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THE DETERMINATION OF AGE AND GROWTH PARAMETERS OF ATLANTIC LITTLE TUNNY *EUTHYNNUS ALLETERATUS* (RAFINESQUE, 1810) IN TURKISH WATERS.[1]

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SUMMARY

The length and weight frequency distributions, length-weight, age-length and age-weight relationships, growth parameters, condition factors and mortality rates of 1599 individuals of Atlantic little tunny- Euthynnus alleteratus *(Rafinesque, 1810) caught in the Aegean and the Mediterranean Seas from April 1994 to May 1998 were studied.*

The fishing restrictions, depending on the scientific criteria, were determined by the age and growth parameters. For the determination of age, the first spine rays of the first dorsal fins were used.

The sexual maturity periods of representative samples of the gonads obtained from females were examined. The ages of the little tunny were determined as age groups of I - VI for the Aegean Sea and I - IX for the Mediterranean Sea. For the Aegean Sea, the average of fork length age groups were 53.87 cm, 61.27 cm, 67.93 cm, 73.92 cm, 79.31 cm, 84.16 cm, and these values for the Mediterranean Sea, were 56.57 cm, 64.53 cm, 71.52 cm, 77.69 cm, 83.12 cm, 87.90 cm, 92.12 cm, 95.83 cm, and 99.09 cm respectively. The length-weight relationship was determined in accordance with Le Cren's (1951) allometric growth equation; $W=0.0000476\ L^{2.72562}$ *for the Mediterranean Sea, and* $W=0.0000575\ L^{2.69693}$ *for the Aegean Sea. As a result of regression analyses, the growth in* Euthynnus alleteratus *was determined to be allometric.* L_∞ *value was calculated to be 127.500 cm for individuals caught in the Aegean Sea, whereas for the Mediterranean Sea the* L_∞ *was 123.229 cm. It can be concluded that the minimum catch size of the little tunny of 30 cm is not realistic. The minimum size to catch little tunny in Turkish waters should be 60 cm.*

RÉSUMÉ

*Le présent document examine les distributions des fréquences de taille et de poids, les rapports taille-poids, âge-taille et âge-poids, les paramètres de croissance, les facteurs conditionnels et les taux de mortalité de 1.599 spécimens de thonines atlantiques (*Euthynnus alleteratus*) (Rafinesque, 1810) capturés dans la mer Égée et en Méditerranée d'avril 1994 à mai 1998.*

Les restrictions de la pêche, en fonction de critères scientifiques, ont été déterminées par les paramètres d'âge et de croissance. Pour déterminer l'âge, on a eu recours aux premiers rayons épineux des premières nageoires dorsales.

On a examiné les périodes de maturité sexuelle d'échantillons représentatifs de gonades prélevées sur des femelles. Les âges des thonines ont été déterminés comme des groupes d'âge de I-VI pour la mer Égée et I-IX pour la mer Méditerranée. Pour la mer Égée, la moyenne de la longueur à la fourche des groupes d'âge a été respectivement de 53,87 cm, 61,27 cm, 67,93 cm, 73,92 cm, 79,31 cm, 84,16 cm, et pour la Méditerranée, ces valeurs ont été de 56,57 cm, 64,53 cm, 71,52 cm, 77,69 cm, 83,12 cm, 87,90 cm, 92,12 cm, 95,83 cm, et 99,09 cm. Le rapport taille-poids a été défini selon l'équation de croissance allométrique de Le Cren (1951);

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$W=0,0000476\ L^{2,72562}$ pour la Méditerranée, et $W=0,0000575\ L^{2,69693}$ pour la mer Égée. À la suite d'analyses de la régression, la croissance du Euthynnus alleteratus *s'est avérée être allométrique. La valeur L4 a été calculée comme étant 127,500 cm pour les spécimens capturés dans la mer Égée, tandis que pour la Méditerranée, la valeur L4 était de 123,229 cm. On peut en conclure que le chiffre de 30 cm n'est pas réaliste pour définir la taille minimale de la prise de thonines. Il conviendrait de capturer dans les eaux turques des thonines dont la taille minimale serait de 60 cm.*

RESUMEN

Se estudiaron las distribuciones de las frecuencias de talla y peso, talla-peso, relaciones edad-talla y edad-peso, parámetros de crecimiento, factores condicionantes y tasas de mortalidad de 1.599 ejemplares de bacoreta (Euthynnus alletteratus) *(Rafinesque 1810) capturados en el Egeo y el Mediterráneo entre abril de 1994 y mayo de 1998.*

Por media de parámetros de edad y crecimiento se determinaron las restricciones a la pesca, dependiendo de los criterios científicos. Para determinar la edad, se usaron las primeras espinas de la primera aleta dorsal.

