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## Age and growth of the four-spotted megrim (*Lepidorhombus boscii* Risso, 1810) from Saros Bay (Northern Aegean Sea, Turkey)

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### Abstract

In this study, the growth parameters of the four-spotted megrim, (*Lepidorhombus boscii* Risso, 1810), were studied in Saros Bay, which had been closed to bottom trawl fishing since 2000. The sex ratio of females to males was 1:0.42. Length-weight relationships were  $W=0.0032L^{3.31}$  and  $W=0.0069L^{3.04}$  for females and males, respectively. Growth parameters of the populations were  $L_{\infty}=49.8$  cm,  $k=0.09$  year<sup>-1</sup>,  $t_0=-2.15$  year for females;  $L_{\infty}=39.1$  cm,  $k=0.11$  year<sup>-1</sup>,  $t_0=-2.59$  year for males. The growth performance index ( $\Phi'$ ) was found to be 2.35 and 2.23 for females and males, respectively.

**Keywords:** Four-spotted megrim, age, growth, Saros Bay, northern Aegean Sea.

### Introduction

Age and growth of fish are fundamental to stock assessment. Information on age is significant because it sets the basis for the calculations of growth, mortality rates and productivity estimates (Campana, 2001), making it a necessity for fisheries management (Cailliet *et al.*, 2001). Growth, however, is one of the most important life history processes influencing the dynamics of a fish population (Zhan, 1995).

The four-spotted megrim (*Lepidorhombus boscii* Risso, 1810), a sinistrally orientated flatfish belonging to Scophthalmidae, is one of most important groundfish species, inhabiting the Mediterranean Sea and the eastern part of the Atlantic from the British Isles to Angola (Baucho, 1987) and is common on soft sea bottoms at depths down to 700-800 m (Nielsen, 1986). In Turkey, this species occurs in the Mediterranean, Aegean and Marmara seas (Bilecenoglu *et al.*, 2002). It is of commercial interest, particularly when longer than 20.0 cm in length (Vassilopoulou, 2000).

The age and growth of the four-spotted megrim in the Atlantic were studied by Fuertes (1978), Castilho *et al.* (1993), Santos (1994), Landa *et al.* (2002) and Teixeira *et al.* (2010), while Bello & Rizzi (1987), Mannini *et al.* (1990), Stergiou & Politou (1995) and Vassilopoulou & Ondrias (1999) reported data from the Mediterranean. In addition, Robson *et al.* (2000) presented the growth parameters off the west coast of Ireland.

Published literature on the biology of this species

from the Turkish Seas, however, is extremely limited. Jica (1993) conducted its stock assessment in the Northern Aegean Sea. Bostanci & Polat (2008) studied the otolith structure, otolith dimensions-fish length relationships and age determination of *L. boscii*. Ismen *et al.* (2007) and Ozekinci *et al.* (2009) reported the length-weight relationships of the four-spotted megrim from Saros Bay.

The main aim of the present study was to estimate some basic biological parameters such as length distribution, sex ratio, age, growth, and length-weight relationships of the four-spotted megrim captured from Saros Bay and to compare these results with those of the previous studies.

### Materials and Methods

All individuals were collected, monthly, between September 2006 and September 2008 using a commercial bottom trawl net of 44 mm codend stretched mesh size at depths ranging between from 0 m to 500 m in Saros Bay (Fig. 1), which had been closed to trawl fishing since 2000.

The samples were measured to the nearest 1 mm (total length), and weighed to the nearest 0.01 g (total weight). Differences in the sex ratio (female: male) were examined using a chi-square ( $\chi^2$ ) test, while the Mann-Whitney U test was used to analyze the differences between the mean total length and total weight of the sexes. The length-weight relationship was calculated applying the equation  $W=aL^b$ , where  $W$  is the total weight,  $L$  is the total length and  $a$  and  $b$  are the parameters of the equa-

