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Population Dynamical Parameters of Brushtooth Lizard Fish [*Saurida undosquamis* (Richardson, 1848)] from the Northeastern Mediterranean Coast of Turkey

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Özet: ***Babadıllimanı Koyu'ndaki (Kuzeydoğu Akdeniz) İndo-Pasifik Iskarmoz Balığı'nda (*Saurida undosquamis *Richardson, 1848) popülasyon parametreleri.*** Bu çalışma, kuzeydoğu Akdeniz'deki Indo-Pasifik Iskarmozu (*Saurida undosquamis* Richardson, 1848)'nun yaş, büyüme, üreme ve ölüm oranlarını belirlenmek amacıyla yapılmış olup; Mayıs 1999-Nisan 2000 tarihleri arasında aylık olarak gerçekleştirilen dip trolü örneklemeleri sonucunda elde edilen 2757 adet S. undosquamis incelenmiştir. Boy-Ağırlık ilişkisinin W=0.0047*L3.095 olduğu hesaplanmış; von Bertalanffy'nin boyca ve ağırlıkça büyüme sabitlerinin ise, L = 41.57cm, K = 0.118yıl-1, to = -1.895yıl ve W=474.59gr olduğu belirlenmiştir. Ölüm oranları Z=0.7664yıl-1, M=0.4033yıl-1 ve F=0.3631yıl-1 olduğu, stoktan yararlanma düzeyleri dikkate alındığında ise, bölgede hemen hemen optimum düzeyde yararlanıldığı (0.47 yıl-1) belirlenmiştir.

Anahtar Kelimeler: Indo-Pasifik Iskarmozu (*Saurida undosquamis*), Von Bertalanffy büyüme sabitleri, Ölüm oranları, Stoktan yararlanma

Abstract: This study was performed to assess exploitation, growth characteristics, reproduction, mortality rates and exploitation rate of the Brushtooth lizardfish (*Saurida undosquamis*), from the Babadillimanı Bight, located in the Western entrance of Mersin Bay. For this purpose, 2757 individuals Brushtooth lizardfish were obtained by monthly samplings between May 1999 and April 2000, and they consisted of 39 % males, 29% females and 32% juveniles. Considering growth characteristics, Length-weight relationship was W = 0.0047xL3.095, and von Bertalanffy growth constants in length and weight were L∞ = 41.57 cm, K = 0.118 year-1, to =-1.895 year and W∞ = 474.59 g, respectively. It was also estimated that total mortality was Z = 0.7664 year-1, and its components were M = 0.4033 year-1, F = 0.3631 year-1. When exploitation rate was taken into account, it was found that the Brushtooth lizardfish was under exploited (E=0.47 year-1) in the Babadillimanı Bight.

Key Words: Brushtooth Lizardfish (*Saurida undosquamis*), Von Bertalanffy growth constants, Mortality rates, Exploitation rate

Introduction

The Brushtooth lizardfish [*Saurida undosquamis* (Richardson, 1848)] is a Lessepsian migrant species that penetrated into the Mediterranean Sea from the Indo-West Pacific through the Suez Canal (Ben-Tuvia, 1966; Gucu *et al*., 1994). The first report about Brushtooth lizardfish in Turkish seas was by Kosswig (1951). This species is one of the most successful colonizers throughout the Levant Basin, which extends as far as the Aegean Sea (Bilecenoglu *et al*., 2002). The Brushtooth lizardfish is among the most common species caught in the trawl fishery in Turkey, accounting for 17-18 % annually (Bingel *et al*., 1993), and one-third of the commercial catch in the northeastern Levant (Cınar *et al*., 2005).

There are some studies on the age, growth, maturation, ecology, and seasonal distribution of this commercially important species in the eastern Mediterranean (Ben-Yami and Glaser, 1974; Fischer *et al*., 1987; Bingel and Avsar, 1988; Golani, 1990; Golani, 1993; Gucu *et al*., 1994; Torcu,

1995; Tureli and Erdem, 1997; Ismen, 2003 and Gokce *et al*., 2007).

This study was conducted to determine the growth constants, reproduction, mortality and exploitation rates of this species habiting in the coast of Babadillimani Bight (Northeastern Mediterranean).

