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RESEARCH ARTICLE

Growth and reproduction of the greater weever (*Trachinus draco* L., 1758) along the eastern coast of the Black Sea

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Abstract

A total of 636 specimens of the greater weever, *Trachinus draco*, was collected monthly by bottom trawlers in the Eastern Black Sea. In order to identify some biological features of this species in the Black Sea, reproductive characteristics and growth parameters such as sex ratio, maturity stage, length at first maturity, spawning time, reproduction period, age, length-weight relationship, and condition factor were recorded. The female:male ratio was 1:1.04 (x^2: 0.27, $x^2_{0.05,1}$=3.84; P>0.05). Mean condition factors of females and males were 0.99055 and 0.95625, respectively. Taking into consideration of gonadosomatic index (GSI) and egg diameter, reproduction occurred in July and August. The age at first maturity was 1^+ year and the first reproduction length was 12.01 cm for females. The average diameter of mature egg was 0.91 ± 0.265 mm. Growth parameters of the von Bertalanffy equation were for females and males as follows: $L\infty$ = 32.62 cm, K = 0.18 y^{-1}, to = −1.74 year, and $W\infty$ = 232.54 g, and $L\infty$ = 29.31 cm, K = 0.17 y^{-1}, to = −2.28 year, and $W\infty$ = 232.54 g, respectively. The growth performance index (Φ) was 2.29, 2.17 and 2.36 for females, males and all specimens, respectively. The maximum age was 6+ years for females and 5+ years for males.

Key words: Greater weever, *Trachinus draco*, first maturity length, growth parameters, gonadosomatic index, Black Sea.

Introduction

The greater weever, *Trachinus draco,* is a venomous marine fish, lives near the eastern Atlantic coastline from Norway all the way to Morocco, even in the area extending to Madeira, Canary Islands, and the Mediterranean, Aegean, and Black Seas (Slastenenko 1956; Whitehead *et al.* 1984; Turan 2007). It's a

benthic species, living most of its life on sandy or muddy bottoms along the upper slope of the continental shelf from 15 to 150 m depth (Froese and Pauly 2007). Maximum length is 37.6 cm (Bagge 2004) and mainly brown individuals have poisonous spines on their first dorsal fin and gills. At night, this fish swim around freely, even pelagically. Spawning usually takes place from June to August (Muus and Nielsen 1999). It feeds on small invertebrates and fish; chiefly nocturnal (Morte *et al.* 1999).

The greater weever is caught mainly as bycatch in the Black Sea by purse seines, bottom trawl and gill nets. In Turkey, the greater weever is not of direct use to humans; however, this species has wide distribution and contributes to the biological richness of the fish fauna. Despite the wide distribution and the ecological importance of greater weever in the Black Sea, some aspects of its biology, such as reproduction traits, growth, distribution and feeding aspects are partially unknown. In the other areas of its distribution, the information on the greater weever comprises biological data such as length-weight relationship (Dorel 1986; Coull *et al.* 1989; Dulčić and Kraljević 1996; Merella *et al.* 1997; Gonçalves *et al.* 1997; Moutopoulos and Stergiou 2002; Abdallah 2002; Mendes *et al.* 2004), distribution (Nelson 1994), feeding aspects (Morte *et al.* 1999), growth (Bagge 2004) and egg and larvae distribution (Ferreiro and Labarta 1988; Rodriguez *et al.* 2001; d'Elbée *et al.* 2009). In Turkey, the length-weight relationship of this species has been studied (Karakulak *et al.* 2006; Sangun *et al.* 2007; Kınacigil *et al.* 2008; Ak *et al.* 2009) as well as egg and larval distribution (Dehnik 1973; Yüksek 1993; Ak and Hoşsucu 2001; Satılmış 2001; Ak 2004; Çoker 2003; Ak 2009).

Although, this species has no commercial value, its importance in the food chain and the Black Sea ecosystem is recognized. Undoubtedly, it is important to investigate also the population structure and changes of non-commercial fish species which are often taken as (partly unreported) bycatch. Knowledge on the sex ratio, spawning period, fecundity, condition factor, length frequency and growth aspects of the greater weever populations in the Black Sea is highly incomplete. Thus, this study aimed to elucidate some biological aspects of this species in the Black Sea.