Se examinaron los periodos de madurez sexual de muestras de gónadas obtenidas en hembras. Las edades de la bacoreta se establecieron en grupos de edad I-VI para el Mar Egeo y I-IX para el Mediterráneo. Respecto al Egeo, la media de longitud a la horquilla por grupos edad era 53.87 cm, 61.27 cm, 67.93 cm, 73.92 cm, 79.31 cm, 84.16 cm y respecto al Mediterráneo, 56.57 cm, 64.53 cm, 671.52 cm, 77.69 cm, 83.12 cm, 87.90 cm, 92.12 cm, 95.83 cm y 99.09 cm, respectivamente. La relación talla-peso se estableció de acuerdo con la ecuación de crecimiento alométrico de Le Cren (1951): $W = 0.0000476\ L^{2.72562}$ para el mar Egeo. Como resultado de los análisis de regresión, se determinó que el crecimiento del Euthynnus alletteratus *era alométrico. Se calculó que el valor de L4 era 127.500 cm en los ejemplares capturados en el Egeo, mientras que respecto a los del Mediterráneo L4 era 123,229 cm. Se puede llegar a la conclusión que la talla mínima de captura de la bacoreta, de 30 cm, no es realista. Esta talla mínima de captura de la bacoreta en aguas turcas debería ser de 60 cm.*

I. INTRODUCTION

The Atlantic Little Tunny, *Euthynnus alleteratus* (Rafinesque, 1810), a member of Scombrids, has a wide distribution. It is found in the Atlantic Ocean and all over the Mediterranean and in the adjacent seas.

The studies about the first maturity length, fecundity, condition factor, gonosomatic indices, sex ratio, and spawning period of this species have been investigated by Frade and Postel (1955), Calkins and Klawe (1963), Landau (1965), Rodriguez-Roda (1966; 1979), Klawe et al. (1970), Diouf (1980), Miyake (1982), Cayre and Diouf (1983), Yesaki (1994), and Anonymous (1984 ; 1989). The length and weight frequency distributions, length-weight, age-length and age-weight relationships, growth parameters, and mortality rates of *E. alleteratus* have also been studied by Landau (1965), Rodriguez-Roda (1966), Cayre and Diouf (1980;1983), Antoine et al. (1983), Johnson (1983), Hattour (1994) ve Allman and Grimes (1997).

Atlantic Little Tunny is one of the most important species of Turkish fisheries. It has an export potential and economical value. The fishing areas in Turkish waters are the Bay of Ýskenderun, the Bay of Antalya, northeast area of Cyprus, the area between the Bay of Güllük and TurgutReis, Foça, Aliağa, Badem Islands, the Bay of Edremit, between Cape Kadýrga and Babakale, and around Gökçeada and Bozcaada Islands (Figure 1). In Turkey, Atlantic Little Tunnies are caught by purse-seiners.

In Turkey, the catches of Little Tunny, especially in the last three-year period, decreased and in this period, approximately between 500 and 750 MT / year were caught. It is stated that this amount of Atlantic Little Tunny is actually 2,5 - 3 times (average 1500 MT) more than the estimated statistical data. (Anon., 1998).

II. MATERIALS AND METHOD

In April 1994 – May 1998, studies on Atlantic Little Tunnies, caught by the commercial purse-seiners, were carried out in the Aegean Sea (on 145 fish) and in the Mediterranean Sea (on 1454 fish). On representative samples of the gonads from females, the sexual maturity has been examined. In some months during the research period in which little tunas were caught as a by product, could not be obtained. This was to not a permanent fishing activity for little tunas.

The fork length (FL, in centimeters) and the total weight (TW, in grams) for each specimen of *E. alleteratus* were measured. The length frequency distributions were arranged in 2.0 cm intervals. A calliper of 100 cm has been used to determine the size of the fish. When assessing the metric characters, the standard methods of FAO have been applied.

During the research period, the length and weight frequency distributions of all samples obtained from the Aegean and the Mediterranean Seas were investigated. In addition; some biometric parameters, which are the aritmetic average (X), standard deviation (S), variance (S^2), variance coefficient (CV), standard error (Sx), minimum, and maximum values, were estimated.

The length and weight frequency distributions of individuals obtained during the research period were investigated separately for two-month or three-month periods. The relationship between these values was obtained by applying logaritmic regression equation for the Aegean Sea and for the Mediterranean Sea respectively. All parameters were studied and examined.

For the determination of age, the first spine rays of the first dorsal fins were used. For the theoretical lengths in different ages of *E. alleteratus*, the formulas of Ford (1933) and Walford (1946), $L(t+\Delta t) = a\,Lt + b$, and Von Bertalanffy (1938), $Lt = L\infty\,[1-e^{-k(t-to)}]$, were used. Furthermore; the length-weight relationship was determined in accordance with Le Cren's (1951) allometric growth equation; $W = a\,L^{n}$.

In order to determine the sexual maturity of the samples, the gonad weights have been measured with 0.01 g sensitivity through weighing them by digital balance. When determining the sexual maturity of the Little tunnies, the macroscobic and microscobic structures and positions of the gonads have been observed especially for the individuals whose gonads were developed. The degree of maturity of gonads was determined according to the scale by Laevastu (1965).

