



Body Performance Indices of the Invasive Red Cornetfish (*Fistularia petimba* Lacepède, 1803) in Taşucu Bay, Türkiye

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Please cite this paper as follows:

Bozkaya, S., Taşkavak, E., & Gürkan, Ş. (2026). Body Performance Indices of the Invasive Red Cornetfish (*Fistularia petimba* Lacepède, 1803) in Taşucu Bay, Türkiye. *Acta Natura et Scientia*, 7(1), 65-73. <https://doi.org/10.61326/actanatsci.v7i1.463>

ARTICLE INFO

Article History

Received: 04.02.2026

Revised: 15.10.2026

Accepted: 16.10.2026

Available online: 12.06.2026

Keywords:

Red cornetfish

Length-weight relationship

Condition factor

Hepatosomatic index

Eastern Mediterranean

ABSTRACT

The red cornetfish (*Fistularia petimba* Lacepède, 1803) is an invasive fish species commonly found along the eastern Mediterranean coast of Türkiye. This study examined the length-weight relationship (LWR), condition factor (Fulton-K), and hepatosomatic index (HSI) of *F. petimba* specimens by sex. Between 2021 and 2024, 306 individuals (♂: 224, ♀: 56, juvenile: 26) were collected as bycatch from commercial fishing vessels in Taşucu Bay, Mersin Province. The sex ratio was 1:0.3 (♂:♀). The length-weight relationship was $W = 0.0002 \times L^{3.289}$ ($r^2 = 0.952$) for all individuals, $W = 0.0002 \times L^{3.222}$ ($r^2 = 0.949$) for females, and $W = 7E-05 \times L^{3.514}$ ($r^2 = 0.951$) for males. Positive allometric growth was detected. Fulton-K condition factor values were 0.49 ± 0.03 for all individuals, 0.50 ± 0.03 for females, and 0.47 ± 0.06 for males. Hepatosomatic index (HSI) values were 0.85 ± 0.05 for all individuals, 0.94 ± 0.06 for females, and 0.57 ± 0.08 for males. The data from this study on the red cornetfish population in Taşucu Bay, Mersin Province, may contribute significantly to understanding the body dynamics of the species.

INTRODUCTION

The eastern Mediterranean coasts of Türkiye have long served as critical habitats for numerous Lessepsian vertebrate and invertebrate species, providing essential areas for feeding and reproduction. Invasive fish species exert significant impacts on ecosystems by altering biodiversity through competition, predation, hybridization, and displacement of native species (Bariche et al., 2009).

This process places considerable pressure on the ecological balance of the Mediterranean and directly affects the population dynamics of native species (Galil et al., 2019).

The red cornetfish, *Fistularia petimba* Lacepède, 1803, is an invasive species in the family Fistulariidae found in coastal and benthic regions. This benthopelagic carnivore feeds primarily on small fishes and invertebrates, playing a notable role in trophic networks (Bozkaya et al., 2023). *F. petimba*

ranges from the Atlantic coasts (eastern and western) to the Indo-Pacific region, inhabiting sandy bottoms, coral reefs, and seagrass beds (Bray, 2023). The species was first recorded in the Mediterranean in the early 2000s and has since been increasingly reported along Turkish coasts (Ünlüoğlu et al., 2018; Çiftçi et al., 2019; Cerim et al., 2021; Tsaousi & Kalogirou, 2023). Additional eastern Mediterranean records include the Syrian coast (Hussein et al., 2019) and Oman Sea (Yasemi, 2012), with sightings also documented in Atlantic waters (Bañón & Sande, 2008). Recent biodiversity compilations confirm its continued expansion in the Mediterranean basin (Dragičević et al., 2019; Kovačić et al., 2021).

Although the red cornetfish has no commercial value, it is frequently caught as bycatch in fishing nets. It is currently listed as “Least Concern (LC)” on the IUCN Red List (Carpenter et al., 2015). Its expanding distribution is documented in various regional checklists and biodiversity reports (Bañón & Sande, 2008; Dragičević et al., 2019; Kovačić et al., 2021). Research on the species has focused on length–weight relationships, condition factors, hepatosomatic indices, and morphometric and meristic characteristics, aiming to better understand its population dynamics (Azevedo et al., 2004; Dias et al., 2014; Carassou et al., 2017; Ergüden et al., 2023). These studies highlight the species’ adaptation to the Mediterranean and its potential ecological impacts.

