



## RESEARCH ARTICLE

### The length-weight relationship and condition factor of yellowspotted puffer *Torquigener flavimaculosus* Hardy & Randall, 1983 in the Eastern Mediterranean (Yumurtalık Bight, Turkey)

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#### ABSTRACT

The length-weight relationships (LWRs) of fish are helpful in fisheries science. A total of 504 yellowspotted puffer (*Torquigener flavimaculosus*) specimens (257 female and 247 male) were caught from the Yumurtalık coast of Turkey (Eastern Mediterranean Sea) between 2018 and 2019 by using a trammel net set with a depth range between 5 and 42 m. The sex ratio was found 1:1.08 for males and females, respectively. The length-weight relationship was described for combined both sexes by the following formula  $W = 0.00130 \times L^{3.094}$  ( $r^2 = 0.918$ ) with a positive allometric growth. Fulton condition factor (CF) was calculated as  $1.713 \pm 0.145$  for combined sexes. This study presents the first results available for the length-weight relationships and condition factor of *T. flavimaculosus* according to both sexes in the Yumurtalık coast of Turkey.

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#### Introduction

The length-weight relationships (LWRs) are an important indicator in fisheries management and conservation (Froese,

2006). In addition, condition factors are also important parameters for the evaluation of fish stocks (Ergüden and Turan, 2017; Ergüden et al., 2018).

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The yellowspotted puffer, *Torquigener flavimaculosus* Hardy & Randall, 1983, is a reef-associated species, found at depths ranging from 3 to 57 meters (Randall, 1995), commonly feeding on marine invertebrates and reaching a maximum total length of 16.0 cm (Sabour et al., 2014). The species is distributed in the western Indian Ocean, from East Africa to Seychelles, in the Red Sea and Persian Gulf (Randall, 1995). It is also found in the Mediterranean Sea, introduced via the Suez Canal (Golani et al., 2002) being one of the seven non-native puffers (belongs to the Tetraodontidae family). *T. flavimaculosus* has been also recorded from the Turkish coasts of the Levantine Sea and the Aegean Sea (Bilecenoglu, 2005; Erguden and Gurlek, 2010; Bilecenoglu et al., 2014).

The knowledge of length-weight relationships is important in fisheries science while length-weight relationships are essential to better understand the ecology and life characteristics of fish species. Fulton's condition factor (CF) is widely used in fisheries and fish biology studies (Erguden and Turan, 2017; Erguden et al., 2017; Aydın and Sözer, 2019). LWRs are used by fisheries scientists to convert growth in length equations to growth in weight for stock assessment models (Morato et al., 2001; Stergiou and Moutopoulos, 2001), and also to estimate biomass from the length-frequency distribution (Petrakis and Stergiou, 1995; Erguden et al., 2009; Erguden et al., 2011).

To date, length-weight relationship studies have been reported very scarcely for the pufferfish species (Erguden et al., 2015; Bilge et al., 2017; Ayas et al., 2019). Besides, LWRs and condition factors according to sexes for *T. flavimaculosus* have not been reported from the Eastern Mediterranean. Thus, the present study provides the first detailed information on the length-weight relationships and condition factor of *T. flavimaculosus* on the Eastern Mediterranean coast of Turkey (Yumurtalık Bight).

## Material and Methods

For this study, 504 specimens (257 female and 247 male) of *T. flavimaculosus* were caught by using a trammel net (22 mm (bar length) inner panel mesh size and 110 mm outer panel mesh size) between September 2018 and November 2019 from Yumurtalık Bight, Turkey (Fig 1). The sampling areas are characterized by sandy-muddy substrates and depths between 5-42 meters. After captured, all samples were transported immediately to the laboratory in an ice bag and then frozen (-20°C) for preventing deterioration. Species identification was based on Golani et al. (2002). Total length (nearest 0.1 cm) and total weight (nearest 0.01 g) were recorded for its specimen while the sex of each specimen was determined by examining the gonads macroscopically.