Material and Methods

A total of 636 individuals of the greater weever, *Trachinus draco*, was collected from the Eastern Black Sea monthly between January 2009 and December 2010 from the shore to a depth of 60 m (Figure 1) using a bottom trawl with 22.5 m width and 14 mm codend mesh size. All hauls were taken at durations ranging between 25 and 30 min during daytime. The trawling speed was around 2.5 knots, depending on the depth and the type of the substrate.

For each specimen, total length (TL, ≈0.1 cm) and total weight (W, ≈0.01 g) were measured. Age determination was carried out by reading whole otoliths (sagittal) against a black background under a reflected light in the stereoscopic microscope (Chilton and Beamish 1982) and assigned to age groups 0–6 years.

The growth equation, $W = a*L^b$, was used to determine length-weight relationship (Ricker 1975) [W: total weight (g), L: fork length (cm), and "a" and "b": regression parameters]. The age-length and age-weight relationships were used to determine the formulas $Lt = L\infty[1-e^{-k(t-to)}]$ and $Wt = W\infty\ [1-e^{-k(t-to)})]^b$ respectively (Erkoyuncu 1995). The values of the compiled growth exponent were used for the calculation of condition factor (K), $K=100*W/L^b$, W= total body weight (g), L= total length (cm), b= growth exponent (Erkoyuncu 1995). The growth performance index (Φ ($cm.y^{-1}$) = lnk+2 ln $L\infty$.) was calculated according to Sparre *et al.* (1989).

Figure 1. Sampling area of the greater weever, *Trachinus draco*, along the Turkish coast of the Black Sea

Gonads were dissected and structural differences of the gonad were used to identify sex. Female: male ratio was calculated using mature individuals. Spawning period was established with monthly variations of the gonado somatic index GSI = [Wg/(Wt-Wg)]*100, Wg: gonad weight (g), Wt : total weight (g) (Ricker 1975). The maturity stages were assessed according to Gunderson's (1993) scale: stage I juvenile; stage II resting; stage III developing; stage IV maturity; and stage V spent. Length at first maturity was defined as the length at which 50% of the population was near to spawning and it was calculated with the equations of r(l) = exp(–exp(–(a+bl))) and L50 = (–ln(–ln(0.5))–a)/b, where r(l) (%) is the proportion of matures in each length class, l (cm) is the fish length, L50 (cm) is the mean length at sexual maturity (50%), a is the intercept and b is the slope (King 1995).

Statistical Analysis

Differences in samples were presented based on the sample mean and standard error. Chi-square test was used to analyze differences in the sex ratio. All data sets were tested for normality and equal variances prior to further statistical analysis. T-test was used to elucidate the correlation between total lengths, weight (Zar 1996).

Results

Length Frequency

A total of 636 individuals were sampled during the study period. All observed specimens varied in total length from 5.0 to 25.8 cm (Figure 2). The means, ranges and SE for total length and weight of male, female and immature fish are shown in Table 1.

While males were dominant in smaller size classes (10-16 cm), females were represented by larger length classes (17-22 cm). The maximum length (35 cm), however, was that of a male fish (Figure 2). In other words, the sex ratio of *T. draco* specimens in smaller length classes was in favour of males. The proportion of females increased in length classes greater than22 cm.

Sex Composition

The sex ratio was dominated by males. It attained its maximum value in November and December (m/f = 0.66 and 0.63, respectively).

The proportion of male, female and undetermined were 50.15% (n = 319), 48.11% (n = 306) and 1.72% (n = 11), respectively. The overall sex ratio did not significantly deviate from the hypothetical distribution of 1:1 ($\chi^2_{0.05,1}$=3.84; P>0.05), (Table 2).