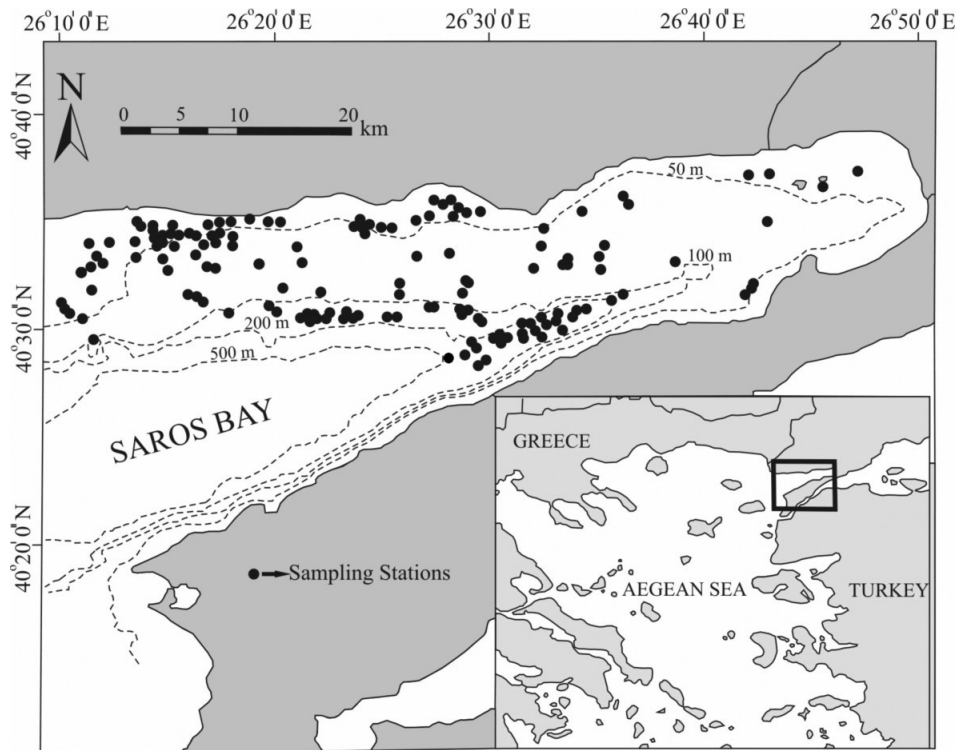


Fig. 1: Saros Bay and sampling stations.

tion (Ricker, 1973). The growth type was identified using student's *t*-test.

The otoliths from the blind side were used for age determination, as the nucleus was more central here than the otoliths in the ocular side (Fig. 2) and it was easier to interpret the zones (Bostanci & Polat, 2008).

Following removal, the blind side otoliths were first soaked in 5% HCL and 3% NaOH solutions, respectively, and washed in distilled water and subsequently dried. Age determination was performed using a stereoscopic zoom microscope under reflected light against a black background, filled with the water. Opaque and transparent zones were counted; one opaque zone plus one transparent zone was assumed to be one age mark.

The von Bertalanffy growth equation was calculated according to  $L_t = L_\infty [1 - e^{-k(t-t_0)}]$  for total length TL, where  $L_t$  is fish total length (cm) at age  $t$ ,  $L_\infty$  is the asymptotic fish length (cm),  $t$  is the fish age (year),  $t_0$  (year) is the hypothetical time at which the fish length is zero,  $k$  is the growth coefficient (year<sup>-1</sup>) (Sparre & Venema, 1992). We used the growth performance index ( $\Phi'$ ) of Pauly & Munro (1984), which takes into account the correlation between  $L_\infty$  and  $k$ , to compare the growth parameters estimated by different authors.

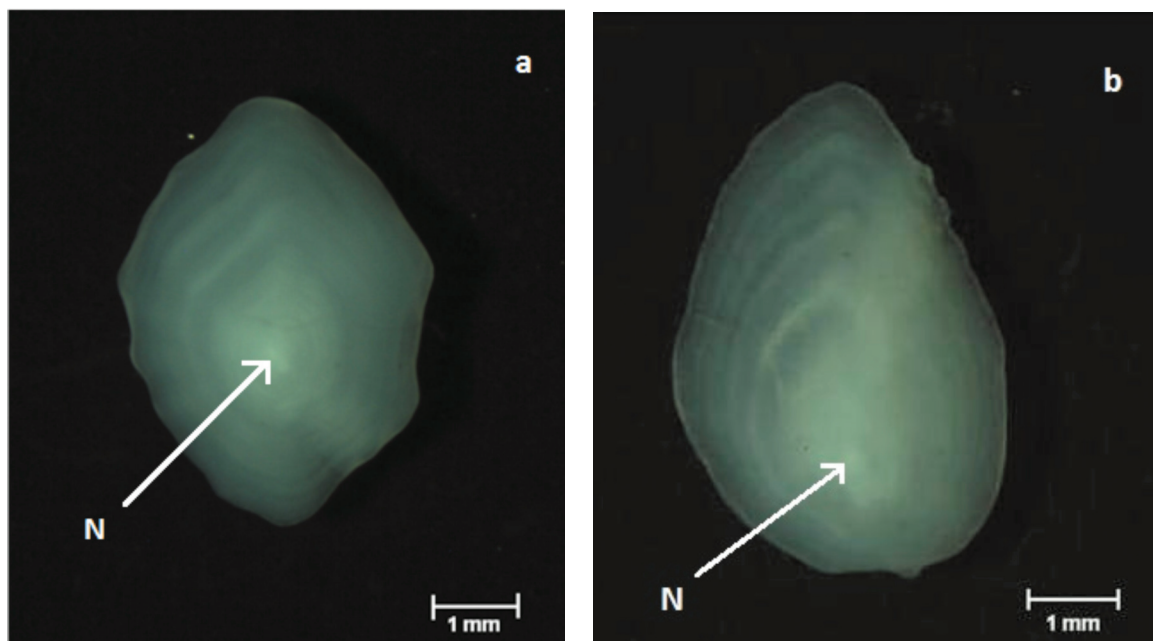
## Results

In this study, a total of 2224 individuals were sampled during the study period. Of the 788 specimens examined by picking the sub-samples randomly, 553 were females

and 235 were males. The sex ratio was calculated as 1:0.42 (F:M). The fish size ranged from 10.9 to 40.8 cm (TL) and weighed between 9.9 and 679.2 g. The mean total length and total weight of the females were  $25.6 \pm 0.32$  (11.4-40.8) cm and  $202.68 \pm 7.35$  (10.74-679.18) g, respectively, while that of the males were  $17.6 \pm 0.26$  (10.9-30.3) cm and  $50.00 \pm 2.67$  (9.88-271.18) g, respectively. The Mann-Whitney U and chi-square tests showed that the mean total lengths and total weights between the sexes and the sex ratio were significantly different ( $P < 0.05$ ). The length-frequency distribution for females and males of the four-spotted megrim (*Lepidorhombus boschii* Risso, 1810) from Saros Bay is displayed in Figure 3.