Regarding *F. petimba*, most studies conducted in the Mediterranean and elsewhere have focused on occurrence records, while relatively few have examined growth values (b). Existing studies suggest that *F. petimba* may exhibit positive allometric growth ($b > 3$) across a wide range of marine environments, from the Brazilian coast to the Pacific Ocean and the south-eastern Mediterranean coasts (Letourneur et al., 1998; Dias et al., 2014; Bozkaya et al., 2023; Ergüden et al., 2023; Papageorgiou et al., 2023). Recent studies show that the rapid spread of *F. petimba* in the Mediterranean may increase competition with native species and alter ecosystem services (Bozkaya et al., 2023; Papageorgiou et al., 2023). Studies along the eastern Mediterranean coasts of Türkiye offer valuable insights into the condition and energy reserves of local populations (Çiftçi et al., 2019;

Ragheb, 2022). This study examines the length–weight relationship (LWR), condition factor (Fulton’s K), and hepatosomatic index (HSI) of *F. petimba* individuals in Taşucu Bay by sex. The findings may help clarify the species’ body dynamics and its role in the Mediterranean ecosystem.

MATERIAL AND METHODS

In this study, 306 *F. petimba* specimens were collected as bycatch from commercial trawl vessels operating along Türkiye’s eastern Mediterranean coast (Taşucu Bay) across four seasons between 2021 and 2024. The sample consisted of 224 females, 56 males, and 26 juveniles (Figure 1). Specimens were transported to the laboratory under cold chain conditions to ensure tissue integrity and subsequently dissected. Prior to dissection, total lengths (TL, cm, excluding filament) were measured using a standard fish measuring ruler, while total body weights (W , g) and internal organ weights (g) were recorded with a precision balance accurate to 0.01 g. Sex determination was performed macroscopically during dissection, following established ichthyological protocols (Lagler et al., 1977).

The length–weight relationship (LWR) was calculated using the following equation (Eq. 1) (Pauly, 1983):

$$W = aL^b \quad (1)$$

where W represents body weight (g), L is total length (cm), a is the intercept, and b is the slope. Parameters a and b were estimated after \log_{10} transformation of the data, as recommended for linearization of exponential growth models (Froese, 2006). A slope value (b) equal to 3 indicates isometric growth, values below 3 indicate negative allometry, and values above 3 indicate positive allometry (Ricker, 1975; Froese, 2006). The length–weight (L–W) relationship of the population was estimated separately for females, males, and all individuals combined. Additionally, the standard error and confidence intervals for the parameter b , derived from the length and weight measurements, were calculated using the Student’s t -test. Analysis of covariance



Figure 1. *Fistularia petimba* Lacepède, 1803 (Photo: Simge Bozkaya)

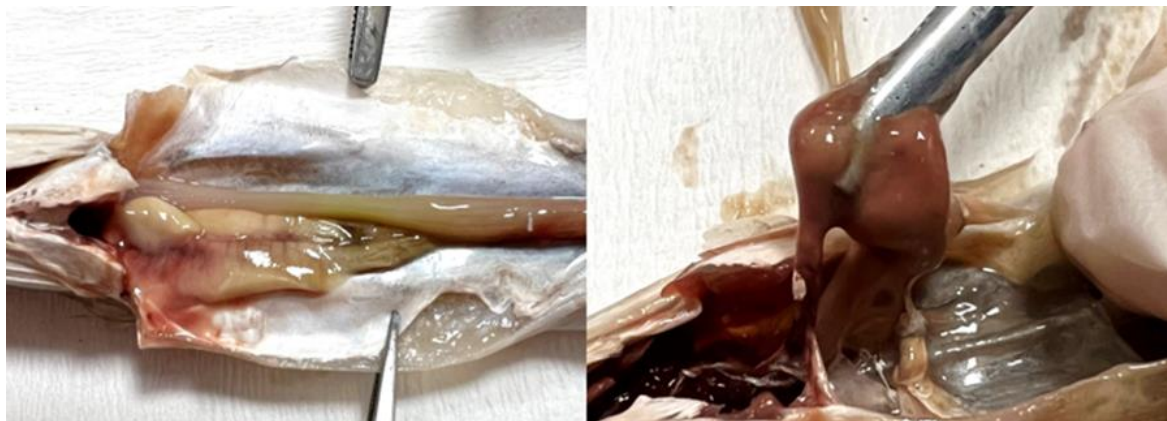


Figure 2. Photographic documentation of liver tissue structure in red cornet fish specimens

(ANCOVA) was employed to test for statistically significant differences in the length-weight relationships between groups. The hepatosomatic index (HSI) was calculated using the following formula (Eq. 2) (Sulistyo et al., 2000):

$$HSI = 100 \times \frac{\text{liver weight (g)}}{\text{body weight (g)}} \quad (2)$$

HSI is widely used as an indicator of energy reserves and metabolic activity in fish, reflecting both nutritional status and environmental stress (Lambert & Dutil, 1997; Lloret et al., 2014).