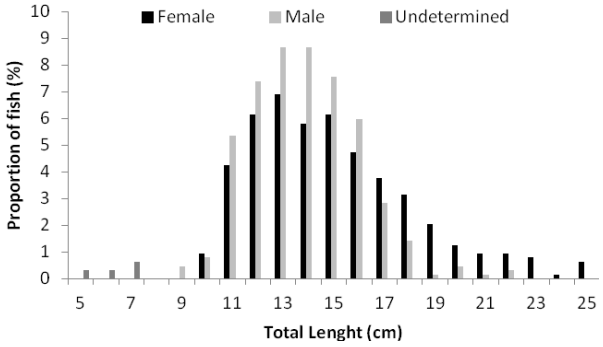

Figure 2. Length frequency distribution of females, males and undetermined of the greater weever, *Trachinus draco*, along the Turkish coast of the Black Sea

Table 1. Descriptive statistics for males, females and immature individuals of the greater weever, *Trachinus draco*, along the Turkish coast of the Black Sea

Sex	N	Min Length (cm)	Max Length (cm)	Mean Length±Std. E (cm)	Min. Weight (g)	Max. Weight (g)	Mean Weight±Std. Dev (g)
Male	319	9,5	22,5	14.31±0.121	5,34	75,84	22.08±0.601
Female	306	10	25,8	15.43±0.184	6,96	131,76	29.87±1.245
Immature	11	5	7,5	6.68±0.265	1,01	2,93	2.12±0.196
All fish	636	5	25,8	14.76±0.116	1,01	131,76	25.61±0.698

Table 2. Age composition and sex ratio of the greater weever, *Trachinus draco*, along the Turkish coast of the Black Sea

Age	Males		Females		Total		χ^2
	N	%		%	N	%	
0	-	-	-	-	-	-	
1	170	53,29	161	52,61	331	52,96	0,24
2	116	36,36	92	30,07	208	33,28	2,77
3	23	7,21	28	9,15	51	8,16	0,49
4	6	1,88	14	4,58	20	3,2	3,20
5	4	1,25	7	2,29	11	1,76	0,82
6	0	0,00	4	1,31	4	0,64	4,00
Total	319	100	306	100	625	100	0,27

$\chi^2 < \chi^2_{0.05,1} = 3.84$

Male/female ratio is not significantly different in the all age groups.

Maturity Stages

The reproduction period of the greater weever occurred in the summer months. According to the monthly percentage composition of gonad maturity stages, immature fish were observed from early spring to late summer. In females, gonads started to mature in March and April. Within these months females were in juvenile and resting stages. In May and June, females were in juvenile, resting and developing stages. Mature stages peaked in July and August and were recorded until September (Figure 3).

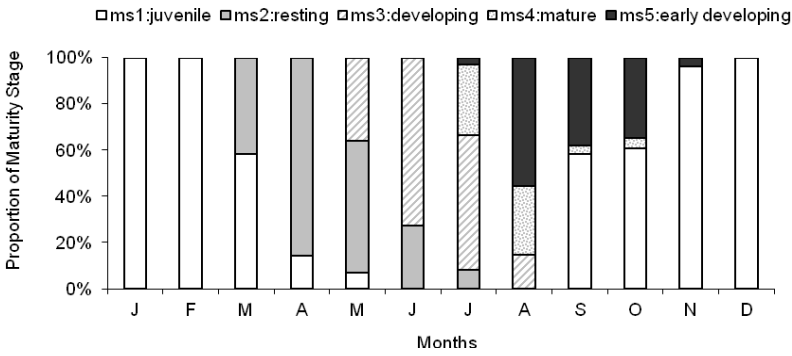

Figure 3. Monthly changes in the proportions of different maturity stages (ms) for female greater weever *Trachinus draco*, in 2008-2009, along the Turkish coast of the Black Sea

Gonadosomatic Index (GSI)

Seasonal alternations in mean monthly gonadosomatic indices (GSI) of males and females are shown in Figure 4. Monthly variation in GSI followed that of maturity stages of gonads. The increase of GSI for females started in May until September with a peak in July (8.42 ± 0.58) with the minimum value of 1.05 ± 0.28 in December. For males the increase of GSI started in May until October with the maximum value of 5.64 ± 0.58 in June and the minimum value of 0.57 ± 0.06 in November and 0.56 ± 0.15 in December.

