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Research Article

Length-Weight and Length-Length Relationships of *Etrumeus golanii* DiBattista, Randall & Bowen, 2012 (Clupeiformes: Dussumieriidae) in Antalya Bay (Mediterranean Sea of Türkiye)

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ABSTRACT

Some population biology characteristics of *Etrumeus golanii* DiBattista, Randall & Bowen, 2012 were estimated for 438 individuals captured using gillnets in Antalya Bay (Mediterranean Sea of Turkey) between November 1997 and May 1998. Fish size in TL (total length) ranged from 8 cm to 26.4 cm and the length-weight relationships (LWRs) were calculated for males, females and all individuals as $W=0.0042L^{3.2309}$, $W=0.0086L^{2.999}$ and $W=0.0059L^{3.1218}$ respectively. The results additionally showed that length-length relationships (LLRs) were significantly correlated ($r^2>0.985$, $P<0.001$). This study aims to contribute to the Bayesian hierarchical approach used in LWR calculations in the FishBase database. Additionally, 11 LWRs were gathered from 11 studies carried out between 1984 and 2021 in different marine waters. The present study is an evaluation of previous scientific studies from different areas. The value of the b slope for *E. golanii* varies between 2.626 and 3.443. The mean value of b was 3.0750 and the median value of b was 3.0435, and the Log10 a and b plot was used to detect outliers.

Keywords: *Etrumeus golanii,* length-weight relationships (LWRs), lessepsian fish, Mediterranean Sea, ORMEF

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INTRODUCTION

At the beginning of the 20th century, there has been a steady increase in non-native fish species on the Levant coast (Galil, 2000). The colonisation of Indian-Pacific and Red Sea species in the Mediterranean, known as Lessepsian migration, began with the construction of the Suez Canal in 1869 (Por, 1978; Golani, 1998). Approximately 63 % of all non-native fish species in the Mediterranean enter the sea through the Suez Canal (Bella, 2000; Galil & Zenetos, 2002). The Suez Canal has become the principal entry point for non-native fish species into the Mediterranean, resulting in vast, self-sustaining populations (Bariche et al., 2003).

The ORMEF database presents information on 188 fish taxa that are thus divided: 106 species entered through the Suez Canal; 25 species introduced by human activities; 57 Atlantic species through the strait of Gibraltar (Azzuro et al., 2022) since the first description of the lessepsian migratory fish species in the Mediterranean (Ben-Tuvia, 1953). The ORMEF database is a Mediterranean database of exotic fish records, containing 4015 geo-referenced data from 20 Mediterranean countries and compiled from 670 scientific papers (Azzuro et al., 2022). There is also new evidence that some fish species have recently formed populations in the Mediterranean basin (Bilecenoğlu et al., 2002; Azzurro & Andaloro, 2004). It would not be incorrect to argue that Türkiye is one of the coun-

tries with the most intense migration and population formation of lessepsian species among the Mediterranean countries. Although this quick and consistent migration has an impact on the entire Mediterranean environment, it is clear that further knowledge on the biological properties of these species is needed. Calculations of the length-weight (LWRs) and length-length (LLRs) relationships are used for basic purposes in the evaluation of fish stocks and populations (Ricker, 1968; Ricker, 1979).

LWRs are one of the most valuable tools for assessing various aspects of fish species, including their overall health, reproductive history, life cycle, and physical condition (Nikolsky, 1963; Wootton, 1992; Pauly, 1993; Edelist, 2012). It is crucial to use standardised measurements across all groups to increase the reliability of comparisons between different populations. This is important in terms of developing information on the LWRs exhibited by species under many environmental conditions. The LLRs are of great importance, especially in comparative growth studies (Moutopoulos & Stergiou, 2002). The length of fish may typically be assessed more rapidly and simply than the weight of fish in fisheries research (Kara & Bayhan, 2008). Calculating the LWR makes determining the mass easier when only the length is known. The tail may be damaged and cut off during hunting activities or in case of tail parasites. Such situations make it difficult to accurately measure TL. However, knowing the SL (standard length) will help to calculate the TL.

This study aims to estimate the LWRs and LLRs of females, males and all individuals of the *E. golanii* species caught in Antalya Bay in 1997 and 1998 and to offer the opportunity to compare research materials with single-length measurement data of the species.

MATERIALS AND METHODS

The fish samples were captured monthly using gillnets during the commercial fishing season conducted between 1997 and 1998 in Antalya Bay (Figure 1).