Length-weight relationships calculated for females and males were:  $W = 0.0032L^{3.31}$  ( $r^2 = 0.99$ , 95% CL of  $b = 3.28-3.33$ ) and  $W = 0.0069L^{3.04}$  ( $r^2 = 0.97$ , 95% CL of  $b = 2.97-3.11$ ), respectively (Fig. 4). The  $b$ -values showed significant differences for females and males ( $P < 0.05$ ). While  $b$ -values and  $t$ -test results indicated a positive allometric growth for females, an isometric growth was noted for males.

The otoliths of 471 individuals were successfully extracted. These otoliths were used to investigate the age and growth by three independent readers. Age was determined from 422 otoliths. The remaining 49 otoliths were rejected due to the disagreement between readers or because they were, generally, considered unreadable. Age distribution ranged from 1 to 13 years. The mean TLs corresponding to each age class are given for females and males in Table 1.



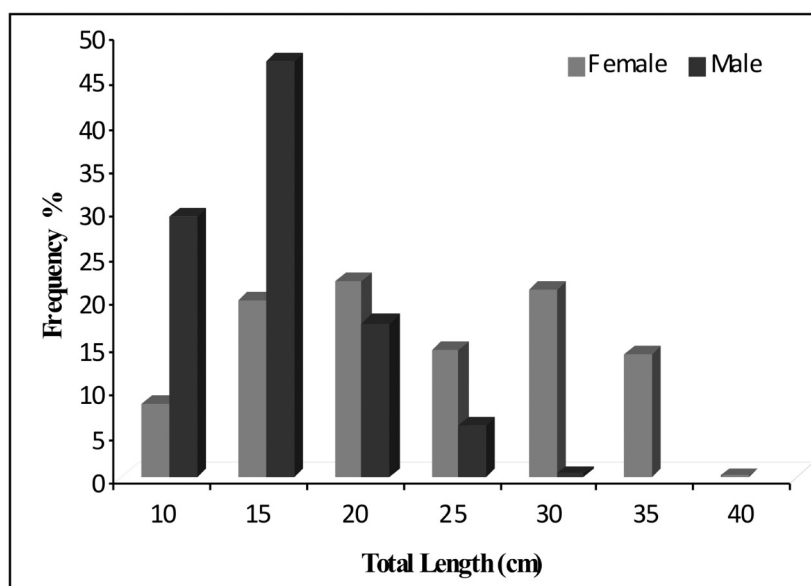
**Fig. 2:** Blind side (a) otolith; ocular side (b) otolith and nucleus (N).

Significant differences were found between the mean lengths of each age class for females and males, except for age class I (Table 1). The von Bertalanffy growth equations were computed as  $L_{\infty}=49.8$  cm,  $k=0.09$  year<sup>-1</sup>,  $t_0=-2.15$  year for females;  $L_{\infty}=39.1$  cm,  $k=0.11$  year<sup>-1</sup>,  $t_0=-2.59$  year for males. The growth performance index ( $\Phi'$ ) was found to be 2.35 and 2.23 for females and males, respectively.

### Discussion

The reasons for the differences in length range have been attributed to various factors such as the type and

the selectivity of the gear (Ilkyaz *et al.*, 2010), sampling strategy, sampling period, variations in temperature and differences between the trophic potential of the various areas (Ozaydin *et al.*, 2000). The possible reasons of differences in the length-weight relationships could be attributed to area, gonadal maturity, habitat, degree of stomach fullness, season, length range, sex, health and preservation techniques (Baganel & Tesch, 1978) and the size selectivity of the sampling gear (Ismen *et al.*, 2007). As Saros Bay had been closed to bottom trawl fishing since 2000 and no industrial activity was prevalent in the area (Sari & Cagatay, 2001), the bay can be considered



**Fig. 3:** The length-frequency distribution for females and males of the four-spotted megrim (*Lepidorhombus bosci* Risso, 1810) from Saros Bay.

