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Age, Growth, and Otolith Morphometrics of *Trachinus draco* (L., 1758) and *Trachinus radiatus* (Cuvier, 1829) in the Eastern Mediterranean

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Abstract: *Trachinus draco* and *Trachinus radiatus* are two bycatch species of low commercial value and no sufficient knowledge on their biological features. In the present study, the weight–length relationship, age, growth, and ten otolith morphometric variables of these species were investigated in the southwestern Aegean Sea for the first time. Positive allometric and isometric growth in the weight were defined in *T. draco* and *T. radiatus*. The weight–length relationship was described by the parameters α = 0.002415 and b = 3.35745 in *T. draco* and α = 0.007582 and b = 3.09452 in *T. radiatus*. The von Bertalanffy growth function parameters were L_∞ = 44.51 cm, k = 0.15 year^{-1}, and t_0 = -1.31 years for *T. draco* and L_∞ = 58.47 cm, k = 0.16 year^{-1}, and t_0 = -0.78 years for *T. radiatus*. Ten otolith variables (radius, length, width, area, perimeter, roundness, circularity, form factor, rectangularity, and ellipticity) showed a significant relationship with size for both species, except the ellipticity in *T. radiatus*. The mean values of all the otolith variables were higher in *T. radiatus* than in *T. draco*. The otolith of *T. radiatus* was found to become more rectangular with size as compared to the otolith of *T. radiatus*. The results of this work can support further research on the behavioral and ecological features of the two species.

Keywords: age; von Bertalanffy parameters; otolith morphometry; weight–length relationship; Aegean Sea; greater weever; starry weever

Key Contribution: The present study includes important information on the age, growth, and otolith morphometrics of *T. draco* and *T. radiatus* in the southwestern Aegean Sea for the first time. It contributes significantly to the life history traits of these two species, providing fishery science and information that is necessary in population dynamics.

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1. Introduction

Age and growth are essential for biology, population dynamics, stock assessment, and fisheries management. Moreover, by examining the structural, functional, and phenotypic variability of otoliths, researchers can acquire major knowledge on stock identification, species interactions, and interactions with their environment [1]. Their biological variables may be affected by a variety of environmental parameters, which may lead to differences in the biological parameters of a species among different regions, even over small geographical ranges [2]. This kind of information is also necessary for less commercial species [3], which contribute to the world's biodiversity and the stability of ecosystems, and for which scientific knowledge is generally scarce. Therefore, improving our knowledge of their life history traits is very important.

The greater weever, *Trachinus draco* (Linnaeus, 1758), and the starry weever, *Trachinus radiatus* (Cuvier, 1829), are demersal species that belong to the family Trachinidae. They occur in the Eastern Atlantic, Mediterranean, and Black Sea. These species inhabit mainly sandy and muddy bottoms ranging from a few meters to 150 m in depth [4]. Both species are oviparous with pelagic eggs and larval stages [5]. The spawning period of *T. draco* is from June to August [6], while in *T. radiatus*, this period begins in May and extends till October [7]. Both species are carnivorous and feed on small fish, invertebrates, and crustaceans [8]. Moreover, they are well known for their venomous dorsal spines [9]. In the Mediterranean Sea, weevers are considered as fish of low commercial value, and are mainly caught as bycatch by bottom trawl and gill nets [10,11]. Although these two species are widely distributed and their ecological role is important [8], published information on their biological characteristics is limited, especially for *T. radiatus*.

Some of the studies have been focused on the weight–length relationship (*WLR*), age, growth, or otolith morphometrics of *T. draco* in the Mediterranean Sea [12–24]. Regarding *T. radiatus*, there are a few studies that have been conducted on the *WLR* for the species in the Mediterranean [14,24–26], while only one has been performed on its age and growth [9].

The objectives of the present work include the study of the age, growth, and otolith morphometrics of *T. draco* and *T. radiatus* in the southwestern Aegean Sea for first time. The aim is to improve the scientific knowledge on the life history traits of these two species and provide information that is necessary in population dynamics.

2. Material and Methods

2.1. Study Area and Data Collection

Samples of *T. draco* (89 individuals) and *T. radiatus* (76 individuals) were collected during experimental bottom trawl surveys conducted at depths ranging between 69 and 127 m in 37 sampling stations of the SW Aegean Sea (Figure 1) during May and June 2015.

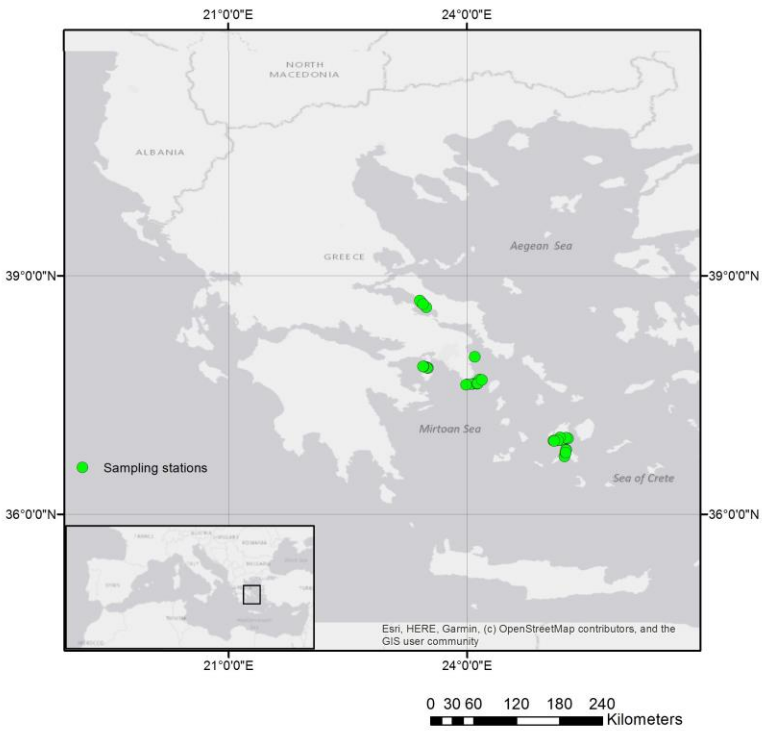

Figure 1. Map of the sampling stations (green dots) in the southwestern Aegean Sea.

The total length (*TL*) and total weight (*TW*) of each specimen were recorded to the nearest mm and g, respectively. Gonads were examined under a microscope to determine their sexual identity. The sagittal otoliths were extracted, cleaned in water to remove the organic matter, and then preserved dry. Each left otolith was placed proximal side down on a glass Petri dish filled with water and then imaged using Image-Pro Plus software (Version 4.5.0.29) under transmitted light against a black backdrop at 6.3× magnification.