The length-weight relationship of the fish was calculated by applying the exponential regression equation  $W = aTL^b$ , (Ricker, 1975). This equation can also be expressed in logarithmic form:  $\log W = \log a + b \log L$ , where  $W$  is the weight (g),  $L$  is the total length (cm),  $a$  is the intercept and  $b$  is the slope of the linear regression. Parameters  $a$  and  $b$  were calculated by least-squares regression, as was the coefficient of determination ( $r^2$ ). 95% confidence limits (CI) of  $b$  was also estimated (Pauly, 1993). The relationships among the variables were identified using the regression analysis by ANOVA. The student's t-test was used to test for the difference of the parameter " $b$ " from the theoretical value of 3 (Sokal and Rohlf, 1969). The sex ratio was checked with a Chi-Square test for equality to determine whether the ratio differ from 1:1.

Fulton's coefficient of condition factor (K) was calculated by  $K=100 \times W/L^3$ , where 'L' is total length (cm) and 'W' is the weight (g) (Le Cren, 1951; Sparre and Venema, 1992). The condition factor was estimated for each sexual category (males, females and individuals with undetermined sex) and for the total samples.

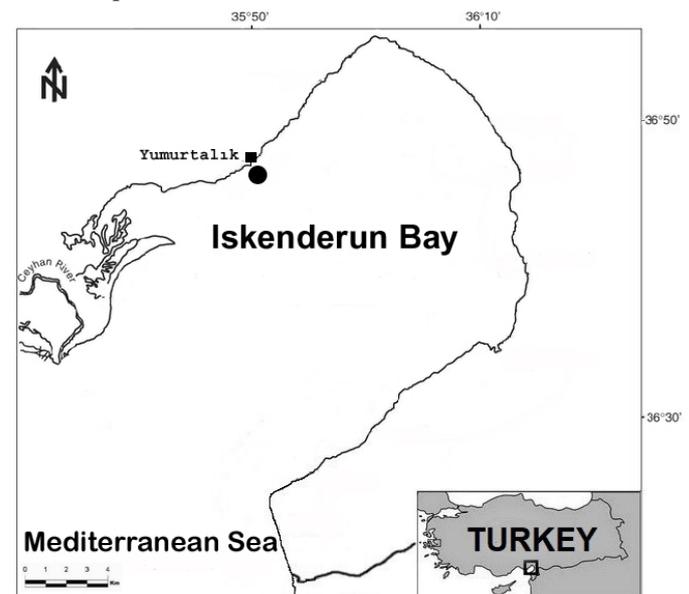


Figure 1. The black circle indicates the sampling area

## Results

In the present study, 257 female and 247 male *T. flavimaculosus* specimens were investigated. The total sex ratio for female and male samples (M:F) was 1.00:1.04. The difference between the sex ratios was not found to be statistically significant ( $X^2= 0.535$ ,  $P > 0.05$ ).