**Table 1.** Age-length key for females and males of *Lepidorhombus boscii* from Saros Bay.

Length class (cm)	Age													Females	Males
	1	2	3	4	5	6	7	8	9	10	11	12	13		
10.0-11.0	1														1
11.1-12.0	4													1	3
12.1-13.0	12													4	8
13.1-14.0	5	10												1	14
14.1-15.0		7												0	7
15.1-16.0		14												9	5
16.1-17.0		2	14											2	14
17.1-18.0		1	7											1	7
18.1-19.0			10	10										6	14
19.1-20.0			12	15	7									16	18
20.1-21.0			3	7	7									3	14
21.1-22.0				17	10									16	11
22.1-23.0				41	7	1								48	1
23.1-24.0				27	13	2	3							40	5
24.1-25.0				4	5	8								10	7
25.1-26.0					2	3	2							5	2
26.1-27.0						12	3	1						13	3
27.1-28.0						7	5	3						12	3
28.1-29.0						2	9							11	
29.1-30.0							3	3	1					5	2
30.1-31.0							2	4	4					9	1
31.1-32.0							2	7	5	1				15	
32.1-33.0							1	4	4	1				10	
33.1-34.0								2		2				4	
34.1-35.0								2	2	6	1			11	
35.1-36.0									4	2	2			8	
36.1-37.0										3	5	3	1	12	
37.1-38.0											2	4	1	7	
38.1-39.0													2	2	
39.1-40.0													1	1	
<b>Females</b>															
N	6	12	21	91	28	25	23	21	18	15	10	7	5	282	
Mean	12.6	15.8	19.4	22.6	23.6	26.8	28.9	31.7	32.7	34.6	36.4	37.2	38.2	25.9	
Min	11.8	14.8	18.4	19.5	22.0	24.8	26.5	29.1	30.2	32.0	34.8	36.1	36.9	11.8	
Max	13.5	17.1	21.0	24.3	25.7	28.9	32.8	34.8	35.6	36.5	37.8	38.0	39.8	39.8	
S.E	0.25	0.17	0.14	0.11	0.16	0.18	0.32	0.30	0.43	0.36	0.27	0.23	0.49	0.36	
%	2.1	4.3	7.4	32.3	9.9	8.9	8.2	7.4	6.4	5.3	3.5	2.5	1.8	100.0	
<b>Males</b>															
N	16	22	25	30	23	10	7	5	2						140
Mean	12.5	14.3	17.1	19.5	20.8	24.0	25.0	27.8	29.9						18.7
Min	10.9	13.1	16.2	18.4	19.6	22.3	23.5	26.4	29.5						10.9
Max	13.4	15.7	18.5	21.3	22.0	25.0	26.7	29.7	30.3						30.3
S.E	0.19	0.18	0.15	0.16	0.18	0.25	0.48	0.55	0.40						0.36
%	11.4	15.7	17.9	21.4	16.4	7.1	5.0	3.6	1.4						100.0

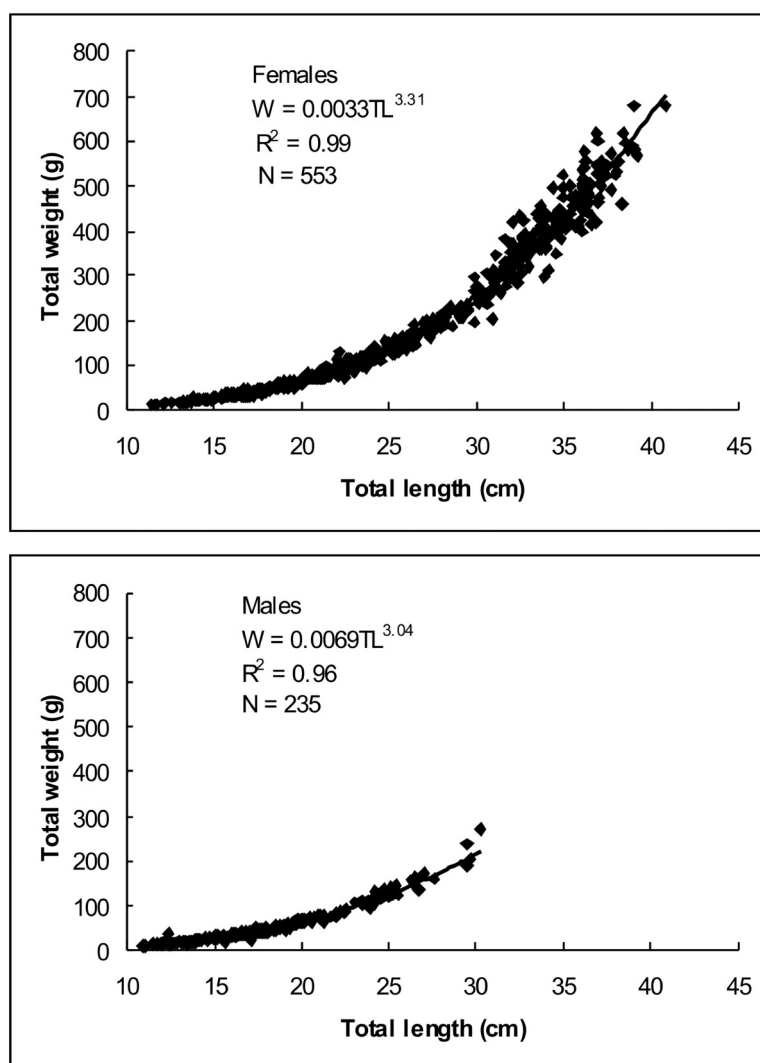
N=Sample size; Min=Minimum; Max=Maximum; S.E=Standard Error

as a pristine environment. Therefore, it is quite possible that the characteristics of the area are more important factors affecting the length-weight relationship of the four-spotted megrim in this study. Some of the available studies on the length-weight relationships and length ranges

for *Lepidorhombus boscii* by various authors are given in Table 2.

The present study showed that the female four-spotted megrims were dominant over the males. The dominance of females has also been reported by other authors





**Fig. 4:** The length-weight relationships for females and males of the four-spotted megrim (*Lepidorhombus boscii* Risso, 1810) from Saros Bay.

except for Bello & Rizzi (1987), Castilho *et al.* (1993) and Santos (1994) (Table 2). It has been suggested that the sex ratio may vary from species to species, even from population to population of the same species, and may change from year to year within the same population (Nikolsky, 1963). This could be attributed to the differences in feeding, maturation, migration, mortality and growth rates between the two sexes (Aysar, 2005; Innal, 2010). The dominance of females over males in the present study is most likely due to the different growth rates between the two sexes.