Counting the annual growth rings, defined as alternating opaque and translucent zones along the left sagittal otolith axis from the core to the post-rostrum edge, served as the basis for age reading by three independent readers. A second reading was conducted when readings differed to reach an agreement or to exclude an otolith in the case of disagreement. Otoliths that were broken or damaged were not used in the age determination or the examination of the morphometric parameters. The final number of otoliths that were used for age determination and otolith morphometrics were 86 and 68 for *T. draco* and *T. radiatus*, respectively. Regardless of the species' spawning season, the date of birth was established on 1 January, in accordance with standards used by the great majority of fish age determination laboratories worldwide [27,28].

Based on the observations of the left sagittal otolith, the following otolith morphometric variables were recorded from the otoliths of both studied species: otolith area (*OA*, mm^2); otolith length (*OL*, mm); otolith width (*OW*, mm); radius (*RA*, mm); perimeter (*PE*, mm) (Figure 2); roundness (*RD*) (the ratio between the actual area and the area of a circle of the same diameter; factor is larger if and when the shape of the otolith is more circular) [29] taking a minimum value of 1 [30]; circularity (*CI*) (provides information on the complexity of the otolith contour) [31] taking a minimum value of 4π [30]. Additionally, the following shape factors were calculated: form factor (*FF*) = ([$4 \times OA/PE^2$]) (a dimensionless value that indicates the similarity of the otolith contour to a circle, taking values from 0 to 1, with a value of 1 corresponding to a perfect circle); rectangularity (*RC*) = ($OA/[OL \times OW]$) (which gives information about the approximation to a rectangular or square shape, indicating a perfect rectangle or square if it has a value of 1); and ellipticity (*EL*) = ($OL - OW/OL + OW$) (reflects the similarity to an ellipse, with values close to 0 indicating a tendency towards circularity) [31].

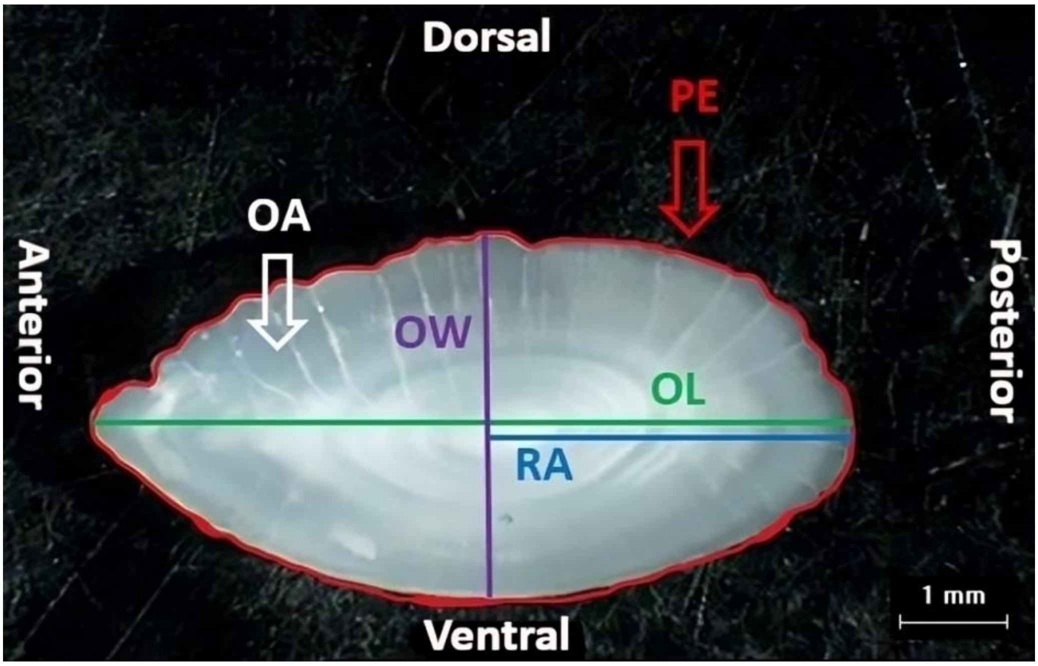

Figure 2. Left otolith of *Trachinus draco* presenting the measurements that were examined *RA*: radius (mm); *OL*: otolith length (mm); *OW*: otolith width (mm); *OA*: otolith area (mm^2); *PE*: perimeter (mm).

2.2. Data Analysis

2.2.1. Growth

Length (*TL*) frequency distribution per species was calculated based on classes of 1 cm intervals. The weight–length relationship (*WLR)* was estimated according to the equation $TW = \alpha TL^b$, where *TW* is the total weight in g, *TL* is the total length in cm, α is the intercept, and *b* is the slope of the log-linear regression. The *WLR* relationship was studied for both sexes and combined since no differences were detected between them [32]. Student's *t*-test was used to examine the isometric growth null hypothesis (H_0: $b = 3$) for each species.

An age–length key was constructed by species based on the otolith age readings. The von Bertalanffy growth parameters [33] were determined through the equation: $L_t = L_\infty (1 - e^{-k(t-t_0)})$ where L_t is the predicted length at age *t* in cm, L_∞ is the mean theoretical asymptotic length in cm, *k* is the rate at which L_∞ is approached in year^{-1}, and t_0 is the theoretical age at zero length in years. The growth performance index Φ' ($\Phi' = \log k + 2\log L_\infty$) [34] was also used to compare the growth parameters of the two species with those available in the published literature.

2.2.2. Otolith Morphometrics

The mean (±standard error), minimum, and maximum values of the studied otolith morphometric variables were calculated by species. ANOVA was performed to investigate the between-species differences in otolith morphometric variables (significance level a = 0.05).

For each species, the relationship between each otolith morphometric variable and *TL* was examined based on the exponential regression $y = Ax^B$ (where *y* is the otolith morphometric variable in mm, *x* is the total length in mm, *A* is the intercept, and *B* is the regression slope). For the regressions presenting statistically significant relationship (p-value < 0.05), comparison of slope *b* between the two species was performed using ANCOVA analysis (significance level a = 0.05).

3. Results

3.1. Growth

3.1.1. Length Distribution

In total, 165 individuals were examined for this study, including 89 samples of *T. draco* and 76 of *T. radiatus*. The size of *T. draco* varied from 13.3 to 30.7 cm *TL*, while that of *T. radiatus* varied from 16.0 to 43.2 cm *TL* (Figure 3). *T. radiatus* presented greater sizes than *T. draco* as a result of the different known somatic types of the two species.