Fish were transported from the commercial boats to the laboratory via a cold chain and measured to the nearest cm TL (total length), FL (fork length) and SL (standard length) and weighed to the nearest g TW (total weight). The correlation between TL and

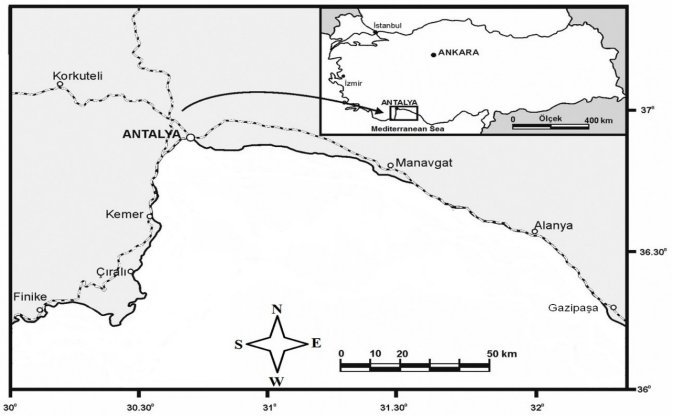

Figure 1. Sampling area.

TW, $W = a \times L^b$, length-weight data can, however, be fitted with a (linear) regression if logarithms are taken of both sides, resulting in $\log_{10} W = a + b \log_{10} L$ (Pauly, 1984). Least-squares regression was used to obtain the parameters a and b, as well as the coefficient of determination (r^2). *A t-test* at the P = 0.05 significance level was used to determine if the b value for each species differed substantially from 3. Furthermore, linear regressions were used for calculating the connections (1) TL vs FL; (2) FL vs SL; and (3) SL vs. TL. To test for potentially significant differences in both the slope and intercept, covariance analysis was performed. All statistical analyses were appraised at $P<0.05$ significance level.

RESULTS AND DISCUSSION

Until a few years ago, the species was frequently used in the literature with the synonym name "*Etrumeus teres*". However, the naming made by Mitchill (1814) was accepted as the real name of the species (Froese and Pauly, 2024). In this study, studies carried out under the name "*Etrumeus teres*" were accepted as *E. golanii* and evaluated for comparison. Keramidas et al. (2023) summarised the invasive history of *E. golanii* in the Mediterranean;

The first record in the Mediterranean was reported by Gruvel, (1931) as *Klupea kowal* (Rüppell, 1837) from Lebanon. It continued to spread westwards with the first record from Lampedusa in the central Mediterranean, and by then the species was recorded under the name *Etrumeus teres* (DeKay 1842). In 2012, DiBattista et al. (2012) reported that the specimens identified as the Lessepsian immigrant *E. teres* in the Mediterranean Sea were actually a completely new species, namely *E. golanii*. For this reason, the *E. teres* species given in the length-weight relationship in the Mediterranean in Table 3 was accepted as *E. golanii*.

Some population biology characteristics of *E. golanii* were estimated for 438 individuals captured using gillnets in Antalya Bay (Mediterranean Sea of Türkiye) between November 1997 and May 1998. Fish size in TL ranged from 8 cm in April to 26.4 cm in December. It was determined that 55.7% of the samples were females (n=244) and 44.3% males (n=194).

The LWRs were calculated for males, females and all individuals as $W=0.0042L^{3.2309}$, $W=0.0086L^{2.999}$ and $W=0.0059L^{3.1218}$ respectively (Table 1). Analysis of covariance revealed significant differences between sexes for the slopes (b) of the regression lines ($P<0.001$). The LWRs of *E. golanii* presented in Table 1 show that the calculated allometric coefficients vary between 3.134 (January) and 3.244 (November) in males and between 2.987 (April) and 3.364 (Nowember) in females.

All LLRs shown in Table 2 were highly significant ($P<0.001$), with all coefficients of determination values greater than 0.985. The LWRs can be obtained from the body length and body weight measurements acquired from the same fish throughout their lifetimes or from a sample of fish caught at some point in time (Wootton, 1990).

All the allometric coefficients (b) estimated in this study were within the expected range between 2.9 and 3.3. Additionallay Bagenal & Tesch (1978); Koutrakis & Tsikliras (2003); Yılmaz & Hoşsucu (2003), allometric coefficients (b) may range from 2 to 4.

Table 1. Estimated parameters of LWRs for both sexes of *E. golanii* in Antalya Bay.

