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Research Article
Condition Factor and Length-Weight Relationship of *Scardinius erythrophthalmus* (Linnaeus, 1758) in Anzali Lagoon

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Abstract

Background and Objective: Studies on fish biology are essential for the sustainable management and conservation of fish biodiversity. This study observed the length-weight relationships and condition factors of common rudd fish, which give us some information about the ecological and nutritional conditions of fish. This information is crucial to fishery management. **Materials and Methods:** The length-weight relationship (LWR) and condition factors (K) of 270 *Scardinius erythrophthalmus* caught in Anzali Lagoon from April to August, 2015. **Results:** The total length and body weight of *S. erythrophthalmus* ranged from 94-179 mm and 11.98-98.5 g, respectively. A strong positive relationship was observed between length and weight ($r = 0.96$). There were no significant differences in the condition factors of males and females ($p>0.05$). The lowest K value was observed in April ($K = 1.5 \pm 0.04$) and the highest in July ($K = 2.25 \pm 0.34$). The sex ratio of 1.0 male: 1.15 female was observed, with no significant difference between males and females ($p>0.05$). **Conclusion:** In this study, the regression coefficient (b) in males and females was 3.35 and 3.29, respectively, more than 3.0, which means they have positive allometry growth in both sexes.

Key words: Length-weight relationship, condition factor, *Scardinius erythrophthalmus*, Anzali Lagoon, fish biodiversity

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Competing Interest: The authors have declared that no competing interest exists.

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

INTRODUCTION

In recent years, eutrophication has been one of the greatest dangers to water resources in the Anzali Lagoon. Eutrophication reduces water quality, protection value and biodiversity of aquatic ecosystems[1]. To understand the effect of eutrophication on a marine ecosystem and fight effectively within that, to know threatened fish species' biological and ecological features is essential[2]. *Scardinius erythrophthalmus* is one of the family Cyprinidae species widely distributed in the Palaearctic region. In Iran, its distribution is in the Caspian Sea, Anzali Lagoon and Aras River. *Scardinius erythrophthalmus* is considered native to the Anzali Lagoon. In the Anzali Lagoon, *S. erythrophthalmus* is considered in Conservation Dependent IUCN categories medium abundance[3]. Their main foods are aquatic plants, invertebrates, planktonic organisms, insect larvae and fish eggs[4]. Also, it has been stated that the species shows an ontogenetic type of feeding and that the species applies strong predation on submerged vegetation, zooplankton and benthic invertebrates[5].

Understanding length-weight relationships in aquatic organisms such as fish are crucial to fishery management[6]. Condition factor for fish has also been widely used as an index of their growth and feeding intensity[7]. The value of this index decreases with any increase in length and impacts the fish's reproductive cycle. The condition factor reflects the effects of seasonal and habitat differences in the species' robustness[8]. This study aimed to evaluate the condition factor and length-weight relationship (LWR) of *S. erythrophthalmus* in the Anzali Lagoon.

MATERIALS AND METHODS

Study area: Specimens of *S. erythrophthalmus* were collected from the Anzali Lagoon. In this study, two localities were used, namely site 1 (GPS coordinates: 37°27'9446.43"N and 49°22'9944.18"E), site 2 (GPS coordinates: 37°28'28.8"N 49°21'03.5"E), which is a preferred habitat for the species. Three traps were randomly selected for the sampling of this fish. All the traps were used simultaneously for the sampling of *S. erythrophthalmus* in this study. The traps were checked every 24 hrs and the samples were collected at night, 10 nights per month for 5 months (April to August, 2015).

Specimen sampling: All collected samples were immediately placed in iceboxes and transported to the fish biology laboratory for further analyses. Samples were sorted into males and females. Total length was measured for each sample with a biometric board nearest 0.1 mm. The fish weighed with a balance to the nearest 0.1 g.

Growth pattern (length and weight): The recorded length (total length) of the individuals of the assessed fish species was used. In all, a total of 270 specimens of *S. erythrophthalmus* were examined for the present study.