Material and Method

This study was performed over a period of 12 months, beginning in May 1999 and concluding in April 2000. Samples were collected at monthly intervals in Babadıllimanı Bight (33˚23'36"-33˚32'57"N 36˚07'00"-36˚09'39"E), situated in northeastern part of the Mediterranean coast of Turkey (Fig. 1).

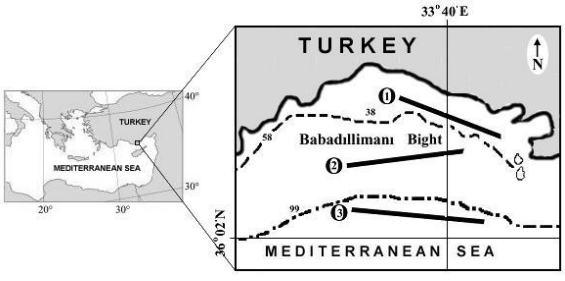

Fig. 1. Trawling stations in the Babadıllimanı Bight

Individuals were caught at the depths ranging from 20 to 120 m by a commercial trawl vessel using the "Mediterranean deep trawl net" with a 22 mm cod end mesh-size; tow duration was restricted to one hour. Samples were collected randomly from each haul as recommended by Holden and Raitt (1974), kept in a 10% formalin solution buffered with borax in plastic barrels, and transported to the laboratory. Then total length (to nearest 1.0 mm), as well as body weight (BW, to the nearest 0.01 g) of these individuals were measured as wet weight in the laboratory. Sex determination was made by examining the abdominal part of each individual after dissection.

Age was determined through sagittal otoliths (Holden and Raitt, 1974). Mean length and weight values were calculated separately for each age group. Growth in length and weight was analyzed separately for each sex using von Bertalanffy's (1938) growth equation $Lt = L_{\infty}$ [1-e-K(t-to)]. For this reason, corresponding numerical values were substituted for the variables in equation Wt = a*Ltb (Ricker, 1974), namely, (t) in place of (Lt); the length-weight relationship constants in place of (a) and (b), to calculate the weight value (Wt), at time t, (W_{∞}) was calculated using the same equation. The Regression Method suggested by Sparre and Venema (1992) was used to estimate the constants of growth in length. With regard to the statistics, the Chi-Square (χ^2) Test was used to determine whether there were any differences between the calculated and measured mean length and weight values for each group.

The total mortality rate (Z) is the sum of fishing (F) and natural mortality rates (M). The natural mortality rate was estimated by using the mean weight method which is described by Ursin (1967) as $M = W^{-1/b}$. The total mortality rate (Z) was determined by using Age Composition as suggested by Avsar (1998), and (F) was estimated from (Z) and (M). The level of exploitation from the stock was determined using the equation E = F/Z, given by Sparre and Venema (1992).

Results

The highest SST value measured was 29.86°C in August and the lowest 15.39°C in March, with a mean of 21.5 ± 5.3°C. Maximum and minimum salinity values were measured in July and in April as 38 ppt and 34.58 ppt, respectively, with a mean of 35.98 ± 0.85 ppt (Fig. 2).

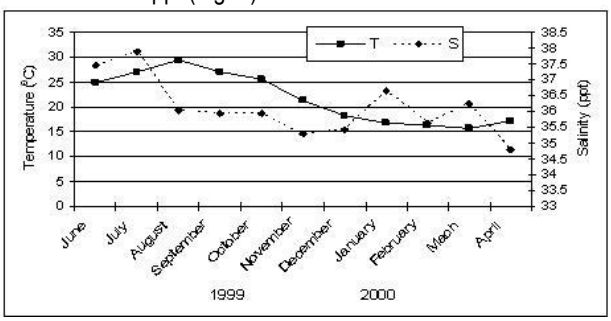

Fig. 2. Monthly changes in mean temperature and salinity in the Babadıllimanı Bight

Age and growth

A total of 2757 Brushtooth lizardfish were examined during the study period, and obtained results were given as follows. Age-frequency distribution, mean total length and weight characteristics for each sex and combined sexes were shown in Table 1.

As shown in Table 1, age groups of Brushtooth lizardfish, varied from 0 to VII for males and 0 to VIII for females. Age I was dominant for males and females, but combined sexes (include 871 juvenile specimens) was dominant in age 0 groups.