III. RESULTS AND DISCUSSION

During the period of investigations, the average fork length values of the individuals obtained from the Mediterranean Sea and the Aegean Sea were calculated to be the 74.0 - 75.9 cm length group. The min., max., and the average length values of the Mediterranean and the Aegean Seas were 52.0 cm, 97.5 cm, 74.02 cm, and 55.0 cm, 85.0 cm, 70.18 cm, respectively. The average FL and TW values of all samples obtained from the both seas were observed as to be in the 70.0 – 85.0 cm length group and weighed 4500 – 6000 g.

In order to determine the relationship between the length and weight values, regression and correlation analyses were applied for the Aegean and the Mediterranean Seas, respectively. The correlation coefficient (r) values calculated as to be around (1) indicates that the relationships between the length and the weight values show that a strong and positive relation was existent.

The relationship between the length and weight was calculated by the allometric growth equation of Le CREN (1951) and was found out to be $W = 0.0000476\ L^{2.72562}$ for the Mediterranean Sea and $W = 0.0000575\ L^{2.69693}$ for the Aegean Sea. As a result of the regression analyses, the growth in *Euthynnus alleteratus* was determined to be allometric. The $L\infty$ value was calculated to be 127.500 cm for individuals in the Aegean Sea, whereas for the Mediterranean Sea the $L\infty$ was 123.229 cm.

The ages of specimens show the age distribution among I – VI (0+ - 5+) age groups for the Aegean Sea and I – IX (0+ - 8+) age groups for the Mediterranean Sea.

The average fork length values were calculated as to be 53.87 cm at the end of I st year, 61.27 cm at the end of II nd year, 67.93 cm at the end of III rd year, 73.92 cm at the end of IV th year, 79.31 cm at the end of V th year and 84.16 cm at the end of VI th year for the Aegean Sea. These values were at the end of the I st year 56.57 cm, at the end of II nd year 64.53 cm, at the end of III rd year 71.52 cm, at the end of IV th year 77.69 cm, at the end of V th year 83.12 cm, at the end of VI th year 87.90 cm, at the end of VII th year 92.12 cm, at the end of VIII th year 95.83 cm and at the end of IX th year 99.09 cm for the Mediterranean Sea.

The total number of gonads collected during the research period was 72. 54.19 % of these (39 samples) belonged to the females; 45.83 % (33 samples) to the males. The proportion of the males to the females was approximately 1:1.

As a result of macroscobic and microscobic examination conducted on a total of 39 gonads; 22 gonads had average fork lengths of 53.4 cm and 57.8 cm respectively, and were in the age groups of 0+ and 1+.

These were in the I st and in the II nd development phase (immature phase). 17 gonads had average fork lengths of 60.2 cm, 69.8 cm, 79 cm, and 83.5 cm respectively being in the II nd, III rd, IV th, and V th development phases (matured phase).

In this research, the total mortality rate (Z) estimated for the Atlantic Little Tunnies obtained from the Aegean and the Mediterranean Seas, according to the model of Beverton and HOLT, has been calculated as **0.44**.

As a result; according to the total mortality rate (Z), the amount of little tunas shortened from the seas is the closest of the half of the stock because of natural mortality and fishing activity.

It can be concluded that the minimum catch size of the Little Tunny of 30 cm in Turkish waters (Anonim, 1997) is not realistic. The minimum size of the Little Tunny in Turkish waters **should be 60 cm**.

The percentage of fish caught under 60 cm was determined to be only 9.75 %, showing that even than the undersized fish are not caught to a small extent.

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Table 1. Biometric Parameters of Fork Length Values (Aegean Sea)

Date	N	Min.	Max.	X	S	S^2	CV	Sx
1994-1998 (March, April, May)	145	55	85	70.18	6.70	44.89	9.54	0.55

Table 2. Biometric Parameters of Fork Length Values (Mediterranean Sea)

Date	N	Min.	Max.	X	S	S^2	CV	Sx
1994, April	35	55	85	69.47	8.51	72.42	12.24	1.43
May	52	55.5	84.5	68.95	7.28	52.99	10.55	0.69
November	49	58	75.5	71.67	3.94	15.52	5.49	0.56
December	54	66.5	74.5	71.03	5.22	27.24	7.34	0.71
1995, April	53	54	73	60.51	3.43	11.76	5.66	0.47
May	41	63.5	73.5	68.99	2.86	8.17	4.14	0.44
November	29	68	74.2	70.72	2.02	4.08	2.85	0.37
December	28	68	75	71.01	2.14	4.57	3.01	0.4
1996, March	59	53	82.5	63.62	9.05	81.90	14.22	1.17
April	272	58	97.5	83.8	6.27	39.31	7.48	0.38
May	57	56.5	96.5	79.89	9.41	88.54	11.77	1.24
October	75	52	84.5	71.17	9	81	12.64	1.03
November	68	54.5	84	71.44	7.74	59.90	10.83	0.93
December	73	53.5	84.5	67.03	7.78	60.52	11.6	0.91
1997,Feb.	38	54	80.5	66.18	5.95	35.40	8.99	0.96
March	67	62	87	72.11	5.62	31.58	7.79	0.68
April	55	66	96.5	80.96	7.44	55.35	9.18	1
May	21	66	92	84.57	5.1	26.01	6.03	1.11
Sept.	95	58	93	74.43	6.99	48.86	9.39	0.71
1998, Jan.	22	58	83	72.05	6.35	40.32	8.81	1.35
Feb.	25	71	84.5	75.43	4.06	16.48	5.38	0.81
March	52	71.4	94.5	80.41	6.17	38.06	7.67	0.85
April	62	71	96.5	82.12	7.04	49.56	8.56	0.89
May	72	71.5	97	84.56	7.02	49.28	8.3	0.82
Total	**1454**	**52**	**97.5**	**74.02**	**9.45**	**89.30**	**12.76**	**0.24**