The condition factor (Fulton's K) was calculated using the following equation (Eq. 3) (Ricker, 1979):

$$\text{Fulton's } K = \frac{100 \times W(g)}{L^3} \quad (3)$$

Fulton's K is a traditional measure of fish well-being and robustness, often applied to assess population health and habitat suitability (Froese, 2006).

All statistical analyses were performed using Statistica 12.5, SPSS 26 and Microsoft Excel. Differences between sexes in HSI and Fulton-K were tested using the Student's t-test, with statistical significance set at $p < 0.05$. The use of parametric tests for biometric indices is consistent with previous studies on fish population dynamics (Sokal & Rohlf, 2012).

RESULTS

The length-weight (LW) relationship was calculated for 306 specimens examined in this study (female: 224, male: 56, immature: 26). The LW relationship was computed separately for females, males, and all individuals combined. For the entire sample, the relationship was $W=0.0002 \times L^{3.289}$ ($r^2=0.952$; 95% CI: 3.289–0.117). For females, the equation was $W=0.0002 \times L^{3.222}$ ($r^2=0.949$; 95% CI: 3.221–0.146), while for males it was $W=7 \times 10^{-5} \times L^{3.514}$ ($r^2=0.951$; 95% CI: 3.514–0.212). Data analysis revealed positive allometric growth across all categories examined (Figure 3).