The length-weight relationship of fishes was estimated using linear regression[9]. According to the following equation:

$$W = aL^b$$

Where:
W = Weight (g)
L = Total Length (cm)
a = Intercept (regression constant)
b = Slope (regression coefficient)[9]

Condition factor: The condition factor (K) shows the physiological wellbeing of the fish. The condition factor (K) was determined for samples taken in each month and sex separately. The condition factor for *S. erythrophthalmus* was calculated using the following equation[10]:

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

Where:
K = Condition factor
L = Length (cm)
W = Weight (g)

Sex ratio: Sex determination was performed by microscopic examination of gonads. The male to female ratio was based on the frequency of fishes caught during the sampling period. The sex ratio of male to female individuals was assessed. The sex ratio was estimated as[11]:

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

Where:
M = Number of males
F = Number of females

Statistical analysis: The Shapiro-Wilk Test was used to determine the normality of the data. Analysis of Variance (ANOVA), with the Tukey's *post hoc* Test, was used to indicate whether the differences obtained were significant. A non-parametric test (Chi-square Test) was employed to assess the significant difference of sexes every month. All statistical analyses were done using SPSS (Version 16), while figures were produced using Excel (Version 2019).

RESULTS

Length-frequency distribution: The mean weight and length of fishes were 37.3±9 g and 136.9±19 mm, respectively. There was a significant difference in total length between samples collected in July ($p<0.05$). However, there was no significant difference in April, May, June and August in Table 1. Analysis of variance of body weight showed significant differences in July ($p<0.05$). However, there was no significant difference in April, May, June and August ($p>0.05$) (Table 1).

Length-frequently between females and males was no significant difference ($p>0.05$). Most percentages of frequent lengths were 110-120 mm. Females were dominant in the older size classes, males in the younger in Fig. 1.

Sex ratio: The majority of fishes were sexually mature and the total male:female ratio was 1:1.15. There was no significant difference in the male and female ratio ($\chi^2 = 0.69$, $p>0.05$), therefore, sexual frequency in this species' population is not equal. However, the sex ratio was not significantly different in some months. The highest difference between the number of males and females was in June (1:1.37) and the lowest was in August (1:1.01) (Table 1).

Length-weight relationship: Plots of the length-weight relationship *S. erythrophthalmus* from the Anzali Lagoon are shown in Fig. 2-4. A robust positive coefficient of determination was observed between length and weight in *S. erythrophthalmus* $r^2 = 0.95$ for females in Fig. 2, $r^2 = 0.96$ for males in Fig. 3 and $r^2 = 0.92$ for sex combined in Fig. 4. The regression coefficient (b) ranged from female (3.29) and male (3.35). Comparison of allometric growth rates (b-values) of this fish using t-test showed significant differences ($p<0.05$) indicated positive allometry growth for *S. erythrophthalmus* from the Anzali Lagoon. The regression correlation and coefficient factors are provided in Table 1.

Condition factor: The condition factor of *S. erythrophthalmus* for males ranged from 1.58 in April to 2.3 in July and for females 1.6 in April and 2.2 in July in Fig. 5. Condition factor of males and females did not differ significantly ($p>0.05$).

Table1: Biological data of examined specimens of *S. erythrophthalmus* in the Anzali Lagoon

Month	M/F ratio	Weight±SE (g)	Length±SE (cm)
April	1:1.25	32.3±8[a]	131.9±16[a]
May	1:1.20	35.5±8[a]	134.3±15[a]
June	1:1.37	37.4±11[a]	135.9±19[a]
July	1:1.23	45.8±16[b]	145.8±21[b]
August	1:1.01	35.5±12[a]	136.6±19[a]