Total length of all individual varied from 1.9 to 33.0 cm; male specimens varied from 5.0 to 29.0 cm, and females specimens ranged from 6.9 to 33.0 cm. Mean total length was calculated as 13.30±3.48 cm for males, 14.47±5.62 cm for females and 10.91±5.87 cm for combined sexes.

Total weight ranged from 1.65 to 174.5 g for males, 1.5 to 224.9 g for females and 1.0 to 224.9 g for combined sexes. The mean weight for males, females and combined sexes were calculated as 18.02±18.54 g, 31.21±41.98 g and 16.33±28.08 g, respectively.

The mean annual growth rate in length between Age groups 0 and I was the highest (3.92 cm in males, 4.05 cm in females, and 6.32 cm in combined sexes). The highest increase in the mean annual growth rate as weight was found in the age groups of V and VI (46.60 g for males, 41.03g for females, and 40.03 g for combined sexes).

Table 1. Age groups frequency distribution, minimum (min) and maximum (max) length values (cm) (n: Sample numbers) for each sex

Age	Male			Female			Combined Sex		
	n	Mean TL TL range	Mean TW TW range	n	Mean TL TL range	Mean TW TW range	n	Mean TL TL range	Mean TW TW range
0	101	7.64±1.0 5.0-8.6	3.65±1.0 1.7-7.8	94	7.57±0.7 6.9-10.9	4.08±3.0 1.5-22.4	1066	5.23±2.3 1.9-11.9	1.29±1.7 1.0-22.4
I	498	11.56±1.5 7.7-12.6	9.89±4.9 1.8-37.4	351	11.62±1.6 7.3-15.4	9.96±5.2 2.0-56.4	860	11.55±1.6 6.6-16.0	9.84±5.0 1.4-56.4
II	319	14.51±1.3 10.3-15.9	19.55±6.5 3.5-57.0	152	14.71±1.3 10.1-17.7	19.62±6.5 5.3-62.4	471	14.58±1.4 10.1-17.8	19.57±6.5 3.5-62.4
III	102	17.60±1.1 14.7-19.8	35.14±9.2 13.8-76.5	60	18.02±1.2 15.8-20.7	37.98±9.7 16.3-72.8	149	17.73±1.7 14.7-20.7	36.04±9.4 13.8-76.5
IV	37	20.86±1.0 18.6-23.3	60.34±10.1 34.0-78.2	47	21.45±1.2 18.4-24.9	67.94±15.0 20.5-99.4	97	21.23±1.2 18.4-24.9	65.04±13.8 20.5-99.4
V	10	23.79±1.2 22.1-26.4	86.15±15.7 66.1-117.0	38	23.92±1.1 21.6-25.7	93.46±4.2 64.4-122.0	48	23.89±1.1 21.1-26.4	91.94±14.6 64.4-122.0
VI	5	27.15±0.8 26.5-28.2	132.74±4.3 129.7±135.8	25	26.27±0.8 24.0-27.5	134.40±19.3 62.7-154.6	30	26.84±0.8 24.0-28.2	132.24±18.8 62.7-154.6
VII	3	28.18±1.1 27.1-29.0	151.92±17.8 126.6-174.5	17	28.19±1.2 26.7-31.5	161.96±14.6 128.6-174.6	20	28.15±1.1 26.7-31.5	158.86±15.0 126.6-174.6
VIII	-	- -	- -	16	30.50±1.2 29.0-33.0	196.03±19.4 160.7-224.9	16	30.36±1.3 28.2-33.0	196.03±19.4 160.7-224.9
Top.	1075	13.30±3.5 5.0-29.0	18.02±18.5 1.65-174.5	800	14.74±5.6 6.9-33.0	31.21±41.9 1.5-224.9	2757	10.91±5.9 1.9-33.0	16.33±28.0 1.0-224.9

The v. Bertalanffy growth constant in length and weight were shown in Table 2.

Table 2. Von Bertalanffy growth constants in length and weight

Sex	Growth Constants			
	L_∞ (cm)	K (year^{-1})	t_0 (year)	W_∞ (g)
Males	41.44	0.105	-2.209	468.70
Females	43.55	0.106	-2.285	573.09
Combined	41.57	0.118	-1.895	474.59

As shown in Table 2, the asymptotic length and weight for females were higher than those of males (Table 2).