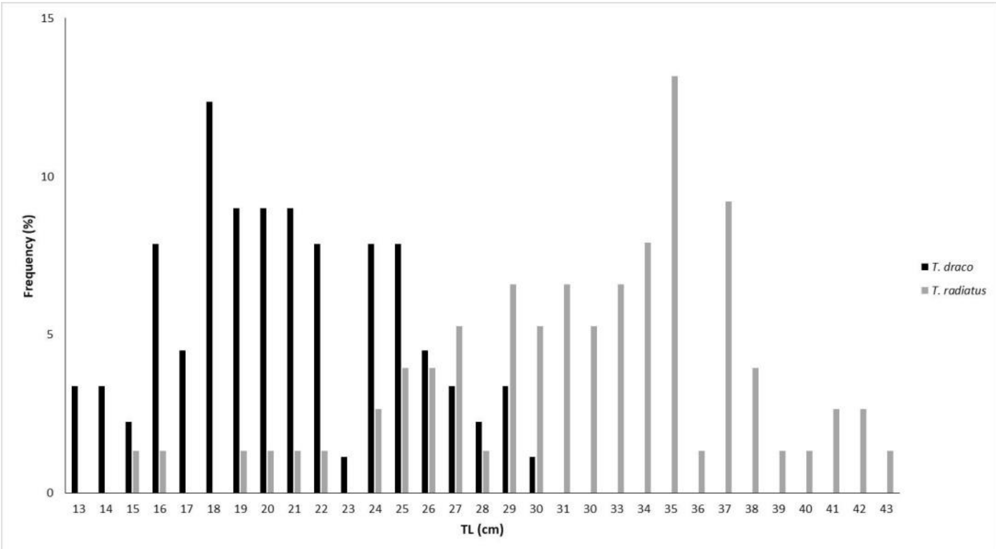

Figure 3. Length frequency distribution (TL, cm) of *Trachinus draco* (black) and *Trachinus radiatus* (grey) in the SW Aegean Sea.

3.1.2. Weight–Length Relationship

The total weight (*TW*) values varied from 16.0 to 244 g in *T. draco* and from 45.0 to 1042.0 g in *T. radiatus*. *WLR* for each species was as follows: $TW = 0.00242 \times TL^{3.357}$ (R^2 = 98%) for *T. draco*; $TW = 0.00758 \times TL^{3.095}$ (R^2 = 98%) for *T. radiatus*. The *WLR* showed that *b* was statistically significantly higher than three in *T. draco* (t-test = 6.62, p-value < 0.01), while no statistically significant difference was found in *T. radiatus* (t-test = 1.73, p-value = 0.09).

3.1.3. Age and Growth

Based on the otolith readings, 6 (from 1 to 6) and 7 (from 1 to 7) age groups were identified from 86 *T. draco* and 68 *T. radiatus*, respectively. The first visible ring around the nucleus of the otoliths of both species was considered a false ring (Figures 4 and 5). Table 1 displays the relevant age–length keys for *T. draco* and *T. radiatus*. The majority of *T. draco* belonged to age group two; *T. radiatus* to age group four. The von Bertalanffy parameters and the growth performance index Φ' for each species are shown in Table 2 and the von Bertalanffy growth curves per species are presented in Figure 6.

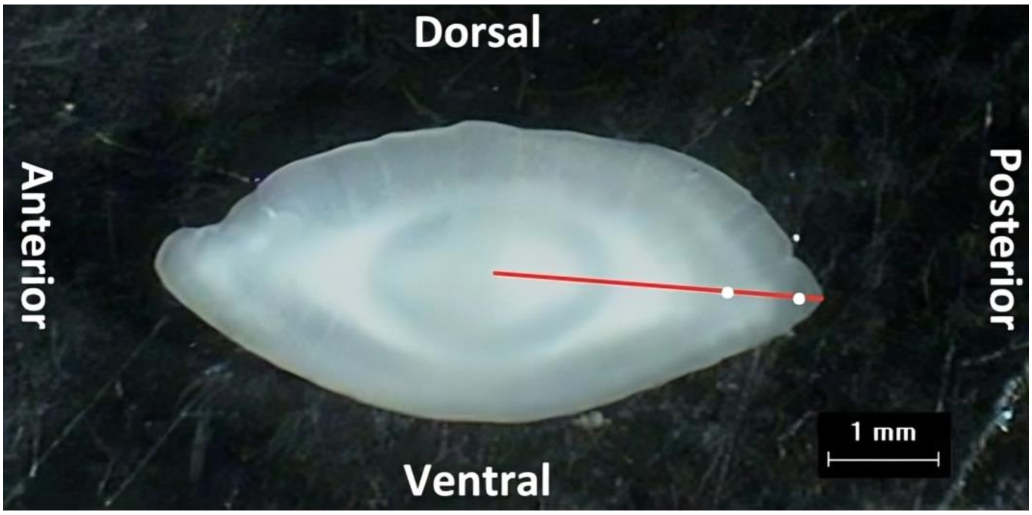

Figure 4. Otolith of *Trachinus draco* with two annual rings (white dots); total length 15 cm; date of capture 30 May 2015.

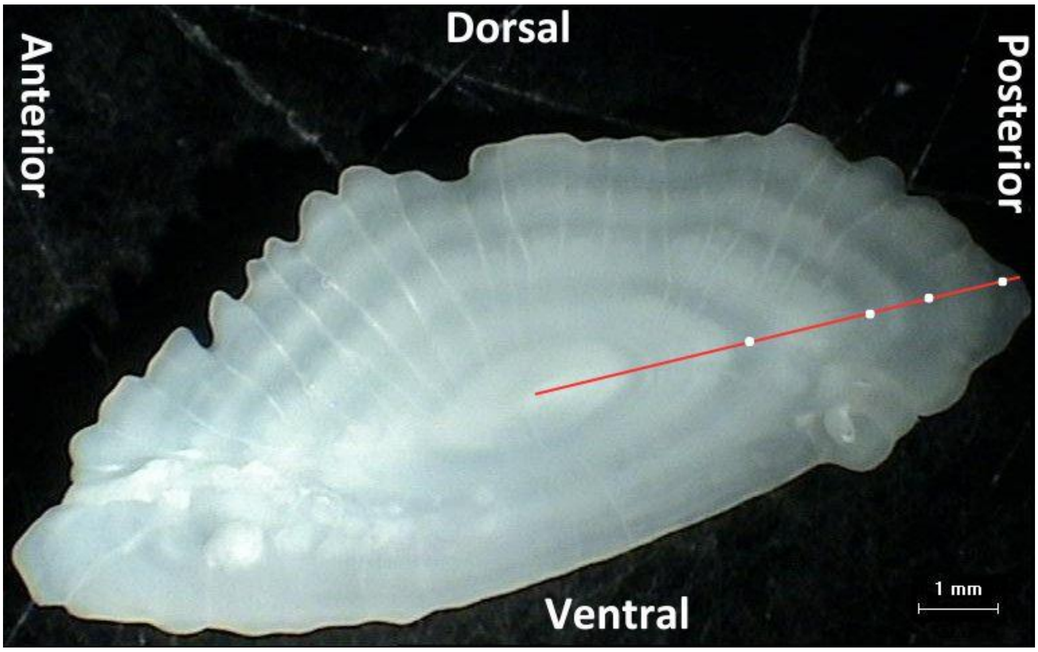

Figure 5. Otolith of *Trachinus radiatus* with four annual rings (white dots); total length 36 cm; date of capture 10 June 2015.