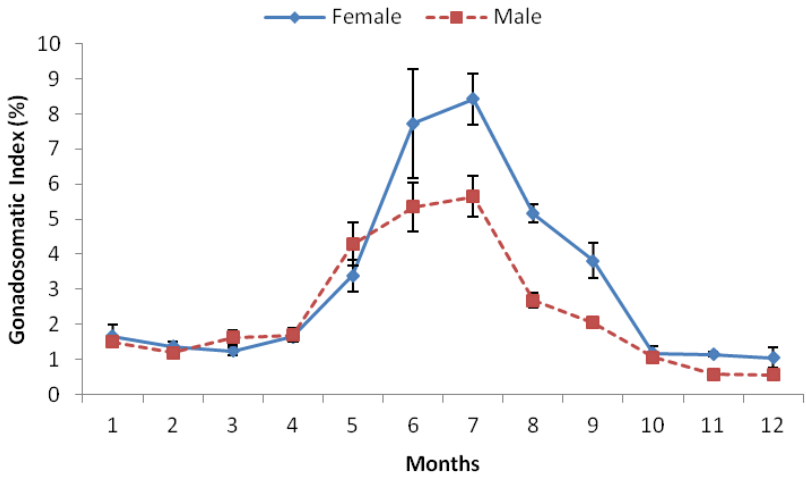

Figure 4. The monthly variation of GSI (means ± SE) in the greater weever *Trachinus draco* for females and males, along the Turkish coast of the Black Sea

Egg Diameter

The mean egg diameter at maturity was 0.91 ± 0.265 mm. In this study, oocytes were recognized and the diameters thus ranged between 0.64 and 0.98 mm.

Length and Age at the First Sexual Maturity

Length at the first maturity (Lm50) was 12.01 for females (Figure 5). Age at first maturity was calculated by converting Lm50 to age by von Bertalanffy equation. There were no mature individuals observed in the age 0 group. Female reached the sexual maturity for the first time within one year.

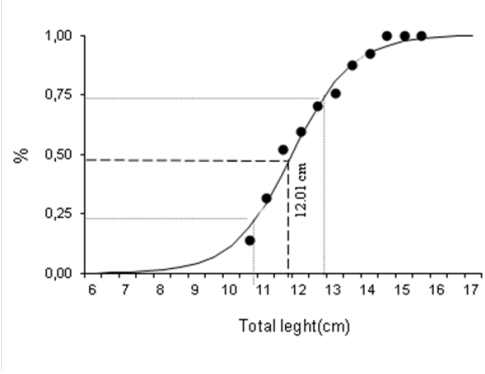

Figure 5. The length at first maturity (Lm50) in female of the greater weever *Trachinus draco* along the Turkish coast of the Black Sea

Condition Factor

For females, the monthly condition factor was the highest (0.79 ± 0.02) during May (Figure 6). Compared to other months of the year, higher condition factors observed during the period from May to August. The same tendency was observed for males; the maximum value was 0.82 ± 0.02 in May and the minimum was 0.59 ± 0.03 in April.

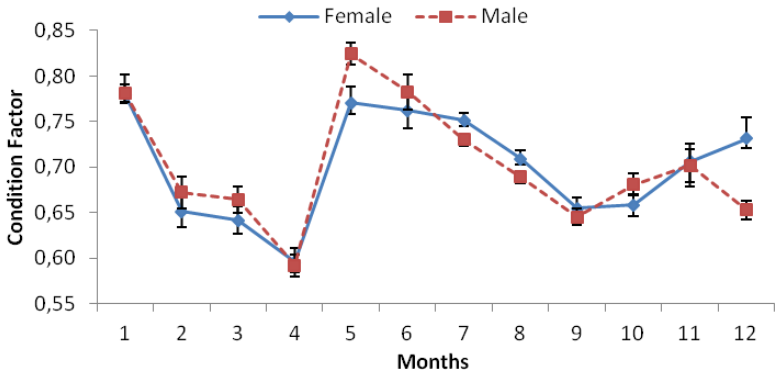

Figure 6. The monthly variation of condition factor (means ± SE) in the greater weever, *Trachinus draco* for females and males, along the Turkish coast of the Black Sea

Length-Weight Relationship

The length–weight relationship was estimated for the total samples and for both sexes separately (Figure 3). The mean total length and mean weight varied significantly between males and females (t-test; $F_{Length} = 38.411$; $F_{Weight} = 63.423$; $n = 625$; $P<0.01$). All sampled fish exhibited positive allometric growth ($b<3$). Male fish, however, showed negative allometric growth ($b>3$) (Figure 7).