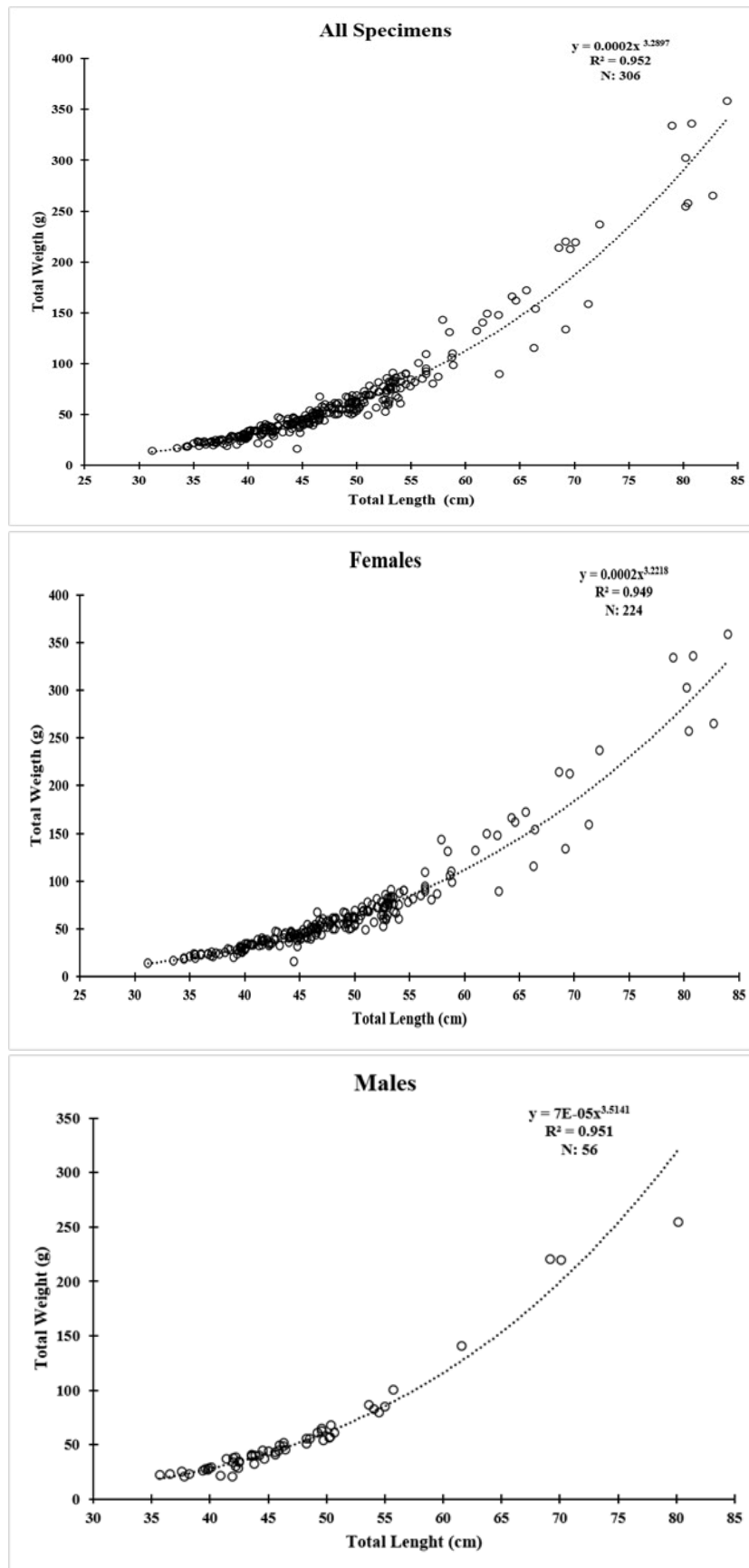


Figure 3. Graphical representations illustrating the length-weight relationship (LWR) among individual specimens

Table 1. Calculated biological index data presented as mean values with standard error (Mean±SE) and corresponding statistical difference ($p < 0.05$)

Biological Index	Female	Male	Combined Sex	p
Condition Factor (Fulton-K)	0.50±0.03	0.47±0.06	0.49±0.03	$p < 0.05^*$
Hepatosomatic Index (HSI)	0.94±0.06	0.57±0.08	0.85±0.05	$p < 0.05^*$

Note: *: statically differences

The t-test indicated that both sexes exhibited positive allometric growth, with no statistically significant differences in their LW relationships. In this study, we examined the effect of sex on body weight (W, g) using analysis of covariance (ANCOVA), controlling for total length (TL, cm). Of the 280 individuals analyzed, 56 were male and 224 were female. Descriptive statistics showed that mean female weight (65.95 ± 53.79 g) was higher than mean male weight (56.52 ± 47.59 g). ANCOVA results indicated that total length had an extremely strong, statistically significant effect on weight ($F_{1,277} = 1842.11$; $p < 0.001$). In contrast, after controlling for total length, sex did not have a significant effect on weight ($F_{1,277} = 0.022$; $p = 0.882$). Parameter estimates showed that a 1 cm increase in total length corresponded to an average 5.41 g increase in weight ($B = 5.411$; 95% CI: 5.162–5.659). However, the weight difference for males compared with females of the same length was not statistically significant ($B = 0.424$; $p = 0.882$). The model showed high explanatory power: 87% of the variance in weight was explained by total length and sex ($R^2 = 0.870$; adjusted $R^2 = 0.869$). These findings indicate that the raw weight differences between sexes are driven not by sex itself, but by differences in length among individuals. In conclusion, total length is the primary determinant of weight in the studied population, and there is no significant difference in weight between females and males of the same length.

Fulton's K condition values were examined for individuals distributed throughout the region. Immature individuals were not included in the Fulton's K calculation. The analysis revealed that female individuals exhibited a higher mean condition value when compared to their male counterparts (♀: 0.50 ± 0.03 ; ♂: 0.47 ± 0.06). Statistical analysis demonstrated that this observed difference between

the sexes was statistically significant (t -test = 2.36, $p = 0.018$, $p < 0.05$).

In determining hepatosomatic index values, only sexes were considered; index values for immature individuals were not evaluated. Hepatosomatic index (HSI) values were calculated and analyzed, and the results demonstrated that female individuals had a considerably higher mean HSI value when compared to male individuals (♀: 0.94 ± 0.06 ; ♂: 0.57 ± 0.08). Statistical testing confirmed that this observed difference between the sexes was statistically significant (t -test = 3.57, $p = 0.0004$, $p < 0.05$).

Table 1 comprehensively presents and summarizes the Fulton-K condition factor values and HSI hepatosomatic index values that were obtained from this study, along with the statistical differences that were observed between the male and female sexes.