Similar letter(s) in a column are non-significant statistically at $p \leq 0.05$

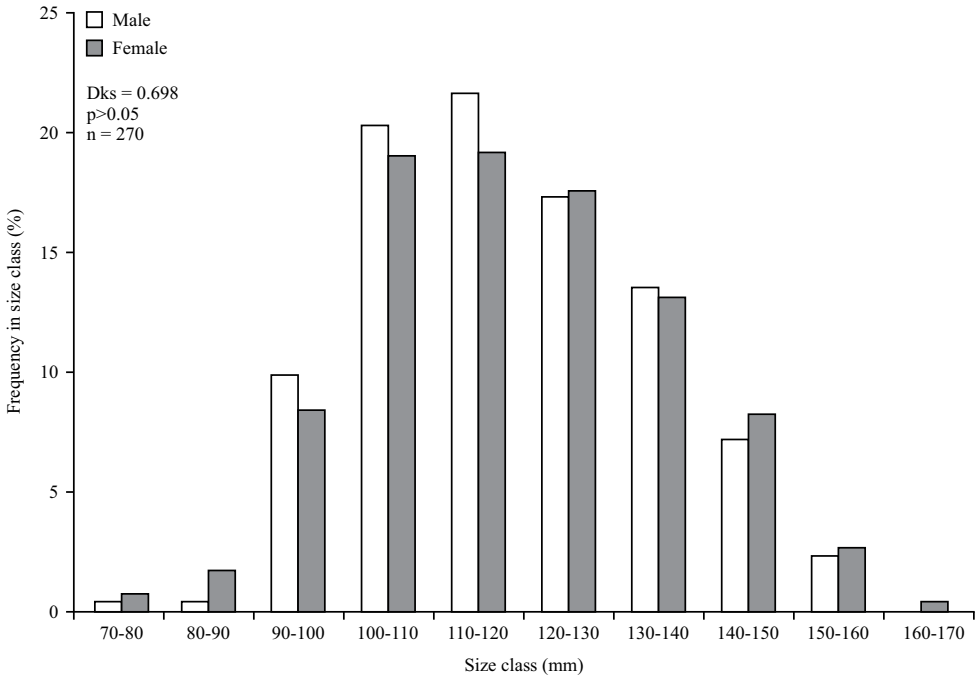

Fig. 1: Percentage length-frequency distributions of *S. erythrophthalmus* for males and females