Table 3. Regression Formulae and Parameters

	VARIABLES Depended (log y)	Non-depended (log x)	**REGRESSION FORMULAE** $\log y = \log a + b \log x$
the Aegean Sea	Weight (g)	Fork Length (cm)	$y = 0.0000575 * x^{2.697}$
the Medit. Sea	Weight (g)	Fork Length (cm)	$y = 0.0000476 * x^{2.723}$

Table 4. Values of Correlation Coefficient (r) , r^2 and (%)

	Variables	Correlation Coefficient (r)	r^2	(%)
the Aegean Sea	Weight (g) FL (cm)	0.966198	0.933539	93.35
the Medit. Sea	Weight (g) FL (cm)	0.980495	0.961371	96.13

Table 5. Values of Confidence intervals (% 95)

	Variables	n	r^2	a	b	Confidence intervals (95%)
the Aegean Sea	Weight (g) FL (cm)	104	0.9335	-4.27027	2.69693	2.57972 < ...< 2.81413
the Medit. Sea	Weight (g) FL (cm)	1085	0.9613	-4.32195	2.72562	2.69864 < ...< 2.75256

Table 6. Fork Length Values in Accordance with the Ages (Mediterranean Sea, 1994-1998)

Date	Age	n	X	S
1994-1998	0+	12	55.75	1.96
	1+	65	61.6	4.39
	2+	134	71.46	3.47
	3+	90	77.2	4.61
	4+	63	79.28	6.43
	5+	30	83.98	7.52
	6+	8	93.06	1.34
	7+	7	94.35	0.55
	8+	7	96.43	0.73

Table 7. Fork Length Values in Accordance with the Ages (Aegean Sea, 1994-1998)

Date	Age	n	X	S
1994-1998	0+	3	56	1.322
	1+	3	58.3	1.04
	2+	14	65.57	1.382
	3+	38	71.56	2.218
	4+	12	80.75	2.775
	5+	2	84.75	0.353

Table 8. Parameters of Length Growth Estimated with Von Bertalanffy Equation

Area	L_∞	K	t_o	Equation
the Medi t. Sea	123.229	0.127	-3.839	$L=123.229\ [1-e^{-0.127\ (t-(-3.839))}]$
the Aegean Sea	127.500	0.106	-4.180	$L=127.500\ [1-e^{-0.106\ (t-(-4.180))}]$

Table 9. Values of the Mean Length Estimated with Von Bertalanffy Equation for Each Age Group (Mediterranean Sea)

Age Groups	Mean Length (cm)	According to Von Bertalanffy
I	55.75	56.57
II	61.6	64.53
III	71.46	71.52
IV	77.2	77.69
V	79.28	83.12
VI	83.98	87.90
VII	93.06	92.12
VIII	94.35	95.83
IX	96.43	99.09

Table 10. Values of Mean the Length Estimated with Von Bertalanffy Equation for Each Age Group (Aegean Sea)

Age Groups	Mean Length (cm)	According to Von Bertalanffy
I	56.0	53.87
II	58.3	61.27
III	65.57	67.93
IV	71.56	73.92
V	80.75	79.31
VI	84.75	84.31