Table 1. Age–length key of *Trachinus draco* and *Trachinus radiatus* from SW Aegean Sea [*TL*: total length (cm); *N*: total number of individuals].

	Trachinus draco						*Trachinus radiatus*						
Length Classes (*TL*, cm)	**Age Classes**												
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
13.0–13.9	2												
14.0–14.9	2	1											
15.0–15.9		3											
16.0–16.9		5					1						
17.0–17.9		4											
18.0–18.9		10											
19.0–19.9		8	2					1					
20.0–20.9			7										
21.0–21.9			7					2					
22.0–22.9			9										
23.0–23.9				1					1				
24.0–24.9				6					2				
25.0–25.9				5					2				
26.0–26.9				5	1				4				
27.0–27.9					2				4				
28.0–28.9					2								
29.0–29.9						3				5			
30.0–30.9						1				4			
31.0–31.9										6			
32.0–32.9										1	2		
33.0–33.9										1	3		
34.0–34.9											2		
35.0–35.9										3	7		
36.0–36.9										1	1	1	
37.0–37.9											2	5	
38.0–38.9											1	1	
39.0–39.9												1	
40.0–40.9												2	
41.0–41.9												1	
42.0–42.9													
43.0–43.9													1
N	4	31	25	17	5	4	1	3	13	21	18	11	1

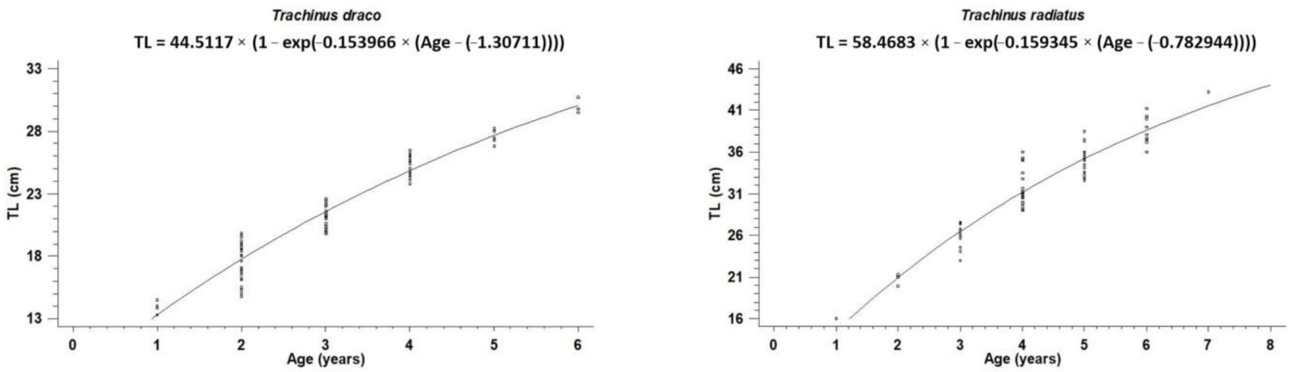

Figure 6. The von Bertalanffy growth curves for *Trachinus draco* and *Trachinus radiatus* (**left**) and (**right**), respectively.

Table 2. The von Bertalanffy growth parameters of *Trachinus draco* and *Trachinus radiatus* in the SW Aegean Sea (N: total number of individuals; L_∞: the mean theoretical asymptotic length in cm; k: a growth rate parameter in year^{-1}; t_0: the theoretical age at zero length in years; $S.E$: standard error; Φ': the growth performance index).

Species	N	$L_\infty \pm S.E$ (cm)	$k \pm S.E$ (Year^{-1})	$t_0 \pm S.E$ (Year)	Φ'
Trachinus draco	86	44.51 ± 5.48	0.15 ± 0.04	−1.31 ± 0.37	2.47
Trachinus radiatus	68	58.47 ± 10.22	0.16 ± 0.06	−0.78 ± 0.63	2.74

3.2. Otolith Morphometrics

The mean (±standard error) as well as the maximum and minimum values of the *RA* (radius), *OL* (otolith length), *OW* (otolith width), *OA* (otolith area), *PE* (perimeter), *RD* (roundness), *CI* (circularity), *FF* (form factor), *RC* (rectangularity), and *EL* (ellipticity) of the left otolith for each species are given in Table 3. Statistically significant differences were defined in all the otolith morphometric variables between the two species (ANOVA, p-value < 0.05) (Table 3).

Table 3. Mean (±standard error), minimum, and maximum (in parenthesis) values of the otolith morphometric variables: *RA* (radius, mm), *OL* (otolith length, mm), *OW* (otolith width, mm), *OA* (otolith area, mm^2), *PE* (perimeter, mm), *RD* (roundness), *CI* (circularity), *FF* (form factor), *RC* (rectangularity), and *EL* (ellipticity) of *Trachinus draco* and *Trachinus radiatus* from the SW Aegean Sea. The p-values for the comparison of the otolith morphometric variables between the two species (ANOVA) are also shown.

Morphometric Variable	*Trachinus draco*	*Trachinus radiatus*	ANOVA (p-Value)
RA (mm)	3.60 ± 0.06 (2.75–4.97)	5.61 ± 0.09 (3.75–6.84)	<0.05 *
OL (mm)	7.87 ± 0.14 (5.78–10.83)	11.73 ± 0.19 (7.53–14.81)	<0.05 *
OW (mm)	3.62 ± 0.05 (2.61–4.52)	4.89 ± 0.08 (3.14–6.24)	<0.05 *
OA (mm^2)	20.85 ± 8.42 (11.28–39.48)	44.70 ± 1.36 (16.95–67.42)	<0.05 *
PE (mm)	18.62 ± 0.33 (13.54–26.15)	28.06 ± 0.48 (17.16–34.95)	<0.05 *
RD	1.29 ± 0.00 (1.21–1.43)	1.42 ± 0.01 (1.30–1.56)	<0.05 *
CI	16.23 ± 0.06 (15.18–17.92)	17.90 ± 0.10 (16.34–19.84)	<0.05 *
FF	0.25 ± 0.00 (0.22–0.26)	0.22 ± 0.00 (0.20–0.24)	<0.05 *
RC	0.75 ± 0.03 (0.69–0.83)	0.77 ± 0.00 (0.71–0.83)	<0.05 *
EL	0.37 ± 0.00 (0.31–0.44)	0.41 ± 0.00 (0.33–0.47)	<0.05 *

* Significance level a = 0.05.

In both species, *TL* presented a statistically significant correlation (p-value < 0.05) with all otolith characteristics that were studied, except for the *EL* in *T. radiatus* (Table 4, Figures S1 and S2). No significant differences (ANCOVA, p-value > 0.05) were found for slope b between the two species in terms of the otolith variables (*RA*, *OL*, *OW*, *OA*, *PE*, *RD*, *CI* and *FF*) except for *RC* (ANCOVA, p-value < 0.05) (Table 4).