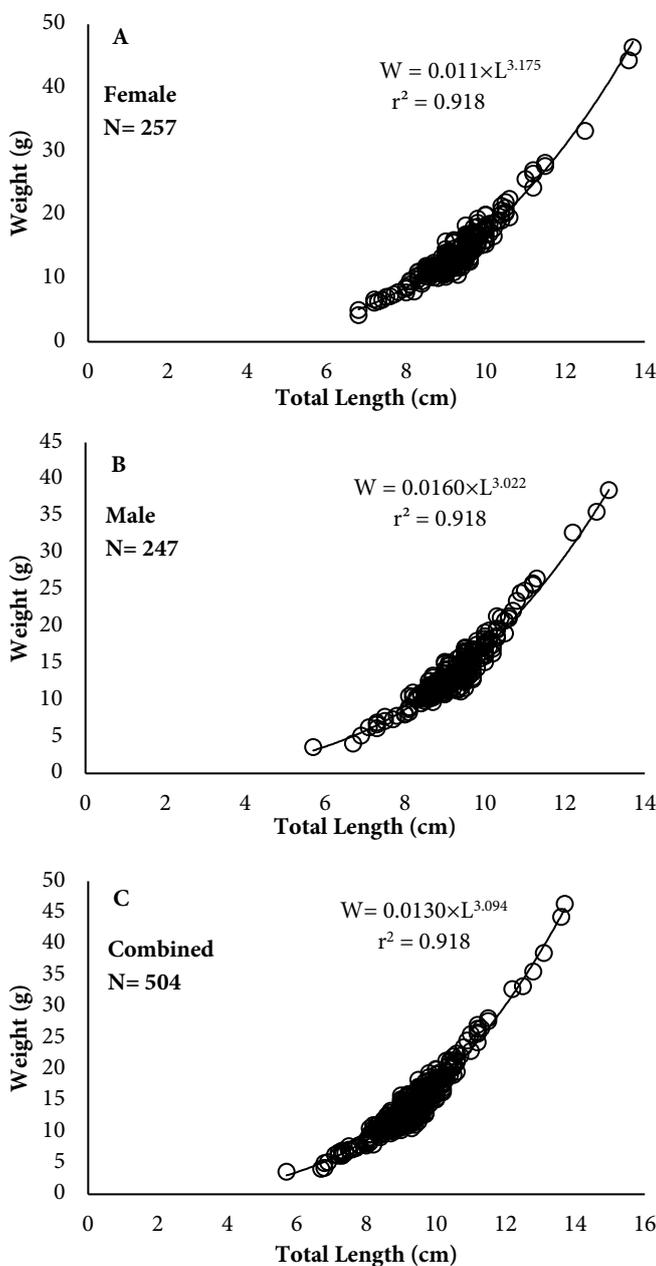
The total length values of females, males, and combined individuals ranged from 6.8-13.7 cm, 5.7-13.1 cm, and 5.7-13.7 cm respectively (Table 1). Descriptive statistics of the total length and weights were offered in Table 1 for females, males, and combined individuals.

**Table 1.** Mean and standard deviation, maximum, minimum for length (L) and weight (W) parameters of each sex of *T. flavimaculosus*

Sex	N	Total Length (TL) (Min-Max)	TL Mean±SD	Total Weight (W) (Min-Max)	W Mean±SD
Female	257	6.80-13.70	9.250±0.853	4.18-46.35	14.06±4.780
Male	247	5.70-13.10	9.213±0.862	3.56-38.50	13.72±4.340
Combined	504	5.70-13.70	9.235±0.857	3.56-46.35	13.89±4.560

**Table 2.** Length-weight relationships of *T. flavimaculosus* from Yumurtalık coast, Turkey

N	Sex	a	b	r <sup>2</sup>	SE of b	95% CI of b	P	Growth Type
257	Female	0.00110	3.175	0.918	0.059	3.059-3.292	>0.05	Allometric (+)
247	Male	0.00160	3.022	0.919	0.058	2.908-3.135	>0.05	Isometric
504	Combined	0.00130	3.094	0.918	0.041	3.013-3.175	>0.05	Allometric (+)



**Figure 2.** Length-weight relationship of female (A), male (B) and combined sexes (C) for *T. flavimaculosus* from the Yumurtalık coast (Turkey)

The length-weight relationships are given in Table 2 for females, males, and sexes combined, providing sample size (N), level of equation parameters, “a” and “b” as well as the 95% confidence limits for both parameters and the coefficient of determination ( $r^2$ ).

The values of the exponent b provide information indicating the type of growth when the isometric growth b is 3.0. When the value of b is higher than 3 ( $b > 3.0$ ), the weight represents positive allometric growth; a lower value ( $b < 3.0$ ) shows negative allometric growth. Our data suggested that *T. flavimaculosus* showed positive allometric growth for combined sexes ( $b=3.094$ ) and females ( $b=3.175$ ). Besides, it shows isometry for males ( $b=3.022$ ). The value of “b” is slightly different than 3 for the female and combined and is not significantly different than 3 for male  $p > 0.05$  (Table 2).

