant difference in total length between samples collected in

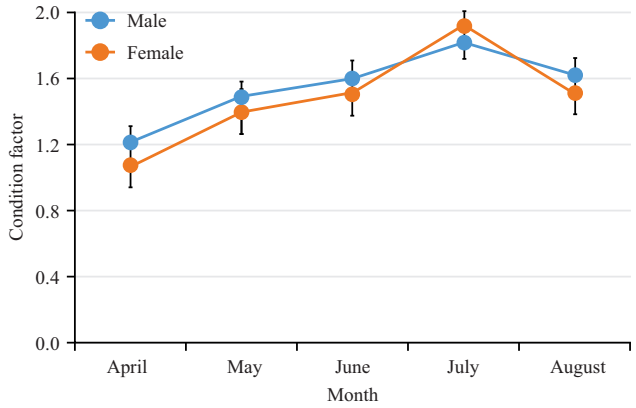

Fig. 1: Condition factor for both males and females in *C. carpio* from Anzali Lagoon (p>0.05)

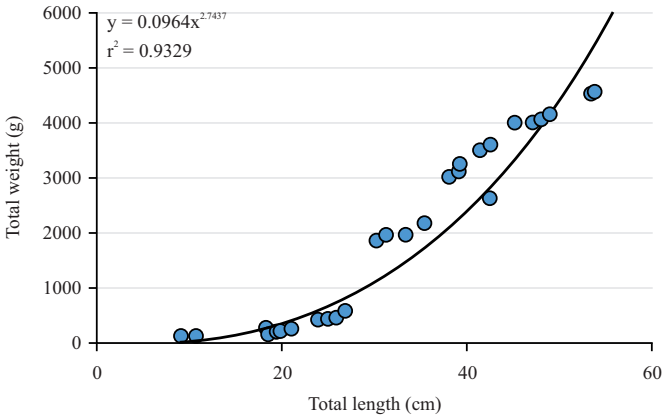

Fig. 2: Length-weight relationship of *C. carpio* for male (p<0.05)

Table 1: Biological data of examined specimens of *C. carpio* in the Anzali Lagoon

Month	Weight±SE (g)	Length±SE (cm)
April	1020.3±8[a]	38.6±6[a]
May	1239.2±8[a]	40.6±5[a]
June	1399.5±11[a]	41.5±9[a]
July	2531.4±16[b]	51.3±21[b]
August	2598.6±12[b]	53.6±23[b]
Mean	1757.7±110	48.12±15

Different letters in superscript signify statistically significant differences from one another (p<0.05) and the ranges are average±standard error

different months (p<0.05). However, no significant difference was observed among the samples collected in April, May and June (p>0.05) (Table 1). The analysis of body weight variance also indicated significant differences among different months (p<0.05). Nevertheless, no significant difference was found in April, May and June (p>0.05), as shown in Table 1.

Condition factor: The condition factors of male and female *C. carpio* fish vary over time, as shown in Fig. 1. Male condition factor ranged from 1.2 in April to 1.8 in July, while female condition factor ranged from 1.07 in April to 1.9 in July (Fig. 2). Importantly, there was no significant difference in condition factor between the two sexes (p>0.05).

Sex ratio: The male-to-female ratio was 1:1.02, indicating equal sexual frequency in this species' population ($\chi^2 = 58$ and p>0.05).

Length-weight relationship: Figure (2-4) display the plots of the length-weight relationship (LWR) for *C. carpio* from the Anzali Lagoon. The results showed a strong positive correlation between the fish's length and weight, with an R-squared value of 0.93 for males, 0.96 for females and 0.95 for both sexes combined. The regression coefficient (b) ranged between 2.74 for males and 2.70 for females. A t-test analysis revealed significant differences (p<0.05) in the allometric growth rates (b-values) of this fish, indicating negative allometry growth for *C. carpio* from Anzali Lagoon.