Table 4. Parameters of the exponential regression of the total length (TL) of *Trachinus draco* and *Trachinus radiatus* with the otolith morphometric variables: *RA*, radius (mm); *OL*, otolith length (mm); *OW*, otolith width (mm); *OA*, otolith area (mm^2); *PE*, perimeter (mm); *RD*, roundness; *CI*, circularity; *FF*, form factor; *RC*, rectangularity; and *EL*, ellipticity of *T. draco* and *T. radiatus*. *A*, intercept; *B*, slope; R^2, coefficient of determination; *r*, correlation coefficient. The *p*-value of the regressions and the *p*-values of the comparison of slope *b* of the regression lines between the two species (ANCOVA) are also shown.

Variables	Species	*A*	*B*	R^2	*r*	Regression *p*-Value	ANCOVA *p*-Value for *b*
TL/RA	*T. draco*	0.11	0.66	0.82	0.90	<0.01 *	0.88
	T. radiatus	0.14	0.65	0.82	0.91	<0.01 *	
TL/OL	*T. draco*	0.14	0.76	0.92	0.96	<0.01 *	0.14
	T. radiatus	0.21	0.70	0.89	0.94	<0.01 *	
TL/OW	*T. draco*	0.13	0.63	0.84	0.92	<0.01 *	0.59
	T. radiatus	0.11	0.66	0.80	0.89	<0.01 *	
TL/OA	*T. draco*	0.01	1.49	0.93	0.97	<0.01 *	0.22
	T. radiatus	0.01	1.40	0.92	0.96	<0.01 *	
TL/PE	*T. draco*	0.29	0.78	0.94	0.97	<0.01 *	0.37
	T. radiatus	0.38	0.75	0.92	0.96	<0.01 *	
TL/RD	*T. draco*	0.90	0.07	0.18	0.42	<0.01 *	0.48
	T. radiatus	0.85	0.09	0.18	0.43	<0.01 *	
TL/CI	*T. draco*	11.26	0.07	0.18	0.42	<0.01 *	0.37
	T. radiatus	10.34	0.10	0.19	0.43	<0.01 *	
TL/FF	*T. draco*	0.36	− 0.07	0.18	−0.42	<0.01 *	0.37
	T. radiatus	0.39	−0.10	0.19	−0.43	<0.01 *	
TL/RC	*T. draco*	0.43	0.10	0.35	0.59	<0.01 *	0.04 *
	T. radiatus	0.59	0.05	0.08	0.28	0.03 *	
TL/EL	*T. draco*	0.17	0.15	0.19	0.44	<0.01 *	-
	T. radiatus	0.34	0.03	0.01	0.10	0.44	

* Significance level a = 0.05.

4. Discussion

T. draco and *T. radiatus* are two widely distributed species, but little is known about their biology and ecology, especially for *T. radiatus*. Although little historical data on the *WLR* for both species from the study area [14] are available, no data exist on their age, growth, and otolith morphometrics. The results of this study produced updated information on the *WLR* of both species. New knowledge on the age and growth of *T. draco* and *T. radiatus* is provided for the southwestern Aegean Sea for the first time. The novelty of this work includes mainly the detailed study on the otolith morphometrics of the two species in the whole Mediterranean Sea.

The *WLR* analysis showed that the growth of *T. draco* was allometrically positive ($b > 3$), while that of *T. radiatus* was isometric ($b = 3$), which shows that the former species grows more in weight that the latter. In *T. draco*, the value of slope *b* of the WLR of the present study was quite similar with that of studies carried out in the Aegean Sea [14–17,35–38], but it was higher than that of other areas of the Mediterranean Sea (Table 5). Variability in the *b* values of *WLR* was also found in *T. radiatus* among the study areas (Table 6). Genetics, habitat, variations in the length composition, number of samples examined, preservation techniques, wellness, stomach conditions, dietary habits, sex, maturity stages, sampling period, rates of growth, and age are some of the factors that are typically attributed to the differences in the parameters of the *WLR* [39–43].

Table 5. Weight–length relationship of *Trachinus draco* from different study areas (*TL* Range: minimum–maximum total length in cm; *α*: intercept; *b*: slope of the weight–length relationship).

Reference	Area	*TL* Range (cm)	*α*	*b*
[12]	Eastern Adriatic	9.2–26.8	0.00002	2.934
[13]	Balearic Islands	14.0–34.0	0.00740	2.930
[14]	Kyklades, Aegean Sea	14.5–32.0	0.00441	3.120
[44]	Alexandria, Egypt	10.0–23.0	0.01400	2.800
[25]	Balearic Islands and eastern coast of the Iberian Peninsula	6.2–26.5	0.01000	2.835
[45]	Gökceada Island, northern Aegean Sea (coastal waters of Turkey)	4.4–35.2	0.02430	2.578
[35]	Saros bay, northern Aegean Sea (Turkey waters)	15.0–37.0	0.00366	3.202
[15]	Izmir bay, Central Aegean Sea, (Turkey waters)	17.2–34.0	0.00400	3.178
[46]	North-Eastern Mediterranean Coast of Turkey	9.0–20.0	0.00520	3.090
[16]	Izmir Bay, Central Aegean Sea, (Turkey waters)	15.3–36.6	0.00520	3.100
[17]	North Aegean Sea	15.0–30.5	0.00540	3.062
[36]	Izmir Bay, Aegean Sea (Turkey waters)	15.3–36.6	0.00500	3.137
[47]	Eastern Black Sea	5.0–35.0	0.00400	3.433
[18]	Gulf of Castellammare (north-western Sicily)	16.0–29.5	0.00540	3.059
[19]	French Catalan coast	15.0–38.5	0.04300	3.070
[11]	Eastern Black Sea	5.0–25.8	0.00690	3.005
[20]	Mallorca, Spain	9.0–29.0	0.00500	3.075
[37]	Gökçeada Island, northern Aegean Sea, (Turkey waters)	2.4–29.3	0.00900	2.847
[22]	Iskenderun Bay, North-eastern Levantine Sea	13.5–32.0	0.00770	2.950
[38]	Gallipoli peninsula, northern Aegean Sea, (Turkey waters)	13.0–36.4	0.00800	2.972
[23]	Gulf of Tunis	10.0–32.0	0.00600	3.040
[24]	Eastern Adriatic Sea	10.4–32.2	0.00820	2.906
[48]	Western Black Sea	5.6–21.5	0.01740	2.657
[49]	Western Egyptian Mediterranean Sea	11.8–27.6	0.00680	2.963
[50]	Sea of Marmara	6.7–24.6	0.00760	2.971
This study	SW Aegean Sea, Eastern Mediterranean Sea	13.3–30.7	0.00242	3.357

Six (1–6) and seven (1–7) age groups were identified in the current study for *T. draco* and *T. radiatus*, respectively. More age groups have been reported in the published literature. This can be related to the larger size range of samples examined in other studies (Table 7) or to differences in the growth pattern of the species between geographical areas because of different environmental conditions. The study of the microstructure of the otoliths and the daily ring readings could clarify these inconsistencies in the age identification of the studied species.