In this study, the age class of the four-spotted megrims ranged between 1 and 13 ages. Castilho *et al.* (1993), Vassilopoulou & Ondrias (1999), Robson *et al.* (2000), Bostanci & Polat (2008) and Teixeira *et al.* (2010) reported the longevity limits as 0-12, 0-8, 4-11, 3-8 and 2-9 ages, respectively. Nash & Geffen (2005) stated that the reasons of differences in longevity could be attributed to latitudinal differences as well as to the effects of temperature, intensities of competition for food,

food availability, life history strategies and fishing efforts. The maximum age of the four-spotted megrim was reported as 15 (Fuertes, 1978). Maximum age can vary widely between populations within species, especially among those that exhibit wide distributions (Gibson, 2005). The mean lengths at different ages for females and males of *Lepidorhombus boscii* given by various authors are listed in Table 3.

In general, the differences in length at different ages and growth parameters between different areas could probably be attributed to a combination of sample characteristics (sample sizes and range sizes), geographical differences, ageing methodology used (Monterio *et al.*, 2006), incorrect age interpretation (Matić-Skoko *et al.*, 2007), size, quantity and quality of food and water temperature (Santic *et al.*, 2002) and differences in length at first maturity (Champagnat, 1983). Besides, gear selectivity can also affect the estimates of growth parameters (Ricker, 1969; Potts *et al.*, 1998). A species which remains in the same habitat throughout its life could main-

**Table 2.** Some of the available studies on the length-weight relationships and length ranges for *Lepidorhombus boscii*.

References	Locality	Sex	N	L <sub>min</sub>	L <sub>max</sub>	a	b
Fuertes (1978)	Galicia (Spain)	♀	1118	–	–	3.70*10 <sup>-6</sup>	3.12
		♂	877	–	–	5.47*10 <sup>-6</sup>	3.05
Bello & Rizzi (1987)	Southern Adriatic (Italy)	♀	109	–	–	0.0032	3.26
		♂	128	–	–	0.0034	3.24
Mannini <i>et al.</i> (1990)	Northern Tyrrhenian Sea (Italy)	♀	–	–	–	0.004	3.26
		♂	–	–	–	0.009	3.02
Castilho <i>et al.</i> (1993)	Portuguese coast	♀	250	–	–	0.002	3.25
		♂	315	–	–	0.0041	3.11
Santos (1994)	Portuguese coast	♀	428	–	–	0.0025	3.36
		♂	448	–	–	0.0045	3.16
Stergiou & Politou (1995)	Northern Euboikos Gulf (Greece)	Σ	219	5.7	37.1	0.0017	3.29
Merella <i>et al.</i> (1997)	Balearic Islands (Western Mediterranean)	Σ	84	7.0	19.5	0.0045	3.14
Vassilopoulou & Ondrias (1999)	Eastern Mediterranean waters (Greece)	♀	1422	–	–	1.89*10 <sup>-6</sup>	3.26
		♂	1009	–	–	1.66*10 <sup>-6</sup>	3.29
		Σ	2431	–	–	1.89*10 <sup>-6</sup>	3.27
Robson <i>et al.</i> (2000)	West coast of Ireland	Σ	150	–	–	0.0062	3.37
Borges <i>et al.</i> (2003)	Algarve (Southern Portugal)	Σ	7	10.3	23.9	0.0035	3.13
Morey <i>et al.</i> (2003)	Western Mediterranean	Σ	364	1.4	37.8	0.0643	2.27
Mendes <i>et al.</i> (2004)	Portuguese west coast	Σ	82	16.2	34.6	0.0041	3.20
Ismen <i>et al.</i> (2007)	Saros Bay (Turkey)	Σ	521	10.2	39.5	0.0032	3.29
Ozekinci <i>et al.</i> (2009)	Saros Bay (Turkey)	Σ	2224	10.9	40.8	0.0039	3.25
This study	Saros Bay (Turkey)	♀	553	11.4	40.8	0.0032	3.31
		♂	235	10.9	30.3	0.0069	3.04

N=Sample size; Min=Minimum; Max=Maximum; *a* and *b* are the parameters of the relationships; Σ=All samples; ♀=Females; ♂=Males

tain the same growth model (Gordoa & Balbina, 1997). However, Avsar (1995) suggested differences in the growth rates of fish sampled at different periods from the same locality and concluded that such differences might be due to annual variations in the mean length of fish corresponding to each age.

The growth coefficient ( $k=0.09 \text{ year}^{-1}$ ) found in this study was of the lowest value in the literature, thus far. This is probably due to the maximum or minimum fish size as it has been shown that the values of  $k$ ,  $t_0$  and  $L_\infty$  are a function of the fish size sampled (King, 1995). An inverse relationship between  $L_\infty$  and  $k$  has been established in fish population studies. (Gallucci & Quinn, 1979). The *t*-test showed no significant differences between the growth performance indexes in the other areas ( $P>0.05$ ). A comparison of the growth parameters and growth performance indexes obtained from previous studies for *Lepidorhombus boscii* are given in Table 4.

In the four-spotted megrim, body size is sexually dimorphic, with females being larger than the males

(Vassilopoulou & Ondrias, 1999). The differences in the growth rate between the male and female four-spotted megrim were also observed by Fuertes (1978), Bello & Rizzi (1987), Castilho *et al.* (1993), Santos (1994), Landa *et al.* (2002) and Teixeira *et al.* (2010). Similarly, our findings indicated that female four-spotted megrims were larger than the males. The greater and faster growth in females over the males is a feature which is common in many pleuronectiforms (Lozan, 1992; Pauly, 1994a; Landa & Pinerio, 2000). This phenomenon may be related to the differences in metabolism between females and males, such as the oxygen consumption rate (Pauly, 1994a; 1994b), level of surplus energy between reproduction and somatic growth (Rijnsdorp & Ibelings, 1989) and food ingestion (Lozan, 1992).