Mean length and weight values calculated for each group and those estimated by von Bertalanfyy growth constants are given in Table 3. No statistical difference was found between the calculated and estimated length and weight values (χ^2; $p<0.05$).

Table 3. Mean total length and weight values obtained for each sex and estimated data for each age group calculated by von Bertalanffy Equation (L=cm), (W =g)

Age	Measured Length (cm)						Calculated Length (cm)					
	Males		Females		Combined		Males		Females		Combined	
	$\bar{L}$	$\bar{W}$	$\bar{L}$	$\bar{W}$	$\bar{L}$	$\bar{W}$	$\bar{L}$	$\bar{W}$	$\bar{L}$	$\bar{W}$	$\bar{L}$	$\bar{W}$
0	7.64	3.65	7.57	4.08	5.23	1.29	7.95	2.97	8.35	3.95	8.27	1.27
I	11.56	9.89	11.62	9.96	11.55	9.84	11.85	9.36	12.80	9.26	11.94	8.09
II	14.51	19.55	14.71	19.62	14.58	19.57	14.80	19.32	14.89	20.17	15.20	16.41
III	17.60	35.14	18.02	37.98	17.73	36.04	17.45	37.51	18.68	39.46	18.10	37.60
IV	21.86	60.34	21.45	67.94	21.23	65.04	22.00	57.12	21.18	67.42	21.68	64.29
V	23.79	86.16	23.92	93.46	23.89	91.94	24.68	91.48	24.80	95.95	24.67	93.95
VI	27.15	132.7	26.27	134.4	26.84	132.24	27.25	136.5	27.27	132.7	26.01	134.1
VII	28.18	151.9	28.19	161.9	28.15	158.85	28.66	140.3	28.91	155.0	28.45	154.9
VIII	-	-	30.50	196.7	30.36	196.03	-	-	30.38	184.7	29.86	186.5

Length –weight relationship

Length-weight relationship parameters for males, females and combined sexes were shown in Table 4.

Table 4. Descriptive statistics and length-weight relationship parameters (n = sample size; a = proportionality constant; b = slope; R^2 = coefficient of determination; A+ = positive allometric growth)

Sex	n	a	b	SE of b	(95% CL of b)	R^2	G.Type
Male	1075	0.0047	3.0906	0.0315	3.0395-3.1200	0.951	A+
Female	800	0.0041	3.1394	0.0255	3.1032-3.2745	0.976	A+
Combined	2757	0.0047	3.0950	0.0078	3.0341-3.1020	0.988	A+

The equations of length-weight relationship for each sex separately and for the total were as follows:

Males: $W = 0.0047 * L\ 3.0906$ ($n = 1075$, $R^2 = 0.9517$)
Females: $W = 0.0041 * L\ 3.1394$ ($n = 800$, $R^2 = 0.976$)
Total: $W = 0.0047 * L\ 3.0950$ ($n = 2757$, $R^2 = 0.9886$)

As is shown in Table 4 "b" values were estimated as 3.0906, 3.1394 and 3.095 for males, females and combined sexes respectively, which implies a positive allometric growth in this species.

Mortality rates and level of exploitation from the stock

Total mortality rate (Z), natural mortality rate (M), fishing mortality rate (F) and the level of exploitation from the stock (E) for each sex and their total are given in Table 5. It was found that the total, natural and fishing mortality rates of the males were higher than those of the females and for both sexes.

Table 5. The total (Z), natural (M), and fishing mortality rates (F) and the level of exploitation from the stock (E) for each sex and their total.

Sexes	Z (year^{-1})	M (year^{-1})	F (year^{-1})	E (year^{-1})
Males	0.9216	0.3886	0.5330	0.57
Females	0.5783	0.3323	0.2460	0.42
Total	0.7664	0.4033	0.3631	0.47

It was found that exploitation rate of males was higher that 0.5, while it was lower than 0.5 in females and combined sexes. Accordingly, the exploitation level is high for males (E=0.57), but insufficient for females and total (E=0.42). Considering these values, it can be said that males are subjected to over-fishing, but females and the species on the whole, are exploited inadequately.