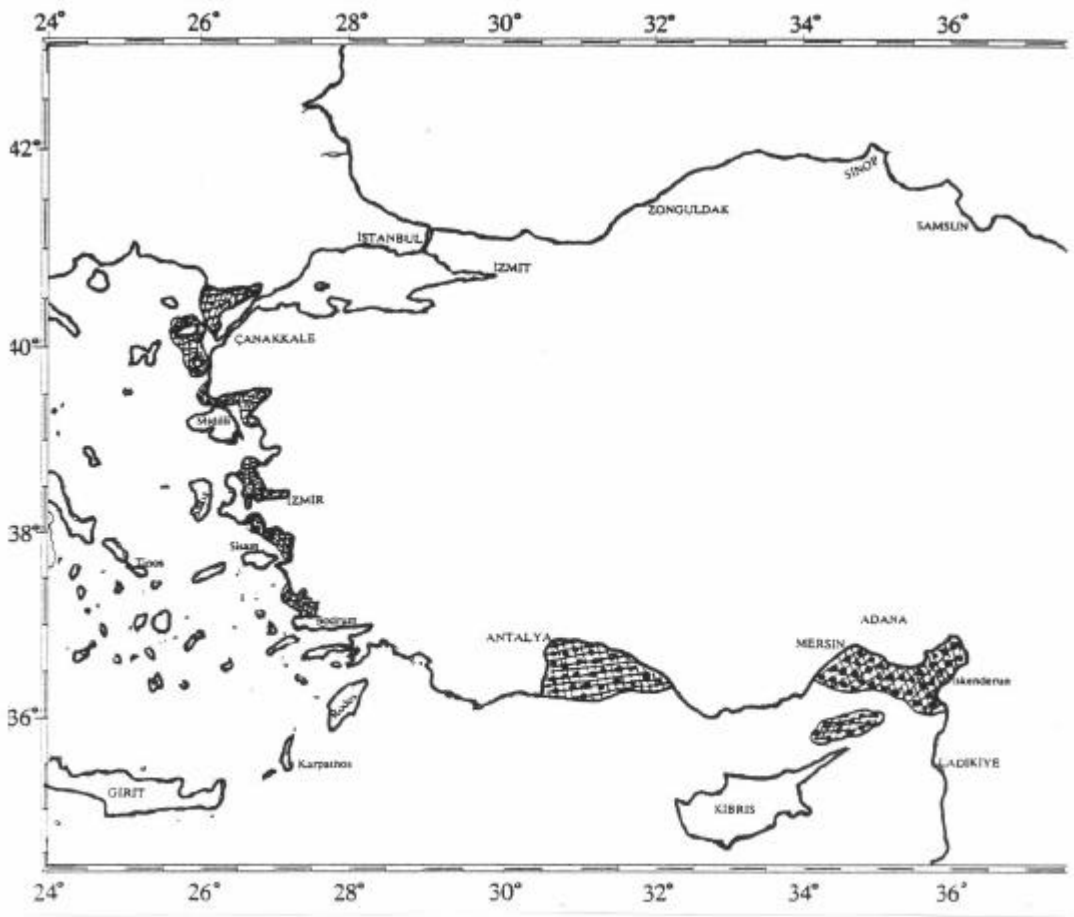

Fig. 1. The Fishing Area of the Little Tunnies in Turkish Waters

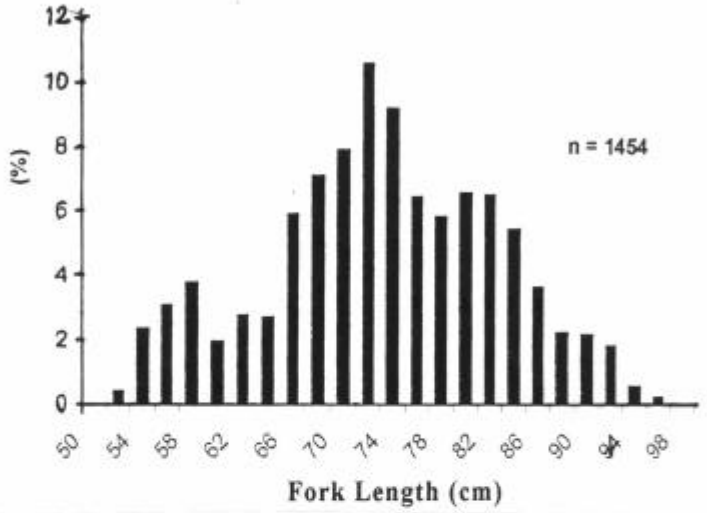

Fig. 2. Distribution of Length Frequency (Mediterranean Sea)

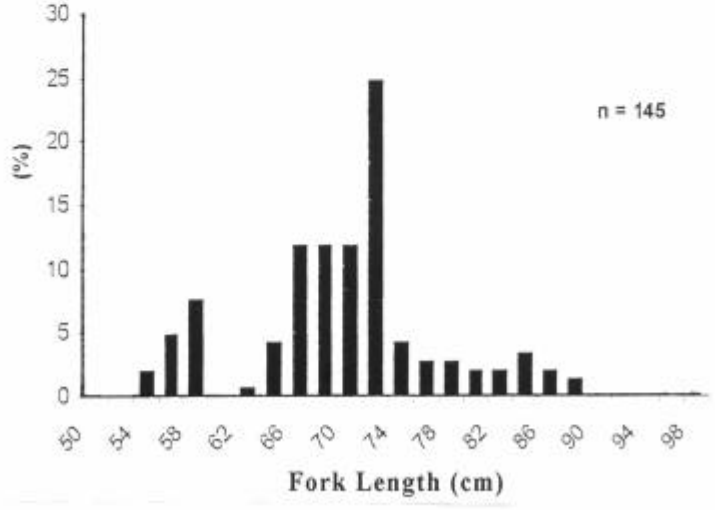

Fig. 3. Distribution of Length Frequency (Aegean Sea)