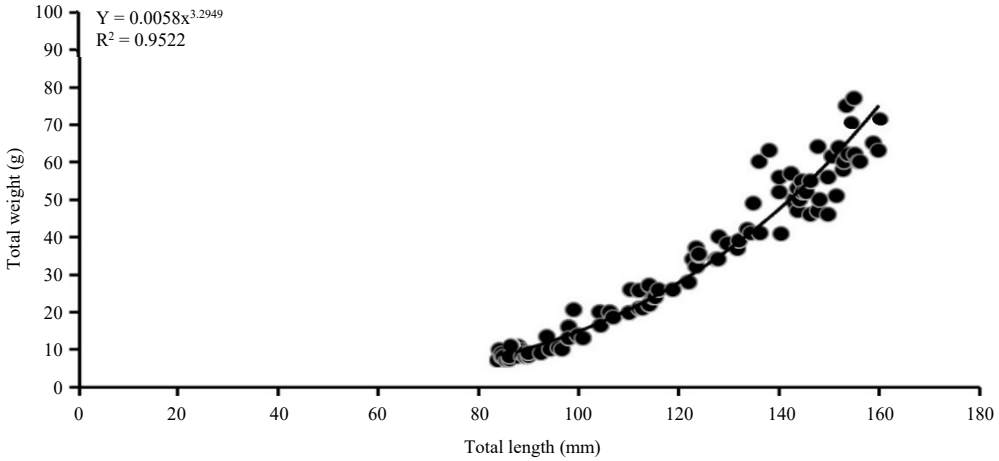

Fig. 2: Length-weight relationship of *S. erythrophthalmus* for female

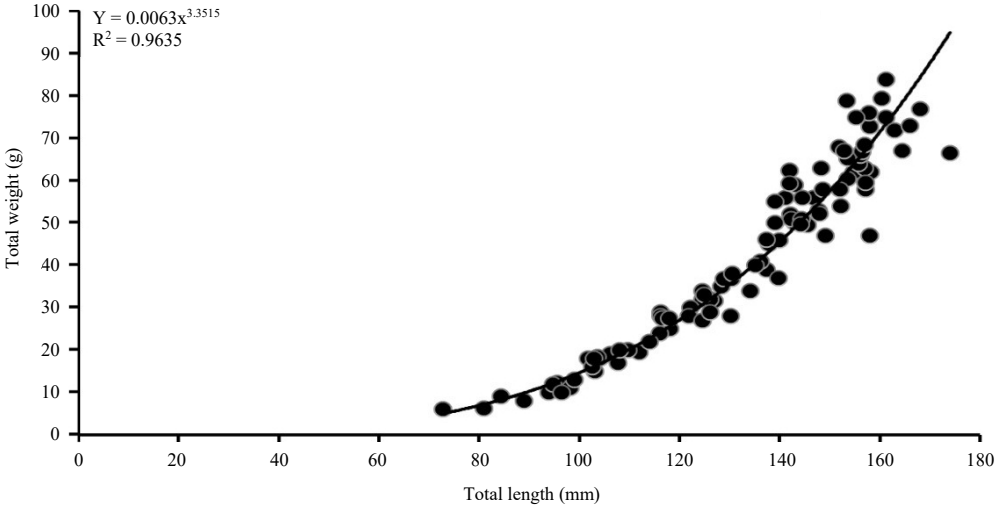

Fig. 3: Length-weight relationship of *S. erythrophthalmus* for male

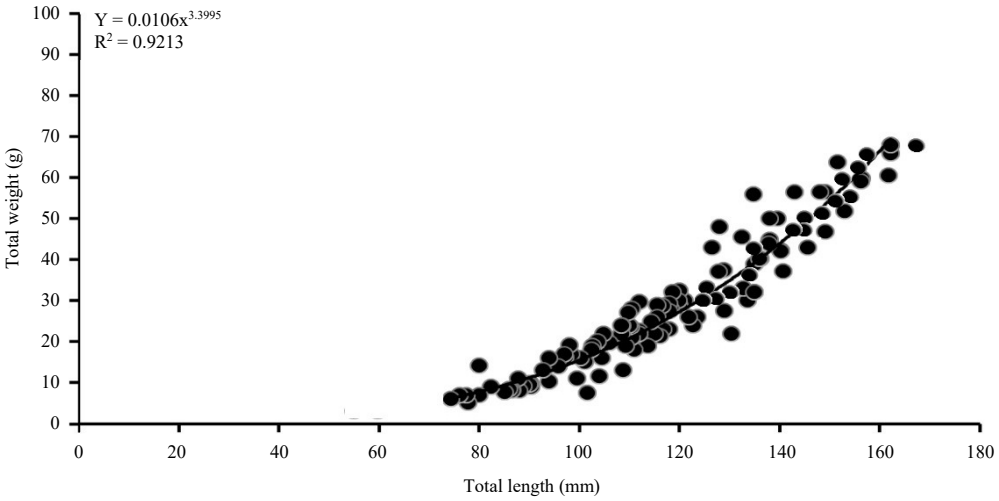

Fig. 4: Length-weight relationship of *S. erythrophthalmus* for both sex

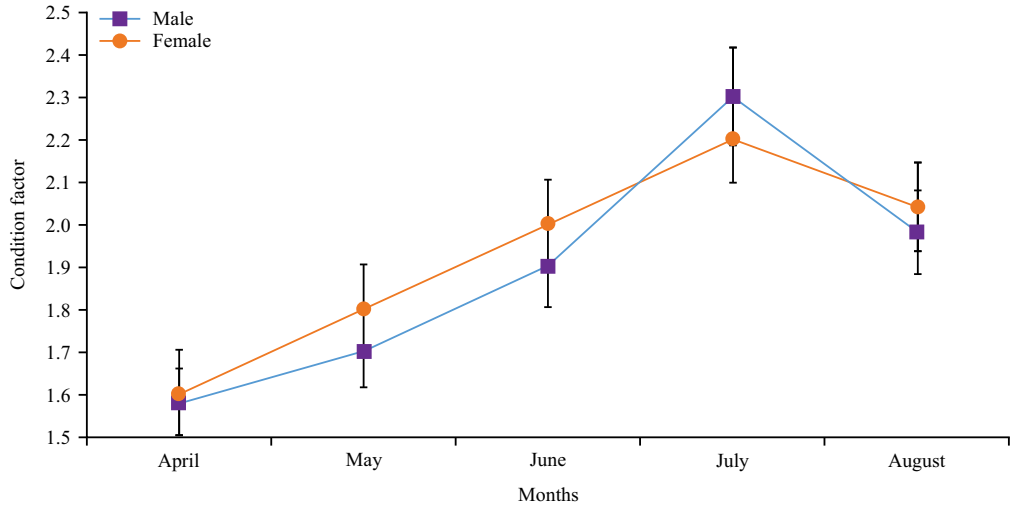

Fig. 5: Condition factor for both male and female in *S. erythrophthalmus* from Anzali Lagoon

DISCUSSION

Analysis of the length-weight relationship (LWR) of *S. erythrophthalmus* samples revealed a highly significant correlation between the total length and weight. During spring and summer, the b-values showed that *S. erythrophthalmus* follow a positive allometric growth pattern, which agrees with some studies[12] on *S. erythrophthalmus*, who also reported an allometric growth pattern[3]. The slight variation in the values of b and r is understandable because the length-weight relationship of a species could vary according to local factors such as salinity, temperature and fish health, sex, stage of maturity, length range of the species, food and season[13]. Abbasi *et al.*[14] reported that the differences in b-values even depend on the time of catching the specimens in terms of fullness or emptying the gut.

Kozhara *et al.*[12] reported the phenetic diversity of the rudd *Scardinius erythrophthalmus* from the Volga River and the Caspian Sea. They reported new data on the meristic characters of external morphology, axial skeleton, somatosensory system and the pharyngeal tooth formula. They find out two phenetically distinct population systems. Positive allometric growth patterns implied that the fish became relatively stouter and deep-bodied as they increased in length, particularly[5]. The correlation coefficient observed in this study ($r^2 = 0.92$-0.96) shows a strong association between length and weight, the high value of the coefficient of determination r^2 indicated that the model applied for analysis fits the data.