In conclusion, this study updated the information on the length-weight relationship, sex ratio, length distribution, age and growth of the four-spotted megrim from Saros Bay. The possible reasons for the differences in the life-history parameters between these results and those of

**Table 3.** The mean lengths at different ages for females and males of *Lepidorhombus boscii* given by various authors.

References	Locality	Sex	Age Group															
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fuertes (1978)	Galicia (Spain)	♀	–	14.9	20.4	23.4	26.0	27.5	28.0	30.6	31.5	32.6	33.0	34.0	35.0	38.2	39.3	40.5
		♂	–	14.6	18.4	20.7	23.0	25.7	26.6	27.5	29.5	30.5	31.5	–	–	–	–	–
Castilho <i>et al.</i> (1993)	Portuguese coast	♀	–	13.2	17.2	20.2	23.3	27.0	28.7	30.2	32.5	35.1	37.1	37.2	37.6	–	–	–
		♂	11.0	13.3	16.4	18.7	22.0	24.4	25.2	27.1	31.8	–	–	32.5	–	–	–	–
Vassilopoulou & Ondrias (1999)	Eastern Mediterranean waters (Greece)	Σ	8.2	11.8	14.9	17.2	19.3	21.2	22.9	24.6	25.7	–	–	–	–	–	–	–
This study	Saros Bay (Turkey)	♀	–	12.6	15.8	19.4	22.6	23.6	26.8	28.9	31.7	32.7	34.6	36.4	37.2	38.2	–	–
		♂	–	12.5	14.3	17.1	19.5	20.9	24.1	25.5	27.8	29.9	–	–	–	–	–	–

Σ=All samples; ♀=Females; ♂=Males

Σ=All samples; ♀=Females; ♂=Males

**Table 4.** A comparison of the growth parameters and growth performance indexes obtained from previous studies for *Lepidorhombus boscii*.

References	Locality	Sex	L <sub>∞</sub>	k	t <sub>0</sub>	Φ
Fuertes (1978)	Galicia (Spain)	♀	42.9	0.15	-1.36	2.44
		♂	34.7	0.19	-1.37	2.36
Bello & Rizzi (1987)	Southern Adriatic (Italy)	♀	28.5	0.26	-	2.32
		♂	27.6	0.21	-	2.20
Mannini <i>et al.</i> (1990)	Northern Tyrrhenian Sea (Italy)	Σ	38.0	0.20	-	2.46
Castilho <i>et al.</i> (1993)	Portuguese coast	♀	44.0	0.14	-1.52	2.43
		♂	37.5	0.14	-1.93	2.29
Santos (1994)	Portuguese coast	♀	39.8	0.16	-1.84	2.40
		♂	34.8	0.20	-1.44	2.38
Stergiou & Politou (1995)	North Euboikos Gulf (Greece)	Σ	43.3	0.26	-	2.69
Vassilopoulou & Ondrias (1999)	Eastern Mediterranean waters (Greece)	♀	30.5	0.18	-1.10	2.22
		♂	25.5	0.22	-1.09	2.16
		Σ	31.2	0.17	-1.12	2.22
Robson <i>et al.</i> (2000)	West coast of Ireland	Σ	34.4	0.27	-1.99	2.50
Landa <i>et al.</i> (2002)	Northeast Atlantic	♀	45.6	0.17	0.07	2.55
		♂	39.9	0.17	-0.37	2.43
Teixeira <i>et al.</i> (2010)	Portuguese coast	♀	38.1	0.14	-2.85	2.31
		♂	32.4	0.20	-2.49	2.32
This study	Saros Bay (Turkey)	♀	49.8	0.09	-2.15	2.35
		♂	39.1	0.11	-2.59	2.23

Σ=All samples; ♀=Females; ♂=Males



the previous studies may be related to the differences in the environmental conditions and/or sampling strategy. The findings from this study can be used for stock assessment studies in the future.