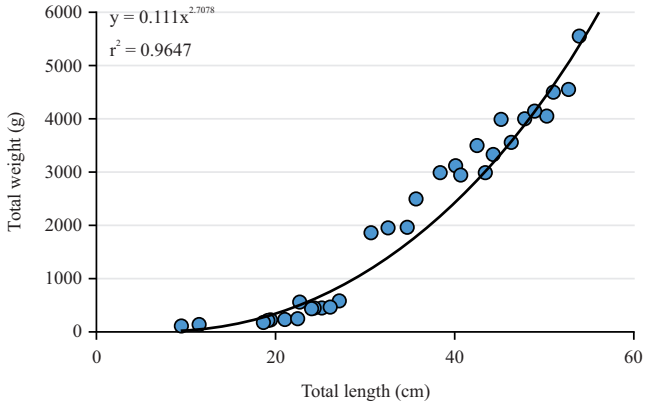

Fig. 3: Length-weight relationship of *C. carpio* for female (p<0.05)

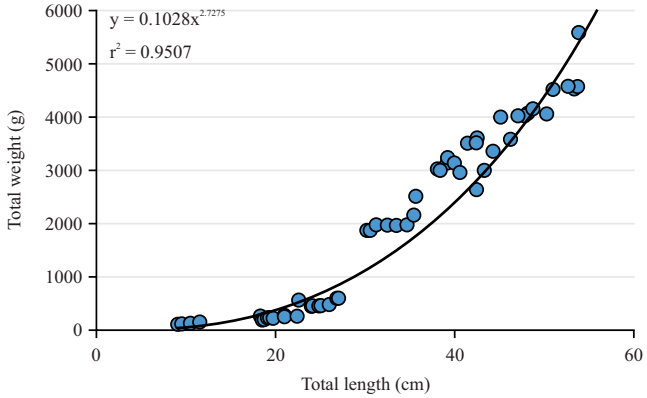

Fig. 4: Length-weight relationship of *C. carpio* for both sex (p<0.05)

DISCUSSION

The results of samples for *C. carpio*, the length-weight relationship (LWR) showed a strong correlation between total length and weight. The b values indicated that *C. carpio* exhibits negative allometric growth, which was consistent with previous studies conducted by Ilhan and Sarı[11] on *C. carpio*. However, Khan *et al.*[12] and Andreu-Soler *et al.*[13] reported an isometric growth pattern for *C. carpio* in Pakistan and Spain, respectively. Some recognized factors that influence the length-weight relationship of a species include the growth phase, salinity, temperature, food, season, stomach fullness, gonad maturity, sex and fish health[6]. The present study did not consider these factors. The present study did not consider these factors. The study found a strong correlation (r^2 = 0.98-0.99) between length and weight. The high coefficient of determination r^2 indicated a good fit for the model analysis. The condition factor results demonstrate *C. carpio* well-being in Anzali Lagoon.

Interestingly, there was no significant difference in the condition factor between males and females. However, the highest condition factor was observed in July, a hot month in Iran. This finding was consistent with the results of a study by İlhan and Sarı[11] compared the condition factors of *C. carpio* from Turkey. They found that the fish was in good condition during the hot season. Additionally, Zargar *et al.*[14] demonstrated that environmental factors strongly influence the condition factor. Aminisarteshnizi[1] further reported that the condition factor can vary due to feeding regime, time of year, organisms used, biological factors and responses to environmental changes.

The study found that gender does not affect the length-weight relationships in *C. carpio*. Additionally, there was no difference in the condition factor between males and females. The carp's growth is influenced by the water's physical and chemical conditions, as well as the availability of food, resulting in allometric growth. As *C. carpio* can significantly impact the diets of other aquatic animals, it is crucial to study their biological factors to effectively manage other species in

the Anzali Lagoon. Therefore, understanding the length-weight relationships and condition factors of *C. carpio* is vital to managing aquatic species efficiently.

CONCLUSION

In the Anzali Lagoon, the *C. carpio* species exhibited allometric growth. Additionally, a strong correlation was observed between length and weight, as indicated by the high correlation coefficient "r" value. The model used for the analysis was also found to be a good fit for the data, as suggested by the high value of the coefficient of determination r^2. The condition factor of *C. carpio* in the Anzali Lagoon was excellent, indicating favorable conditions for the species' growth. Understanding the length-weight relationships and condition factors of introduced or invaded species is crucial for effectively managing alien and native species in aquatic systems.

SIGNIFICANCE STATEMENT

This study discovered the growth indicators such as length-weight relationship and condition factor in *C. carpio* in the Anzali Lagoon. This study can benefit fish ecology and management. Therefore, this study is crucial to understanding the biological factors of fish to manage in the Anzali Lagoon effectively. In addition, this study will help the researchers uncover the critical areas of finding out the feeding strategy of the fishes that many researchers could not explore.

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