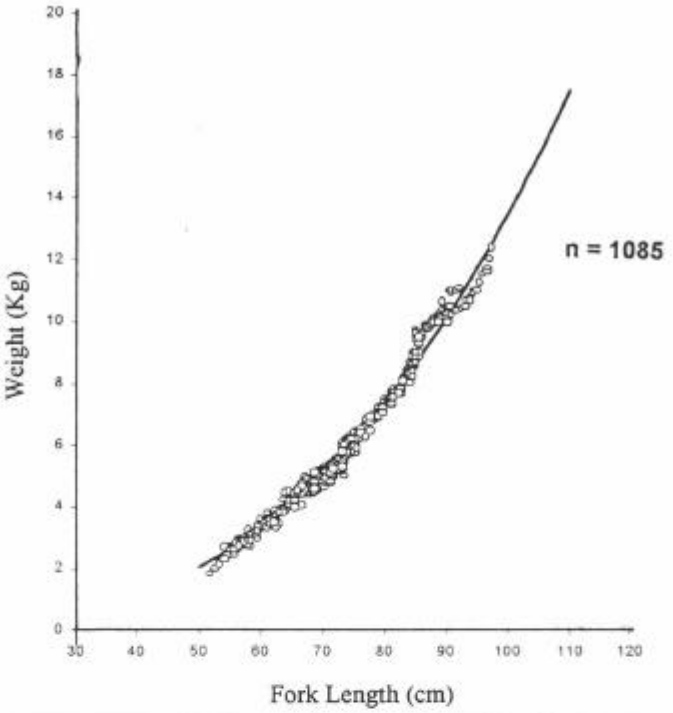

Fig. 4. Length – Weight Relationship (Mediterranean Sea)

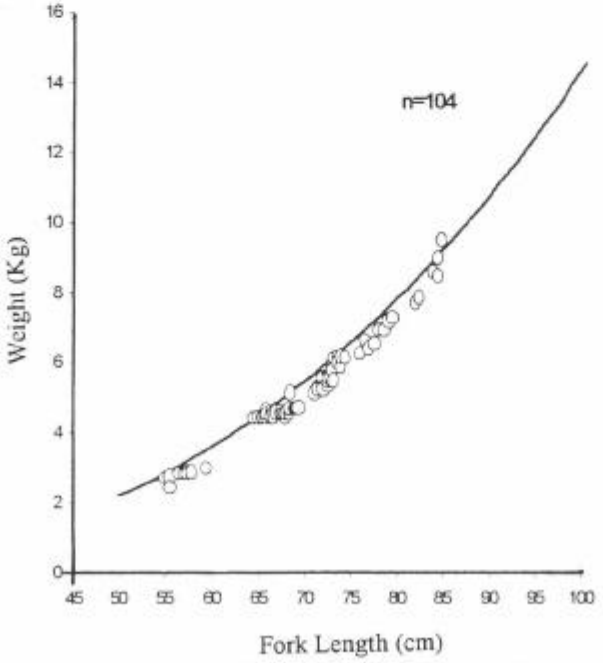

Fig. 5. Length – Weight Relationship (Aegean Sea)