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## References

- Avşar, D., 1995. Population parameters of sprat (*Spratus spratus phalericus* RISSO) from Turkish Black Sea coast. *Fisheries Research*, 21, 437-453.
- Avşar, D., 2005. *Fisheries biology and population dynamics*. Nobel Press, Adana, Turkey, 332 pp. (in Turkish).
- Bagenal, T.B., Tesch, F.W., 1978. Age and growth. p. 101-136. In: *Methods for assessment of fish production in fresh waters*. Bagenal, T.B. (Ed.). Blackwell Scientific Publications, Oxford, UK.
- Bauchot, M.L., 1987. Poissons osseux. p. 891-1421. In: *Fiches FAO d'identification pour les besoins de la pêche. (rev. 1). Méditerranée et mer Noire. Zone de pêche 37. Vol. II*. Commission des Communautés Européennes & FAO, Rome.
- Bello, G., Rizzi, E., 1987. On the growth of the four-spotted scadfish, *Lepidorhombus boscii*, from the Southern Adriatic. p. 142-146. In: *Rapport de la cinquième Consultation technique du Conseil général des pêches pour la Méditerranée sur l'évaluation des stocks dans l'Adriatique et la mer Ionienne: Bari, Italie, 1-5 juin 1987*. Caddy, J.F., Savini, M. (Eds). *FAO Fisheries Report, No. 394*. FAO, Rome.
- Bilecenoglu, M., Taskavak, E., Mater, S., Kaya, M., 2002. Check-list of the marine fishes of Turkey. *Zootaxa*, 113, 1-194.
- Borges, T.C., Olim, S., Erzini, K., 2003. Weight-length relationships for fish species discarded in commercial fisheries of the Algarve (southern Portugal). *Journal Applied Ichthyology*, 19 (6), 394-396.
- Bostanci, D., Polat, N., 2008. Otolith structure, otolith dimensions-fish length relationships and age determination of fourspotted megrim *Lepidorhombus boscii*, (Risso, 1810). *Journal of Fisheries Sciences.com*, 2 (3), 375-381.
- Cailliet, G.M., Andrews, A.H., Burton, E.J., Waters, D.L., Kline, D.E. et al., 2001. Age determination and validation studies of marine fishes: do deep-dwellers live longer? *Experimental Gerontology*, 36 (4-6), 739-764.
- Campana, S.E., 2001. Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods. *Journal of Fish Biology*, 59 (2), 197-242.
- Castilho, R., Dinis, M.T., Erzini, K., 1993. Age and growth of megrim *Lepidorhombus boscii* Risso off the Portuguese continental coast. *Fisheries Research*, 16 (4), 339-346.
- Champagnat, C., Caverivière, A., Conand, C., Cury, P., Durand, J.R. et al., 1983. Pêche, biologie et dynamique du tassergal (*Pomatomus saltator*, Linnaeus, 1766) sur les côtes sénégal-mauritaniennes. *Travaux et Documents de l'ORSTOM, No. 168*. ORSTOM Editions, Paris.
- DEÜ/DBF-JICA, 1993. *Survey report on demersal fishing resources for Marmara, Aegean and Mediterranean Seas*. The Minister of Agriculture & Rural Affairs, Japan International Cooperation Agency, Turkey, 579 pp. (in Turkish).
- Fuertes, J.R., 1978. Edad y crecimiento del gallo (*Lepidorhombus boscii*) en el litoral gallego. *Investigaciones Pesqueras*, 42 (2), 241-253.
- Gallucci, V.F., Quinn, T.J., 1979. Reparameterizing, fitting, and testing a simple growth model. *Transactions of the American Fisheries Society*, 108 (1), 14-25.
- Gibson, R.N., 2005. *Flatfishes: biology and exploitation*. Fish & Aquatic Resources Series 9. Blackwell Science, Oxford.
- Gordoa, A., Molí, B., 1997. Age and growth of the sparids *Diplodus vulgaris*, *D. sargus* and *D. annularis* in adult populations and the differences in their juvenile growth patterns in the north-western Mediterranean Sea. *Fisheries Research*, 33 (1-3), 123-129.
- İlkayaz, A.T., Metin, G., Soykan, O., Kinacigil, H.T., 2010. Age, growth and sexual development of solenette, *Buglossidium luteum* (Risso, 1810), in the central Aegean Sea. *Journal of Applied Ichthyology*, 26 (3), 436-440.
- Innal, D., 2010. Population structures and some growth properties of three Cyprinid species [*Squalius cephalus* (Linnaeus, 1758); *Tinca tinca* (Linnaeus, 1758) and *Alburnus eschschrichtii* (Steindachner, 1897)] living in Camkoru Pond (Ankara, Turkey). *Journal of the Faculty of Veterinary Medicine, University of Kafkas*, 16 (Suppl.), 297-304.
- Ismen, A., Ozen, O., Altinagac, U., Ozekinci, U., Ayaz, A., 2007. Weight-length relationships of 63 fish species in Saros Bay, Turkey. *Journal of Applied Ichthyology*, 23 (6), 707-708.
- King, M., 1995. *Fisheries biology, assessment and management*. Fishing News Books, John Wiley & Sons, Oxford, 341 pp.
- Landa, J., Perez, N., Piñeiro, C., 2002. Growth patterns of the four spot megrim (*Lepidorhombus boscii*) in the northeast Atlantic. *Fisheries Research*, 55 (1), 141-152.
- Landa, J., Piñeiro, C., 2000. Megrim (*Lepidorhombus whiffiagonis*) growth in the North-eastern Atlantic based on back-calculation of otolith rings. *ICES Journal of Marine Science*, 57 (4), 1077-1090.
- Lozán, J.L., 1992. Sexual differences in food intake, digestive tract size and growth performance of the dab, *Limanda limanda*. *Netherlands Journal of Sea Research*, 29 (1-3), 223-227.
- Mannini, P., Reale, B., Righini, P., 1990. Osservazioni sulla biologia e la pesca di *Lepidorhombus boscii* (Risso) (Osteichthyes, Scopthalmidae) nel tirreno settentrionale. *Oebalia*, 16 (1), 245-255.
- Matić-Skoko, S., Kraljević, M., Dulčić, J., Jardas, I., 2007. Age, growth, maturity, mortality, and yield-per-recruit for annular sea bream (*Diplodus annularis* L.) from the eastern middle Adriatic Sea. *Journal Applied Ichthyology*, 23 (2), 152-157.
- Mendes, B., Fonseca, P., Campos, A., 2004. Weight-length relationships for 46 fish species of the Portuguese West Coast. *Journal of Applied Ichthyology*, 20 (5), 355-361.
- Merella, P., Quetglas, A., Alemany, F., Carbonell, A., 1997. Length-weight relationship of fishes and cephalopods from the Balearic Islands (western Mediterranean). *Naga, The ICLARM Quarterly*, 20 (3-4), 66-68.
- Monterio, P., Bentes, L., Coelho, R., Correia, C., Goncalves,