Table 6. Weight–length relationship of *Trachinus radiatus* from different study areas (*TL* Range: minimum–maximum total length in cm; α: intercept; *b*: slope of the weight–length relationship).

Reference	Area	*TL* Range (cm)	α	*b*
[14]	Kyklades, Aegean Sea	15.4–40.4	0.01271	2.897
[25]	Balearic Islands and eastern coast of the Iberian Peninsula	16.5–47.0	0.00520	3.206
[26]	Zakynthos Island, Ionian Sea	16.0–25.4	0.01600	2.923
[9]	Gulf of Tunis	11.0–50.7	0.00900	3.035
[24]	Eastern Adriatic Sea	13.8–33.5	0.00850	3.029
This study	SW Aegean Sea	16.0–43.2	0.00758	3.095

Table 7. Growth parameters of *Trachinus draco* and *Trahinus radiatus* from different study areas (*TL* Range: minimum–maximum total length in cm; N: number of age groups; L_∞: mean theoretical asymptotic length in cm; *k*: growth rate in year^{-1}; t_0: theoretical age at zero length in years; Φ': growth performance index).

Species	Reference	Area	*TL* Range (cm)	Age Groups N (Range)	L_∞ (cm)	*k* (Year^{-1})	t_0 (Year)	Φ'
Trachinus draco	[11]	Eastern Black Sea	5.0–25.8	6 (1–6)	28.62	0.28	−0.89	2.36
	[20]	Mallorca, Spain	9.0–29.0	10 (0–9)	42.3	0.10	−1.83	2.25
	[22]	Iskenderun Bay, North-eastern Levantine Sea	13.5–32.0	10 (2–11)	46.45	0.08	−3.29	2.24
	[49]	Western Egyptian Mediterranean Sea	11.8–27.6	5(1–5)	27.3	0.5	13.29	2.27
	This study	SW Aegean Sea, Eastern Mediterranean Sea	13.3–30.7	6 (1–6)	44.51	0.15	−1.31	2.47
Trachinus radiatus	[9]	Gulf of Tunis	11.0–50.7	15 (1–15)	41.54	0.26	-	2.65
	This study	SW Aegean Sea, Eastern Mediterranean Sea	16.0–43.2	7 (1–7)	58.47	0.16	−0.78	2.74

The growth parameters and Φ' values for both species (Table 7) showed a variability among the different study areas, which can be attributed to variations in the studied samples' size range, life history characteristics, methods of analysis, and the different environmental factors of each study area.

Differences between the values of the otolith morphometric variables (ANOVA, *p*-value < 0.05) of the two species showed that the otoliths of *T. radiatus* are larger than those of *T. draco* as expected.

A statistically significant correlation was found between *TL* and all the otolith morphometric variables studied in *T. draco* and *T. radiatus* except one (*EL*) in the latter species. Our findings agree with those presented by Başusta and Buz (2015), who also reported an important relationship between total length and otolith length and width in *T. draco*. No published information exists for the other otolith variables of *T. draco*. Otolith morphometry of *T. radiatus* has not been studied to date.

No significant differences (ANCOVA, *p*-value > 0.05) were detected for slope *b* of the regression lines of the otolith variables with *TL*, except for *RC* between the two studied species. However, in the case of *RC*, the statistically significant higher value found in *T. draco* showed that the otolith of this species becomes more rectangular as the size increases than the otolith of *T. radiatus*. This may indicate physiological and/or ecological differences between the two species. Otolith morphology is affected by the growth pattern, food availability, and environmental conditions (salinity, temperature, and depth) [51,52], and is used to identify fish species at the taxonomic, phylogenetic, geographic, and dietary levels [51–55]. It is also a source of information on several biological and ecological aspects of teleosts showing the interactions between fish species and their habitat [1].

In future, more research based on the microstructure of the otoliths could clarify the inconsistencies in the age groups identified for the two studied species among different geographical areas and relate them to the local environmental conditions.

5. Conclusions

This study has updated our knowledge of *T. draco* and *T. radiatus* age, growth, and otolith morphometrics. The weight–length relationship, age, growth and ten otolith morphometric variables of these species were investigated in the southwestern Aegean Sea for first time. Positive allometric and isometric growth in weight was defined in *T. draco* and *T. radiatus*, respectively. Six (1–6) and seven (1–7) age groups were identified in the current study for *T. draco* and *T. radiatus*, respectively. Ten otolith variables (radius, length, width, area, perimeter, roundness, circularity, form factor, rectangularity, and ellipticity) showed a significant relationship with the size for both species, except ellipticity in *T. radiatus*. The mean values of all the otolith variables were higher in *T. radiatus* than in *T. draco*. The results of this work can support further research on the behavioral and ecological features of the two species.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/fishes9050152/s1, Figure S1: Exponential relationships of total length (mm) and otolith morphometric variables of *T. draco* for the southwestern Aegean Sea. *RA* (Radius, mm), *OL* (Otolith Length, mm), *OW* (Otolith Width, mm), *OA* (Otolith Area, mm^2), *PE* (Perimeter, mm), *RD* (Roundness), *CI* (Circularity), *FF* (Form Factor), *RC* (Rectangularity) and *EL* (Ellipticity); Figure S2: Exponential relationships of total length (mm) and otolith morphometric variables of *T. radiatus* for the southwestern Aegean Sea. *RA* (Radius, mm), *OL* (Otolith Length, mm), *OW* (Otolith Width, mm), *OA* (Otolith Area, mm^2), *PE* (Perimeter, mm), *RD* (Roundness), *CI* (Circularity), *FF* (Form Factor), *RC* (Rectangularity) and *EL* (Ellipticity).

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Informed Consent Statement: Not applicable.

Data Availability Statement: Data are contained within the article and Supplementary Materials.