The length-weight relationship of *T. flavimaculosus* was calculated as  $W=0.0011TL^{3.175}$  ( $r^2=0.918$ ) for females,  $W=0.0016TL^{3.022}$  ( $r^2=0.918$ ) for males and  $W=0.0013TL^{3.094}$  ( $r^2=0.918$ ) for combined (Fig 2). Fulton’s condition factor (CF) was  $1.720 \pm 0.147$  for females,  $1.707 \pm 0.144$  for males and  $1.713 \pm 0.145$  for combined. Condition factor values also showed significant variations ( $P < 0.001$ ) for female and male individuals of *T. flavimaculosus*.

### Discussion

In this study, we report the length-weight relationships of *T. flavimaculosus* in the Mediterranean, based on 504 specimens collected from the Yumurtalık coast. The sex ratio was found 1:1.04 for males and females (49.0% male and 51.0% female). Çek-Yalnız et al. (2017) reported that the sex ratio of *T. flavimaculosus* was 62.5% female and 37.5% male collected from the Iskenderun Bay, Turkey. Ramadan and Magdy (2019) similarly reported the male:female sex ratio (M/F) as 1.00:1.08 for the species population from the Gulf of Suez (Egypt). According to Mendonca et al. (2006), this small difference may

be related to the variance in the availability of both sexes for the fishery, and their feeding behavior. Besides, this difference may be also associated with the spatial segregation of both sexes and environmental factors. Because different environmental factors can cause spatial segregation of the sexes.

The exponent  $b$  often has a value close to three but varies between 2.5 and 3.5 (Froese, 2006). The relationship between length and weight for this species indicates that growth shows positive allometry ( $b = 3.094$ ) for combined sexes. Ergüden et al. (2015) reported negative growth ( $b=2.970$ ) in their study conducted in Iskenderun Bay. Similarly, Bilge et al. (2017) stated negative allometric growth ( $b=2.836$ ) from the Muğla coast. However, Ayas et al. (2019) reported positive allometric growth (3.326) from Mersin Bay. These small differences could be the result of sample size, fishing equipment, season, fishing pressure and reproduction season (Petrakis and Stergiou, 1995). Besides, these differences depend on environmental or regional changes.

According to our knowledge of fish biology, condition factor (CF) is an expression to assess the condition of the fish and used to allow for comparisons of species growth between different regions. According to Le Cren (1951), CF values greater than 1 indicated the good condition of the fish whereas a value  $< 1$  is indicative of the reverse nature. In this study, the minimum condition factor value was estimated at 1.707, and maximum as 1.720 for *T. flavimaculosus*. The present results revealed that both males and females indicate that both of the sexes are in good condition for *T. flavimaculosus*.

Although length-weight relationships in fish are affected by many factors including habitat, area, seasonal effect, gonad maturity, sex, diet and stomach fullness, health and preservation techniques (Tesch, 1971), all these are not considered in this study.

## Conclusion

The present study is the first study focusing on the length-weight relationship and condition factor for *T. flavimaculosus* in the southern Mediterranean. Besides, this study revealed that both male and female have a uniform CF value, which indicates that both the sexes are in quite well condition for the optimum growth of this fish species. The results obtained from this study will be useful to researchers and fisheries biologists in the Mediterranean, for better understanding of the invasion ecology of the species.

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## Compliance with Ethical Standards

### Authors' Contributions

Author SAE designed the study, DE and DA wrote the first draft of the manuscript, SAE and DE performed and managed statistical analyses. All authors read and approved the final manuscript.

### Conflict of Interest

The authors declare that there is no conflict of interest.

### Ethical Approval

This study was conducted in accordance with ethics committee procedures of animal experiments.

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