- M.S. *et al.*, 2006. Age and growth, mortality, reproduction and relative yield per recruit of the bogue, *Boops boops* Linne, 1758 (Sparidae), from the Algarve (South of Portugal) longline fishery. *Journal Applied Ichthyology*, 22 (5), 345-352.
- Morey, G., Moranta, J., Massutí, E., Grau, A., Linde, M. *et al.*, 2003. Weight-length relationships of littoral to lower slope fishes from the western Mediterranean. *Fisheries Research*, 62 (1), 89-96.
- Nash, R.D.M., Geffen, A.J., 2005. Age and growth. p. 138-153. In: *Flatfishes: biology and exploitation*. Gibson, R.N. (Ed.). Fish & Aquatic Resources Series 9. Blackwell Science, Oxford.
- Nielsen, J.G., 1986. *Scophthalmidae*. p. 1287-1293. In: *Fishes of the North-eastern Atlantic and the Mediterranean*. Whitehead P.J.P., Bauchot M.L., Hureau J.C., Nielsen J., Tortonese E. (Eds). UNESCO/Nikolsky, G.V., 1963. *The ecology of fishes*. Academic Press, New York, 352 pp.
- Ozaydin, O., Bilecenoglu, M., Kaya, M., 2000. Age and growth of the Curled Picarel *Centracanthus cirrus* Rafinesque, 1810 (Osteichthyes: Centracanthidae) in Northern Cyprus, Eastern Mediterranean Sea. *Acta Adriatica*, 41(2), 35-42.
- Ozekinci, U., Cengiz, O., Ismen, A., Altinagac, U., Ayaz, A., 2009. Length-weight relationships of thirteen flatfishes (Pisces: Pleuronectiformes) from Saroz Bay (North Aegean Sea, Turkey). *Journal of Animal & Veterinary Advances*, 8 (9), 1800-1801.
- Pauly, D., 1994a. A framework for latitudinal comparisons of flatfish recruitment. *Netherlands Journal of Sea Research*, 32 (2), 107-118.
- Pauly, D., 1994b. *On the sex of fish and the gender of scientists: essays in fisheries science*. Fish & Fisheries Series 14. Chapman & Hall, London.
- Pauly, D., Munro, J.L., 1984. Once more on growth comparison in fish and invertebrates. *ICLARM Fishbyte*, 2 (1), 21.
- Potts, J.C., Manooch III, C.S., Vaughan, D.S., 1998. Age and growth of vermillion snapper from the southeastern United States. *Transactions of the American Fisheries Society*, 127 (5), 787-795.
- Ricker, W.E., 1969. Effects of size-selective mortality and sampling bias on estimates of growth, mortality, production and yield. *Journal of the Fisheries Research Board of Canada*, 26, 479-541.
- Ricker, W.E., 1973. Linear regression in fishery research. *Journal of the Fisheries Research Board of Canada*, 30 (3), 409-434.
- Rijnsdorp, A.D., Ibelings, B., 1989. Sexual dimorphism in the energetics of reproduction and growth of north sea plaice, *Pleuronectes platessa* L. *Journal of Fish Biology*, 35 (3), 401-415.
- Robson, M.S., King, P.A., Hannan, J., McGrath, D., 2000. Age and growth of a sample of four-spot megrim, *Lepidorhombus boscii*, from off the west coast of Ireland. *Biology & Environment: Proceedings of the Royal Irish Academy*, 100B (3), 143-148.
- Santic, M., Jardas, I., Pallaoro, A., 2002. Age, growth and mortality rate of horse mackerel *Trachurus trachurus* (L.) living in the eastern Adriatic. *Periodicum Biologorum*, 104 (2), 165-173.
- Santos, P.T., 1994. Growth and reproduction of the population of the four-spot megrim (*Lepidorhombus boscii* Risso) off the Portuguese coast. *Netherlands Journal of Sea Research*, 32 (3-4), 379-383.
- Sari, E., Cagatay, M.N., 2001. Distributions of heavy metals in the surface sediments of the Gulf of Saros NE Aegean Sea. *Environment International*, 26 (3), 169-173.
- Sparre, P., Venema, C.S., 1998. Introduction to tropical fish stock assessment - Part 1: Manual. *FAO Fisheries Technical Paper 306/I*, Rev. 2. FAO, Rome, 407 pp.
- Stergiou, K.I., Politou, C.Y., 1995. Biological parameters, body length-weight and length-height relationships for various species in Greek waters. *Naga, The ICLARM Quarterly*, 18 (2), 42-45.
- Teixeira, C.M., Batista, M.I., Cabral, H.N., 2010. Diet, growth and reproduction of four flatfishes on the Portuguese coast. *Scientia Marina*, 74 (2), 223-233.
- Vassilopoulou, V., 2000. Abundance and distribution of four-spotted megrim (*Lepidorhombus boscii*) in the Aegean Sea. *Belgian Journal of Zoology*, 130 (Suppl. 1), 81-85.
- Vassilopoulou, V., Ondrias, I., 1999. Age and growth of the four-spotted megrim (*Lepidorhombus boscii*) in eastern Mediterranean waters. *Journal of the Marine Biological Association of the UK*, 79, 171-178.
- Zhan, B.Y., 1995. *Fishery resources assessment*. China Agriculture Press, Beijing. (in Chinese).