Months	Sex	N	Lenght characteristics		Weight characteristics		Relationship parameters			
			TL Range (cm)	Mean TL (±SD)	W Range (g)	Mean W (±SD)	a	b	SE of b	r^2
November	F	38	15.2-24.6	18.66±3.20	26.8-139.7	61.15±36.69	0.0029	3.364	5.269	0.997
	M	48	14.5-24.7	17.55±3.33	24.2-128.3	50.21±35.46	0.0040	3.244	4.194	0.996
December	F	71	14.4-26.4	21.14±3.35	22.9-168.6	89.27±41.71	0.0036	3.290	7.476	0.995
	M	39	14.8-24.6	19.71±2.52	24.5-137.9	68.90±29.31	0.0033	3.315	6.739	0.984
January	F	24	12.1-20.8	16.60±2.46	14.6-80.2	40.28±19.00	0.0059	3.117	3.820	0.989
	M	32	12.5-24.6	16.85±3.04	15.5-132	43.52±27.41	0.0056	3.134	6.610	0.994
February	F	18	16.1-22.3	19.69±1.56	33.6-94.8	69.94±16.53	0.0050	3.196	3.678	0.955
	M	22	16.1-23.0	19.07±1.77	34.4-109.8	61.79±18.90	0.0039	3.266	3.449	0.983
March	F	42	15.1-22.3	19.51±1.80	30.3-96.4	63.54±17.37	0.0073	3.043	4.083	0.965
	M	5	16.9-21.0	19.34±1.75	36.1-75.0	58.76±16.42	0.0033	3.292	1.293	0.994
April	F	42	8-24.1	20.28±2.52	49.2-128.2	77.74±19.49	0.0092	2.987	4.213	0.970
	M	18	18.1-22.0	20.14±1.08	51.0-92.9	68.09±11.75	0.0051	3.158	2.721	0.960
May	F	9	15.8-22.4	19.07±2.37	33.2-102.6	62.03±23.35	0.0074	3.050	4.882	0.985
	M	30	14.6-24.2	18.24±2.48	23.9-116.9	53.79±23.06	0.0047	3.199	2.864	0.994
Overall	F	244	8-26.4	19.70±3.03	14.6-168.6	71.23±33.45	0.0086	2.999	8.135	0.968
	M	194	12.5-24.7	18.44±2.86	15.5-137.9	56.61±28.61	0.0042	3.231	5.437	0.998
	A	438	8-26.4	19.14±3.02	14.6-168.6	64.76±32.20	0.0059	3.122	7.126	0.982

F: Females, M: Males, A: All Inviduals, N: number of individuals, TL: Total Length, SD: Standard Deviation, W: Weight, a: intercept, b: slope, SE: Standard Error, r^2: coefficient of determination

Table 2. LLRs between the total length, fork length and standard length of *Etrumeus golanii* in Antalya Bay.

Sex	Equation	N	a	b	r^2
Female	TL=a+bFL	244	-0.179	1.124	0.991
	FL=a+bSL		0.468	1.019	0.997
	SL=a+bTL		-0.134	0.865	0.992
Male	TL=a+bFL	194	0.228	1.098	0.992
	FL=a+bSL		0.467	1.020	0.985
	SL=a+bTL		-0.389	0.878	0.990
All	TL=a+bFL	438	-0.013	1.113	0.992
	FL=a+bSL		0.483	1.018	0.992
	SL=a+bTL		-0.255	0.871	0.992

TL: Total Length, FL: Fork Length; SL: Standard Length, N: number of individuals, a: intercept, b: slope, r2: coefficient of determination

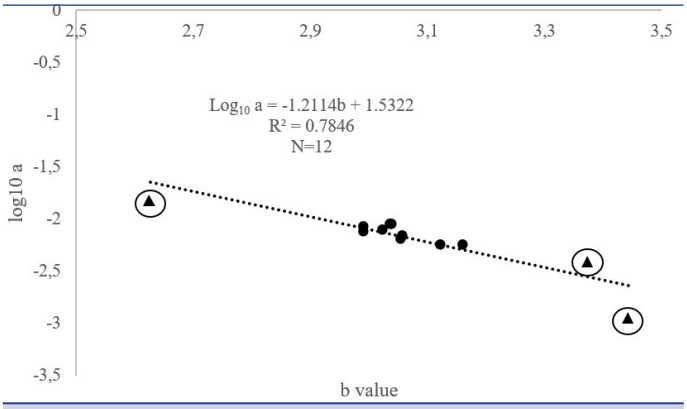

Figure 2. *Log a* and *b* value plot for all available length-weight relationships of *E. golanii* species. The 3 outliers of the type are marked with circular lines in the graph.

Other research on the LWR and LLR connections of *E. golanii* have been conducted in the Turkish Seas and other locations. Table 3 shows the b values reported in this research. Although the majority of the research on the species has been undertaken in the Mediterranean, a comparison of the LWR parameters, particularly the b values, in 11 separate studies conducted in various areas of the Mediterranean has been made. Figure 2 depicts these results.