Age-Length

Six age classes ranging from 1 to 6 years for females and 1-5 years for males were determined (Table 3).

Growth Parameters

Von Bertalanffy Growth Parameters as well as the growth performance index (Φ) are shown for females, males and combined sexes in Table 4.

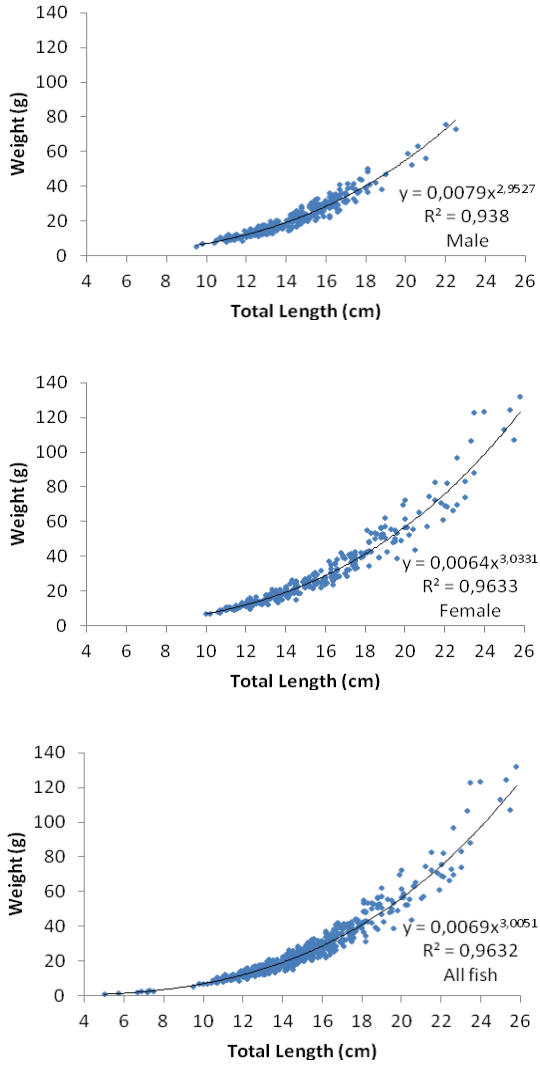

Figure 7. The length-weight relationships of the greater weever (*Trachinus draco*) for males, females and combined fish along the Turkish coast of the Black Sea

Table 3. Age-length for the greater weever, *Trachinus draco* (females and males) along the Turkish coast of the Black Sea

Length (cm)		Age Classes						
		I	**II**	**III**	**IV**	**V**	**VI**	**Total**
9	Female							
	Male	3						3
10	Female	6						6
	Male	5						5
11	Female	27						27
	Male	34						34
12	Female	36						36
	Male	47						47
13	Female	43	1					44
	Male	52	3					55
14	Female	27	10					37
	Male	24	31					55
15	Female	19	10					39
	Male	5	43					48
16	Female	3	26	1				30
	Male		35	3				38
17	Female		21	3				24
	Male		4	14				18
18	Female		11	9				20
	Male			6	2	1		9
19	Female		2	10	1			13
	Male				1			1
20	Female		1	4	3			8
	Male				3			3
21	Female			1	5			6
	Male					1		1
22	Female				5	1		6
	Male					2		2
23	Female					4	1	5
	Male							
24	Female					1		1
	Male							
25	Female					1	3	4
	Male							
Female	n	161	92	28	14	7	4	306
	Mean Length	13,12	16,52	19,04	21,41	23,53	24,95	15,44
	SD	1,37	1,31	0,96	0,92	0,9	1,02	3,12
	SE	0,11	0,14	0,18	0,25	0,34	0,51	0,18
Male	n	170	116	23	6	4		319
	Mean Length	12,73	15,53	17,48	19,37	21,08		14,32
	SD	1,18	0,83	0,51	1,12	1,64		2,17
	SE	0,09	0,08	0,11	0,46	0,82		0,12