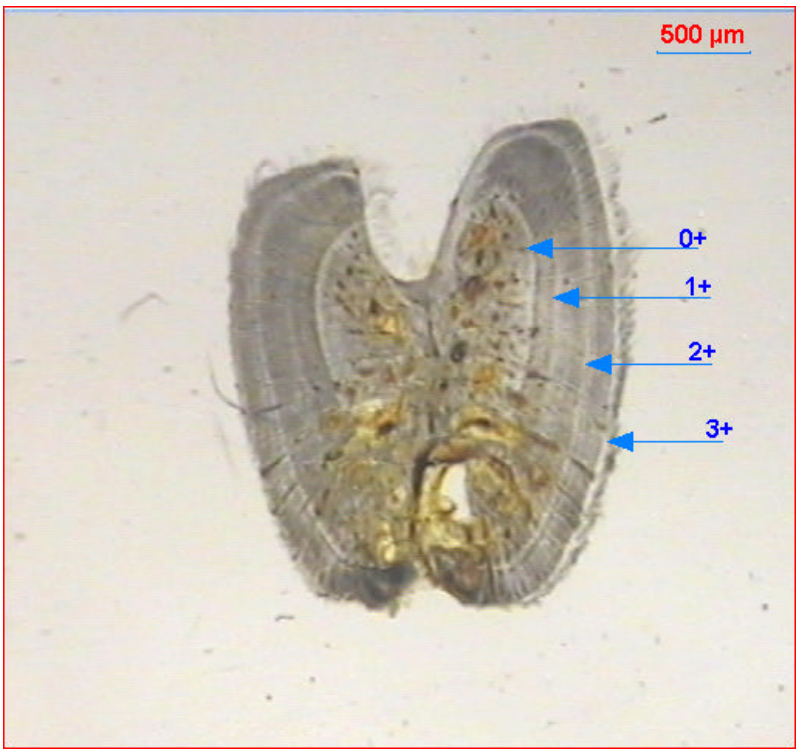

Figure 6. The cross section of the first dorsal fin spine of *E. alleteratus*

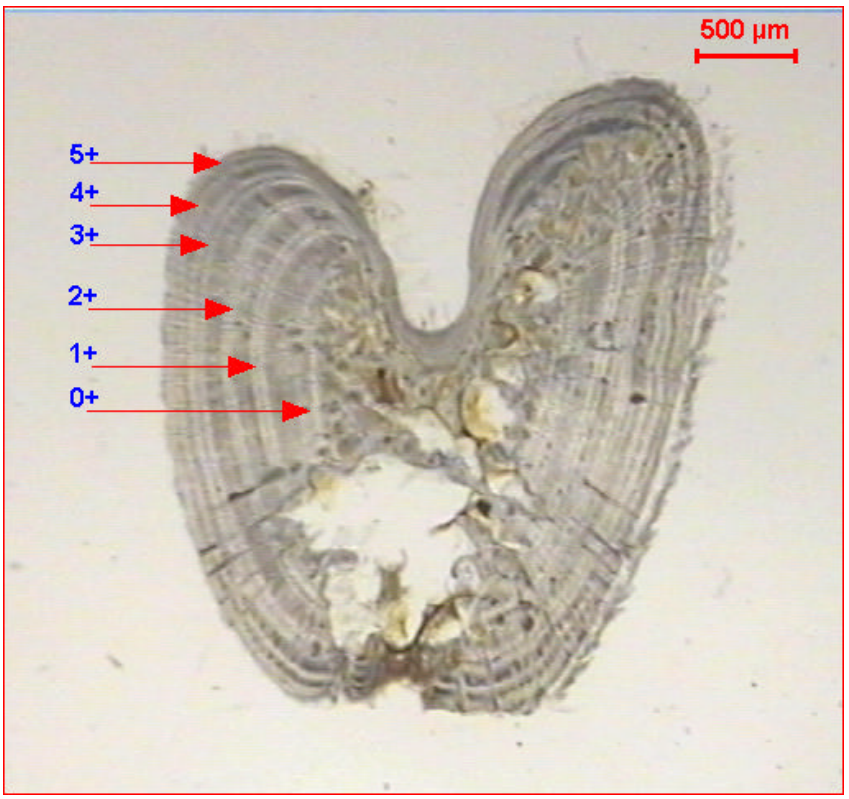

Figure 7. The cross section of the first dorsal fin spine of *E. alleteratus*

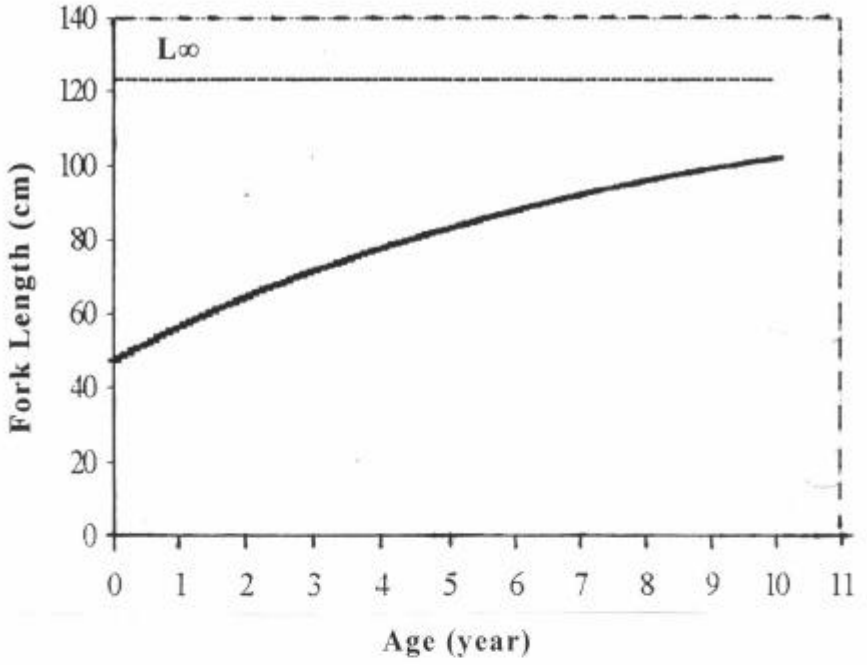

Fig. 8. Age – Length Relationship of *E. alleteratus* (Mediterranean Sea)

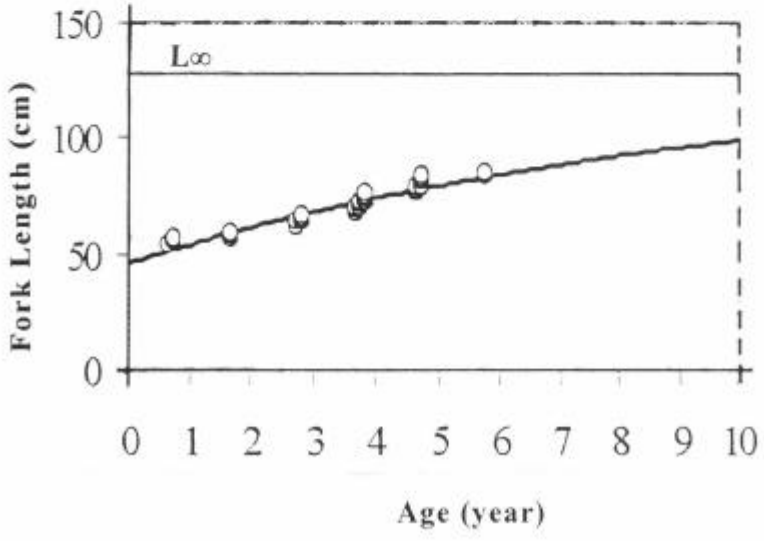

Fig. 9. Age – Length Relationship of *E. alleteratus* (Aegean Sea)