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References

1. Cadrin, S.X.; Friedland, K.D.; Waldman, J.R. Stock identification methods: An overview. In *Stock Identification Methods: Applications in Fishery Science*, 2nd ed.; Cadrin, S.X., Friedland, K.D., Waldman, J.R., Eds.; Elsevier Academic Press: San Diego, CA, USA, 2005; pp. 3–6.
2. Anastasopoulou, A.; Biandolino, F.; Chatzispyrou, A.; Hemida, F.; Guijarro, B.; Kousteni, V.; Prato, E. New Fisheries-related data from the Mediterranean Sea. *Mediterr. Mar. Sci.* **2016**, *17*, 822–827. [CrossRef]
3. FAO. *The State of Mediterranean and Black Sea Fisheries*; General Fisheries Commission for the Mediterranean: Rome, Italy, 2020; p. 172. [CrossRef]
4. Fish Base. Available online: https://fishbase.mnhn.fr/summary/1363 (accessed on 13 March 2023).
5. Tortonese, E. Trachinidae. In *Checklist of the Fishes of the North-Eastern Atlantic and of the Mediterranean (CLOFNAM)*; Hureau, J.C., Monod, T., Eds.; UNESCO: Paris, France, 1986; Volume 2, pp. 951–954, ISBN 92-3-001100-2.
6. Muus, B.J.; Nielsen, J.G. *Sea Fish. Scandinavian Fishing Year Book*; Narayana Press: Hedehusene, Denmark, 1999; p. 340.
7. Hamed, O.; Chakroun-Marzouk, N. Aspects reproductifs de *Trachinus draco* Linnaeus, 1758 du golfe de Tunis. In Proceedings of the Actes des XVIèmes Journées Tunisiennes des Sciences de la Mer, Zarzis, Tunisia, 19–23 December 2015; p. 27.
8. Betogian, L.; Mytilineou, C.; Anastasopoulou, A.; Batzakas, I. Diet composition of *Trachinus draco* and *Trachinus radiatus* from the South Aegean Sea (E. Mediterranean). *Cah. Biol. Mar.* **2019**, *60*, 461–464. [CrossRef]
9. Hamed, O.; Dufour, J.L.; Chakroun-Marzouk, N.; Mahé, K. Age, growth and mortality of the starry weever Trachinus radiatus Cuvier, 1829 in the Tunisian waters. *Cah. Biol. Mar.* **2019**, *60*, 87–94. [CrossRef]
10. Başusta, N.; Erdem, U. A Study on the pelagic and demersal fishes of Iskenderun Bay (in Turkish). *Turk. J. Zool.* **2000**, *24*, 1–19.
11. Ak, O.; Genç, Y. Growth and reproduction of the greater weever (*Trachinus draco* L., 1758) along the eastern coast of the Black Sea. *J. Black Sea/Mediterr. Environ.* **2013**, *19*, 95–110.
12. Dulčić, J.; Kraljević, M. Weight-length relationships for 40 fish species in the eastern Adriatic (Croatian waters). *Fish. Res.* **1996**, *28*, 243–251. [CrossRef]
13. Merella, P.; Quetglas, A.; Alemany, F.; Carbonell, A. Weight-length relationships of fishes and cephalopods from the Balearic Islands (western Mediterranean). *Naga ICLARM Q.* **1997**, *20*, 66–68.
14. Moutopoulos, D.K.; Stergiou, K.I. Length–weight and length–length relationships of fish species from the Aegean Sea (Greece). *J. Appl. Ichthyol.* **2002**, *18*, 200–203. [CrossRef]
15. Özaydin, O.; Uckun, D.; Akalin, S.; Leblebici, S.; Tosunoglu, Z. Length-weight relationships of fishes captured from Izmir Bay, Central Aegean Sea. *J. Appl. Ichthyol.* **2007**, *23*, 695–696. [CrossRef]
16. Ilkyaz, A.T.; Metin, G.; Soykan, O.; Kinacigil, H.T. Weight-length relationships of 62 fish species from the Central Aegean Sea, Turkey. *J. Appl. Ichthyol.* **2008**, *24*, 699–702. [CrossRef]
17. Karachle, P.K.; Stergiou, K.I. Length-length and weight-length relationships of several fish species from the North Aegean Sea (Greece). *J. Biol. Res.* **2008**, *10*, 149–157.
18. Giacalone, V.M.; D'Anna, G.; Badalamenti, F.; Pipitone, C. Weight-length relationships and condition factor trends for thirty-eight fish species in trawled and untrawled areas off the coast of northern Sicily (central Mediterranean Sea). *J. Appl. Ichthyol.* **2010**, *26*, 954–957. [CrossRef]
19. Crec'hriou, R.; Neveu, R.; Lenfant, P. Length–weight relationship of main commercial fishes from the French Catalan coast. *J. Appl. Ichthyol.* **2012**, *28*, 861–862. [CrossRef]
20. Ordines, F.; Farriols, M.; Lleonart, J.; Guijarro, B.; Quetglas, A.; Massutí, E. Biology and population dynamics of by-catch fish species of the bottom trawl fishery in the western Mediterranean. *Mediterr. Mar. Sci.* **2014**, *15*, 613–625. [CrossRef]
21. Başusta, N.; Buz, K. The relationships between otolith dimensions and total length of the greater weever *Trachinus draco* from the North-eastern Mediterranean, Turkey. In *New Fisheries-Related Data from the Mediterranean Sea*; Karachle, P.K., Başusta, A., Başusta, N., Bostanci, D., Buz, K., Girgin, H., Chater, I., Kokokiris, L., Kontaş, S., Ktari, M.H., et al., Eds.; Mediterranean Marine Science: Athens, Greece, 2015; Volume 16, pp. 285–293. [CrossRef]
22. Buz, K.; Başusta, N. Age and growth of the greater weever, *Trachinus draco* (Linnaeus, 1758) inhabiting Iskenderun Bay, North-eastern Mediterranean Sea. *Cah. Biol. Mar.* **2015**, *56*, 289–295.
23. Hamed, O.; Mahé, K.; Chakroun-Marzouk, N. Somatic growth, condition and form factor of *Trachinus draco* (Linnaeus, 1758) in the gulf of Tunis (Tunisia). *INSTM Bull. Mar. Freshw. Sci.* **2017**, *44*, 1–11.
24. Soldo, A. Length-weight relationships for the fifty littoral and coastal marine fish species from the Eastern Adriatic Sea. *Acta Adriat.* **2020**, *61*, 205–210. [CrossRef]
25. Morey, G.; Moranta, J.; Massuti, E.; Grau, A.; Linde, M.; Riera, F.; Morales-Nin, B. Weight–length relationships of littoral to lower slope fishes from the western Mediterranean. *Fish. Res.* **2003**, *62*, 89–96. [CrossRef]
26. Dimitriadis, C.; Fournari-Konstantinidou, I. Length-weight relations for 20 fish species (Actinopterygii) from the southern Ionian Sea, Greece. *Acta Ichthyol. Piscat.* **2018**, *48*, 415–417. [CrossRef]
27. ICES. Workshop on Age reading of Horse Mackerel, Mediterranean Horse Mackerel and Blue Jack Mackerel (*Trachurus trachurus*, *T. mediterraneus* and *T. picturatus*) (WKARHOM3). In Proceedings of the ICES CM 2018/EOSG:28, Livorno, Italy, 5–9 November 2018; p. 186.
28. NOAA (National Oceanic and Atmospheric Administration Fisheries). Available online: https://www.fisheries.noaa.gov/national/science-data/age-and-growth (accessed on 25 October 2022).