DISCUSSION

This study determined length–weight relationship (LWR), condition factor (Fulton-K), and hepatosomatic index (HSI) values for *F. petimba*, an invasive species along Türkiye's Eastern Mediterranean coast. We calculated values by sex and for all individuals combined, providing insights into growth dynamics, energy allocation, and reproductive physiology. The length–weight relationship is a key indicator for assessing fish growth patterns, biological status, and energy allocation. It is widely used to understand population dynamics in teleost fish (Tesh, 1971; Ricker, 1975; Wootton, 1998; Froese, 2006). Our LWR values showed positive allometric growth for all individuals, females, and males. This means body weight increases faster than body length, suggesting sex-specific differences in growth characteristics. In fish, the length–weight relationship is influenced by factors

such as season, habitat, gonad maturity, sex, nutrition and stomach fullness, condition, the number of specimens collected, and sampling frequency (Tesh, 1971; Wootton, 1998). Therefore, differences in length-weight relationships among studies are thought to result from one or more of these factors acting together.

Positive allometry has been reported in other invasive species in the Mediterranean, such as *Fistularia commersonii* and *Siganus rivulatus*, reflecting adaptive strategies in novel ecosystems (Harmelin-Vivien et al., 2005; Bariche et al., 2009; Kalogirou, 2010). The findings align with values reported for *F. petimba* along the coasts of Cyprus and the Eastern Mediterranean (Bozkaya et al., 2023; Ergüden et al., 2023; Papageorgiou et al., 2023). Similar growth patterns have also been observed in populations from the Atlantic and Indo-Pacific regions (Azevedo et al., 2004; Dias et al., 2014), suggesting that environmental conditions, prey availability, and reproductive cycles strongly influence growth trajectories.

Body condition levels in the study area differed significantly between sexes. Females exhibited higher condition values than males, likely explained by reproductive metabolism and energy storage strategies, as females allocate more energy to gonadal development (Lambert & Dutil, 1997; Lloret et al., 2014). The study's mean condition factor (0.49 ± 0.03) indicates moderate energy status and overall health for the species. These results are consistent with values reported by Bozkaya et al. (2023) (0.47 ± 0.06) and Ergüden et al. (2023) (0.52 ± 0.05). However, a population in India showed higher values (0.99 ± 0.04) (Suyani et al., 2024). Such differences may result from geographic location, environmental conditions, prey availability, and sampling period (Adams et al., 1993). Seasonal variation in condition factor has been widely documented in teleosts, with higher values often associated with pre-spawning periods when energy reserves are maximized (Wootton, 1998).

HSI serves as an important biological indicator reflecting the liver's energy storage capacity and overall metabolic status. It varies depending on glycogen and lipid accumulation in liver tissue (Sulistyo et al., 2000). Some pelagic species store

glycogen primarily in muscle tissues due to continuous swimming activity (Timur, 2006), but benthopelagic species such as *F. petimba* rely heavily on liver reserves. In this study, HSI values showed significant sex-based differences. Female individuals exhibited higher HSI values, primarily due to reproductive cycles and vitellogenin synthesis during spawning (Blazer, 2002; Wootton, 1998). During vitellogenesis, females store lipids and glycogen in the liver to support egg development, while males lack this process. Elevated HSI values in females are also influenced by sex hormones such as estrogen, which regulate liver metabolism (Love, 1980; Mommsen & Walsh, 1988).

Feeding strategies, seasonal variation, and environmental conditions further amplify these sex-based differences (Adams et al., 1993; Lloret et al., 2014). When comparing our results with those of Bozkaya et al. (2023), differences were observed despite both studies being conducted in the same region. These discrepancies may be attributed to sampling season, reproductive stage, and nutritional status of individuals at the time of collection.

CONCLUSION

As a conclusion, the comprehensive data obtained from this study on *F. petimba* populations inhabiting the Eastern Mediterranean coastal waters provide valuable insights into the species' body dynamics and physiological characteristics. By integrating LWR, Fulton-K, and HSI analyses, this research contributes to understanding the adaptive strategies of invasive fishes in the Mediterranean and highlights the importance of sex-specific physiological assessments in invasion ecology.

ACKNOWLEDGEMENTS

We thank Paşa Balıkçılık and the crew of the Paşa Fishing Boat for their assistance during fieldwork. This work is partly based on the first author's MSc thesis.

Compliance with Ethical Standards

Authors' Contributions

SB: Conceptualization, Methodology, Data curation, Writing – original draft

ET: Investigation, Resources, Writing – original draft, Writing – review & editing

ŞG: Conceptualization, Methodology, Data curation, Formal analysis

All authors critically reviewed and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

Funding

Not applicable.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request. This work is partly based on the first author's MSc thesis.

AI Disclosure

The authors declare that no generative artificial intelligence was used in creating images, graphs, tables, corresponding titles, or in writing this article.

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