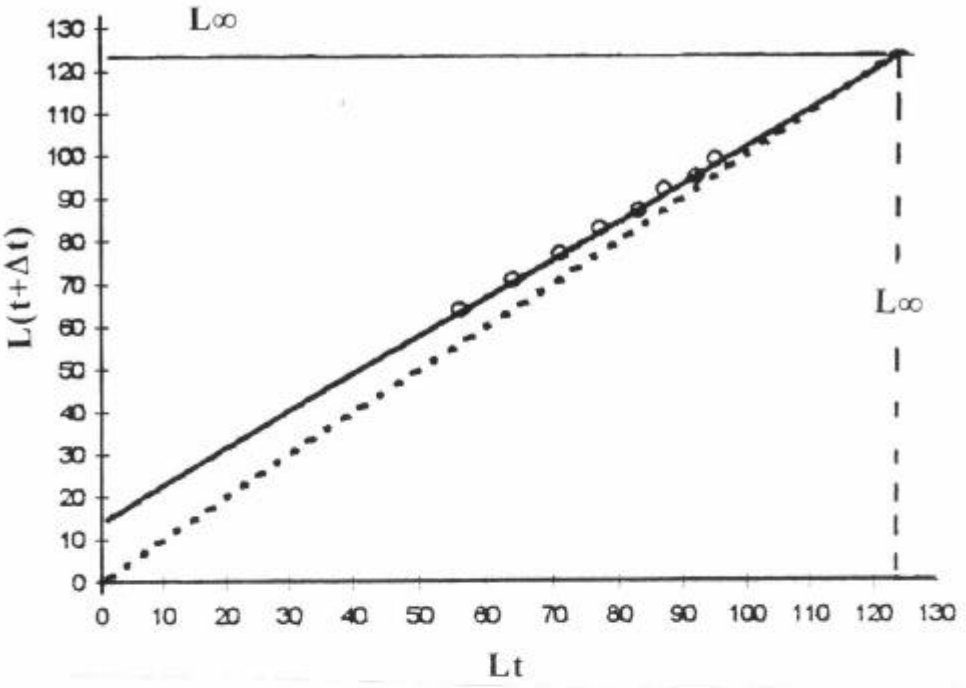

Fig. 10. Ford-Walford Plot (Mediterranean Sea)

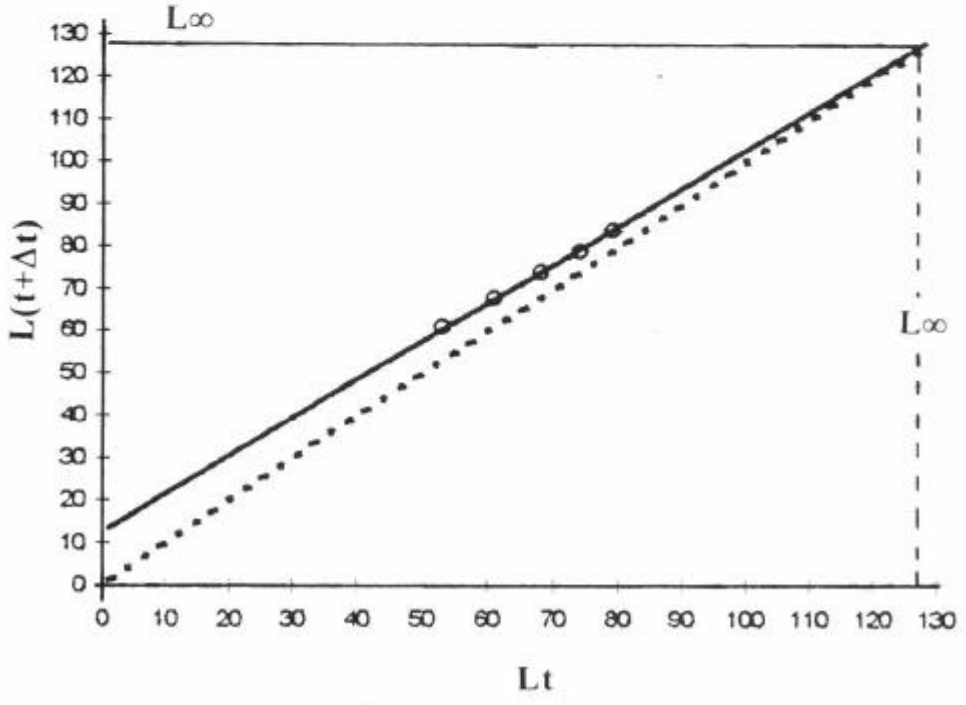

Fig. 11. Ford-Walford Plot (Aegean Sea)