29. Ponton, D. Is geometric morphometrics efficient for comparing otolith shape of different fish species? *J. Morphol.* **2006**, *267*, 750–757. [CrossRef]
30. Pothin, K.; Gonzalez-Salas, C.; Chabanet, P.; Lecomte-Finiger, R. Distinction between *Mulloidichthys flavolineatus* juveniles from Reunion Island and Mauritius Island (south-west Indian Ocean) based on otolith morphometrics. *J. Fish Biol.* **2006**, *69*, 38–53. [CrossRef]
31. Tuset, V.M.; Lozano, I.J.; GonzÍez, J.A.; Pertusa, J.F.; García-Díaz, M.M. Shape indices to identify regional differences in otolith morphology of comber, *Serranus cabrilla* (L., 1758). *J. Appl. Ichthyol.* **2003**, *19*, 88–93. [CrossRef]
32. Nikiforidou, V.; Anastasopoulou, A.; Betogian, L.; Mytilineou, C. *Weight-Length Relationships of Trachinus draco (L., 1758) and Trachinus radiatus (C., 1829) in the Aegean Sea*; Institute of Marine Biological Resources and Inland Waters, Hellenic Centre for Marine Research (HCMR): Argyroupoli, Greece; Attiki, Greece, 2024; *submitted*.
33. Von Bertalanffy, L. A quantitative theory of organic growth (inquiries on growth laws II). *Hum. Biol.* **1938**, *10*, 181–213.
34. Pauly, D.; Munro, J.L. Once more on the comparison of growth in fish and invertebrates. *Fishbyte WorldFish Cent.* **1984**, *2*, 1–21.
35. İşmen, A.; Ozen, E.; Altınagaç, U.; Ozekinci, U.; Ayaz, A. Weight-length relationships of 63 fish species in Saros Bay, Turkey. *J. Appl. Ichthyol.* **2007**, *23*, 707–708. [CrossRef]
36. Kinacigil, H.T.; Ilkyaz, A.T.; Metin, G.; Ulas, A.; Soykan, O.; Akyol, O.; Gurbet, R. Determining the first reproduction length, age and growth parameters of Aegean sea demersal fish for the regulation of fisheries management. *Tubitak-Çaydag* **2008**, 327. (In Turkish) [CrossRef]
37. Altın, A.; Ayyıldız, A.; Kale, S.; Alver, C. Length-weight relationships of forty-nine fish species from shallow waters of Gökçeada Island, northern Aegean Sea. *Turk. J. Zool.* **2015**, *39*, 971–975. [CrossRef]
38. Öztekin, A.; Özekinci, U.; Daban, İ.B. Length-weight relationships of 26 fish species caught by longline from the Gallipoli peninsula, Turkey (northern Aegean Sea). *Cah. Biol. Mar.* **2016**, *57*, 335–342.
39. Tesch, F.W. Age and Growth. In *Methods for Assessments of Fish Production in Freshwaters, International Biological Programme*; Ricker, W.E., Ed.; Blackwell Scientific Publications: Oxford, UK, 1971; Volume 54, pp. 101–313.
40. Shepherd, G.; Grimes, C.B. Geographic and historic variations in growth of weakfish (*Cynoscion regalis*) in the middle Atlantic Bight. *Fish. Bull.* **1983**, *81*, 803–813.
41. Weatherly, A.H.; Gill, H.S. *The Biology of Fish Growth*; Academic Press: London, UK, 1987.
42. Wootton, R.J. Biotic interactions: II. Competition and mutualism. In *Ecology of Teleost Fishes, Fish and Fisheries Series 1*; Chapman and Hall, Ed.; Springer: Dordrecht, The Netherlands; London, UK, 1990; pp. 216–237.
43. Garvey, J.E.; Devries, D.R.; Wright, R.A.; Miner, J.G. Energetic adaptations along a broad latitudinal gradient: Implications for widely distributed assemblages. *Bioscience* **2003**, *53*, 141–150. [CrossRef]
44. Abdallah, M. Length-weight relationship of fishes caught by trawl off Alexandria, Egypt. *Naga ICLARM Q.* **2002**, *25*, 19–20.
45. Karakulak, F.S.; Erk, H.; Bilgin, B. Length-weight relationships for 47 coastal fish species from the northern Aegean Sea, Turkey. *J. Appl. Ichthyol.* **2006**, *22*, 274–278. [CrossRef]
46. Sangün, L.; Akamca, E.; Akar, M. Weight-length relationships for 39 fish species from the north-eastern Mediterranean coast of Turkey. *Turk. J. Fish. Aquat. Sci.* **2007**, *7*, 37–40.
47. Ak, O.; Kutlu, S.; Aydin, İ. Weight-length relationships for 16 fish species from the Eastern Black Sea, Türkiye. *Turk. J. Fish. Aquat. Sci.* **2009**, *9*, 125–126.
48. Gözler, A.M.; Baytaşoğlu, H. Length-Weight Relationship For 14 Fish Species From The South-Western Black Sea, Turkey. *J. Anatol. Environ. Anim. Sci.* **2022**, *7*, 138–144.
49. Heneish, R.; Rizkalla, S.; Abdallah, M. Age Composition, Growth and Mortality of Spotted Weever (*Trachinus araneus*- Cuvier, 1829) and Greater Weever (*Trachinus draco*- Linnaeus, 1758) from the Western Egyptian Mediterranean Sea. *Egypt. J. Aquat. Biol. Fish.* **2022**, *26*, 1039–1051. [CrossRef]
50. Karadurmuş, U. Length–Weight Relationship and Condition Factor of Sixteen Demersal Fish Species from the Southern part of the Marmara Sea, Turkey. *J. Ichthyol.* **2022**, *62*, 543–551. [CrossRef]
51. Lombarte, A.; Lleonart, J. Otolith size changes related with body growth, habitat depth and temperature. *Environ. Biol. Fishes* **1993**, *37*, 297–306. [CrossRef]
52. Tuset, V.M.; Rosin, P.L.; Lombarte, A. Sagittal otolith shape used in the identification of fishes of the genus *Serranus*. *Fish. Res.* **2006**, *81*, 316–325. [CrossRef]
53. Škeljo, F.; Ferri, J. The use of otolith shape and morphometry for identification and size-estimation of five wrasse species in predator-prey studies. *J. Appl. Ichthyol.* **2011**, *28*, 524–530. [CrossRef]
54. Disspain, M.C.; Ulm, S.; Gillanders, B.M. Otoliths in archaeology: Methods, applications and future prospects. *J. Archaeol. Sci. Rep.* **2016**, *6*, 623–632. [CrossRef]
55. Jawad, L.; Hoedemakers, K.; Ibáñez, A.; Ahmed, Y.; Abu El-Regal, M.; Mehanna, S. Morphology study of the otoliths of the parrotfish, *Chlorurus sordidus* (Forsskål, 1775) and *Hipposcarus harid* (Forsskål, 1775) from the Red Sea coast of Egypt (Family: Scaridae). *J. Mar. Biol. Assoc.* **2018**, *98*, 819–828. [CrossRef]