Discussion

The age distribution of the individuals composed of the samples in the study seems to vary from 0 to VIII (Table 1). Mater and Torcu (1996) stated that Age group III was dominant in the samples caught from Mersin and Fethiye Bays, whose ages changed between I and IV; Tureli and Erdem (1997) reported age group I was the dominant in the age groups varied from 0 to III in Iskenderun Bay. As a result, the catching density for Brushtooth lizardfish varies between 0 and III. As to this study, age groups of 0, I and II are common in our studied locale, so the region is subjected to a more intense fishing compared with the locales mentioned above, and unfortunately growth overfishing can be said to take place in the region at present.

The regression coefficient value "b" in length-weight relationship equation was calculated as 3.0906 for the males, 3.1394 for the females and 3.0950 for the total. Bingel (1987) found the "b" value of the Brushtooth lizardfish was 2.4501 for the northeastern Mediterranean; Mater and Torcu (1996), 2.5165 and 3.2792 for the Mersin and Fethiye Bay; Tureli and Erdem (1997) 3.0220 for the Iskenderun Bay. According to FishBase (2008), it was 3.3200 for the west coast of Indoseian, 3.0310 for the coast of India, 3.0000 for the coast of Philippine and 3.0300 for the coast of Yemen. This value is nearly equal to the value calculated for the Brushtooth lizardfish (3.0950) in the Babadıllimanı Bight.

The common total lengths of the Brushtooth lizardfish in Babadıllimanı Bight was 10-21 cm. Sulak (1990) indicated that the common length for this species the Mediterranean Sea was 20-30 cm. However, Ben-Yami and Glaser (1974) reported the common length was 15-35 cm. Hence, the common length reported in present study and in that of Fischer *et al.* (1987) were not quite the same. It might be claimed that the length of the Brusthtooth lizardfish in Babadıllimanı Bight is shorter than those reported by the others for the Mediterranean Sea.

Considering geographical differences, for the northeastern Mediterranean Sea, including Turkish coasts, it is reported that the maximum length of this species, or in other words, its asymptotic length (L ∞), is 40 cm (Aksiray, 1987), 42.11 cm (Bingel, 1987), 42 cm (Gokce *et al*., 2007), for the region from Red Sea to Eastern Africa and from Australian to Southern Japan it was given 50 cm by Bauchot (1987), but 40 cm by CIESM (2008). FishBase (2008) reported 36 cm Egyptian coast of Mediterrenean, 31.5 cm for the coast of Israel, 43 cm for the coast of Philippine and 41.3 cm for the coast of Taiwan. However, in the current study, the asymptotic length was 41.44 cm for the males, 43.55 cm for the females and 41.57 cm for the total. Accordingly, these results were similar to those reported by Aksiray (1987), Bingel (1987) Gokce *et al*. (2007) and CIESM (2008) for the Northeastern Mediterranean stock; but lower than those reported by Bauchot (1987).

Bingel (1987) found the fishing mortality rates (F) were 0809 and 0.609; the natural mortality rates (M) 0.378; and the total mortality rates (Z) 1.070 and 0.870 for Brusthtooth lizardfish in the Mersin and Iskenderun bays respectively, and they reported that the total mortality rates of this species in both bays were very high. In this study, however, the corresponding values were calculated to be (M) = 0.4033; (F) = 0.3631 and (Z) = 0.7664 (Table 5). Compared to the values reported by Bingel (1987), F and Z rates were lower, while M rate was higher, implying less fishing pressure put on to Brusthtooth lizardfish in the Babadıllimanı Bight than in the other states of the region. Numbers show that natural mortality rate is higher than fishing mortality rate, indicating an insufficient stock benefit. Indeed, using the mortality parameters, it was found that the exploitation rate was (E) = 0.47 (Table 5). However, this level is (E) = 0.57 for males, whereas (E) = 0.42 for females, meaning males are subjected to overfishing, while females are not benefited as desired. a higher fishing pressure than females (Table 5). Considering that the maximum level of production was obtained when the exploitation or the utilization rate was E = 0.5 or in other words, when F = M. On the other hand, it is suggested that the existing exploitation rate increase by 6% for total, 14% for females and decrease by 11.4% for males in order to maximize benefit from the stock. Bingel and Avsar (1988), who studied on the Lessepsian Brushtooth lizardfish feeding behavior report that the females of this species in the North-eastern Mediterranean Sea intake nourishment twice as much as males and are more active in any period, which may enable them to avoid deep trawl fishing more effectively. Therefore, it is normal to expect the exploitation rate of males to be higher than that of females studied in the Babadıllimanı Bight.

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