CONCLUSION

E. golanii can easily be misidentified by confusion with similar pelagic species of high economic importance such as *Engraulis encrasicolus* (European anchovy) and the *Sardina pilchardus* (European pilchard)(Keramidas et al., 2023). *E. golanii* is known as one of the most fished species among the small pelagic fish species

Table 3. LWRs of "*Etrumeus golanii*" from different localities.

Area	N	Sex	Length range (cm)	Length	a	b	Author(s)
Gulf of Suez		All	-	TL	0.0059	3.158	Sanders et al., 1984
Gulf of Suez, Red Sea, Egypt		All	12.0 – 27.0	SL	0.0011	3.443*	El-Sayed, 1996
Gulf of Suez, Red Sea, Egypt	600	All	11.0 – 24.8	TL	0.0091	3.0356	Mehanna & El-Gammal, 2005
Lebanese coast, Medi. Sea		All	Up to 25	TL	0.0039	3.375	Bariche et al., 2006
Eastern Alex. Medi. Sea, Egypt		All	11.0 -.25.0	TL	0.0071	3.055	Akel, 2009
Iskenderun Bay	61	All	10.0-16.70	-	0.0078	2.989	Ergüden et al., 2009
Beymelek Lagoon, SW Turkey	10	All	8.2-10.6	TL	0.015	2.626	Sümer, 2012
Israeli Coasts	16	All	8.0-24.0	TL	0.0088	2.989*	Edelist, 2014
Egyptian Mediterranean waters	656	All	9.0 – 25.0	TL	0.0066	3.051	Farrag et al., 2014
Antalya Bay	68	All	14.6 – 24.1	SL	0.0081	3.021	Türker et al., 2020
Eastern Mediterranean, Egypt	630	All	9-11.7	TL	0.0091	3.036	Mehanna1 & Farouk, 2021
Antalya Bay	438	All	8.0 – 26.4	TL	0.0059	3.1218	This study

N: number of individuals, TL: Total Length, FL: Fork Length, SL: Standard Length, a: intercept, b: slope, r^2: coefficient of determination

belonging to the family Dussumieriidae, which is economically valuable in the Türkiye coasts of the Eastern Mediterranean basin. *E. golanii* originated from the Red Sea and was first recorded in 1961 in Ashdod, Israel, when a few individuals were caught from a trawl at a depth of 100 m. Until today, it has been detected at different depths throughout the Mediterranean basin. After this first record in the Mediterranean, it was found that it was limited to form populations in some parts of the Eastern Mediterranean for years and was several decades late in its geographical distribution, and it started to spread more rapidly from the Central Mediterranean to the Western Mediterranean (Azzuro et al., 2016; Galil et al., 2019; Dikou, 2024). Although *E. golanii* is an economically important species, it is an alien species for the Mediterranean basin and should be monitored in terms of fisheries biology and population dynamics.

Season, nutrition, habitat, gonad development, sex, health, stomach fullness, and preservation procedures all have an impact on the parameters of the fish, LWRs (Tesch, 1971; Bagenal & Tesch 1978; Hossain et al., 2006).

All the allometric coefficients (b) estimated in this study were within the expected range between 2.9 and 3.3. Additionallay Bagenal & Tesch (1978); Koutrakis & Tsikliras (2003); Yılmaz & Hoşsucu (2003), allometric coefficients (b) may range from 2 to 4. There has not been much research on growth parameters such as LLRs and LWRs for *E. golanii*, a Lessepsian species. However, as stated in Table 3, the results of the current study are similar to those of other studies.

While the LWR parameter values compiled from these studies are presented in Table 3, a comparison of the parameters is made in Figure 2. According to data obtained from previous studies, the value of the b slope for *E. golanii* varies between 2.626 and 3.443. The mean value of b was 3.0750, the median value of b was calculated to be 3.0435, and the Log_{10} a and b plot was used to detect outliers (Figure 2).

FaroesE (2000) suggested that plotting log a and b for all known LWRs of a species results in a linear relationship and that this relationship can be used to identify outliers (Stergiou & Moutopoulos, 2001). We applied this method to the LWR 12 data (Figure 2). This method resulted in the detection of more than one point with data for the species deviating from the linear graph. Points deviating from the regression line are shown in circles in Figure 2, and the data to which this data belongs is marked as suspicious in Table 3.

Figure 2 is thought that compiling these findings contributes to the Bayesian hierarchical approach used in LWR calculations in the Froese and Pauly, 2024.

Conflict of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics Committee Approval: No need for ethical approval for this study.

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