The condition factor was calculated in other to assess the wellbeing of *S. erythrophthalmus* from the Anzali Lagoon. Condition factor was not significantly different between males and females. Similar results were presented by Okgerman[13] who compared condition factors of male and female *S. erythrophthalmus* from Sapanca Lake. Values obtained for condition factor showed that both sexes of *S. erythrophthalmus* were in good condition. A particular seasonal trend was observed, the best condition factor for males and females was noticed during summer[6]. However, the researcher[13] reported that the best condition factors for males and females of *S. erythrophthalmus* were during autumn. Okgerman[13] attributed these differences to the feeding regime, time of the year, the higher weight of female gonad, organisms used, feeding behaviour, biological factors and responses to environmental perturbations. Differences in the condition factor could be due to the combination of one or more of the above factors[15].

CONCLUSION

Scardinius erythrophthalmus follows an allometric growth pattern in the Anzali Lagoon. On the other hand, the high value of the correlation coefficient "r" indicates a strong correlation between length and weight. In the end, the high value of the coefficient of determination r^2 suggested that the model used for the analysis fits the data, confirming the model's fitness. Knowledge of length-weight relationships and the condition factor of introduced or invaded species are essential for assessing and appropriately managing alien and native species in an aquatic system.

SIGNIFICANCE STATEMENT

This study discovered the length-weight relationship and condition factor in *S. erythrophthalmus* in the Anzali Lagoon that can be beneficial for fish ecology and management. 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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