Table 4. Von Bertalanffy growth parameters of the greater weever, *Trachinus* along the Turkish coast of the Black Sea

	L∞ (cm)	W∞ (g)	K	t0	n	r2	Φ (cm.y-1)
Male	29,31	180,21	0,17	-2,28	319	0.994	2.176
Female	32,62	232,54	0,18	-1,74	306	0.996	2.298
All (add 0+ age)	28,62	164,55	0,28	-0,89	636	0.966	2.364

Discussion

In this study, the maximum total length recorded for the biggest female was 25 cm. The maximum length in the Algarve coast (Southern Portugal) of Atlantic was reported 39.6 cm (Santos *et al.* 2002), in the water of the Kattegat (Denmark) as 38.3 cm (Bagge 2004), in the Western Mediterranean Coast as 26.5 cm (Morey *et al.* 2003), in the Turkish Northeastern Mediterranean Coast as 20 cm (Sangun *et al.* 2007), in the Aegean Sea as 36.6 cm (Kınacıgil *et al.* 2008and as 32 cm (Moutopolus and Stergiou 2002), in the Black Sea as 35 cm (Ak *et al.* 2009). Because of the fact that the Eastern Black Sea is closed to trawling and the greater weever is not targeted species, the maximum length value in our study were low. According to Bagge (2004), the greater weever is a long-lived species and the oldest males and females reach 13 and 14 years and maximum length 38 cm in the Kattegat (Denmark). These fish reached a length of 23.7 and 24.4 cm at the age of 6 years, comparable to the present study. Nevertheless males were not observed within this age group.

It is defined that the sexual development of the greater weever occured in the period between April and May and the spawning period was between June and August. Dekhnik (1973), Satılmış (2001) and Ak (2009) found the eggs of this species during the ichthyoplankton surveys carried out in the same region in July and August in the Black Sea. It is reported that the reproduction period of the greater weever is between April-September in the Aegean Sea (Ak and Hoşsucu 2001; Çoker 2003), May-August in the Marmara Sea (Yüksek 1993) and July-October in the Mediterranean, (Ak 2004). The water temperature in the Aegean Sea starts increasingearlier than in the Black Sea, which may result in earlier induction of gonad development or faster gonad development. Bagge (2004) reported that both males and females reach spawning condition in June - August, peaking in July and >50% of both sexes were spent (post-spawning condition) in July. In September, no individuals in spawning condition were observed. Kınacıgil *et al.* (2008) reported that the gonad of this species in the Aegean Sea developed at the total length of 15.3 cm in males and 16.2 cm in females.

The weight-length relationship which was calculated for the stock showed that female and all sampled fish exhibited positive allometric growth (Table 5). Even

though the change of b values depends primarily on the shape and fatness of the species, more specific factors may be responsible for the differences in parameters of the length-weight relationship among seasons and years, such as temperature, salinity, food (quantity, quality and size), sex, time of year and stage of maturity (Ricker 1973; Pauly 1984; Sparre 1992). The findings in this study were in good agreement with the findings in previous studies.

Table 5. Comparison of length-weight relationships for the greater weever, *Trachinus draco* in various areas

Region	Sex	N	Lmin-max	a	b	Source
Bay of Biscay, France	All	176	7.0-38.0	0,00927	2.874	Dorel 1986
Eastern Adriatic	All	22	9.2-26.8	0,0213	2.934	Dulčić and Kraljević 1996
Balearic Islands, Spain	All	14	9.6-24.2	0,0074	2.930	Merella *et al.* 1997
South coast, Portugal	All	497	14.0-34.0	0,0164	2.930	Gonçalves *et al.* 1997
Greece	All	85	14.5-32.0	0,00441	3.120	Stergiou and Moutopoulos 2001
Mediterranean Sea, Egypt	All	170	10.0-23.0	0,0114	2.800	Abdallah 2002
Portugal	All	65	22.0-36.8	0,0035	3.173	Mendes *et al.* 2004
Gökceada Island, Turkey	All	32	4.4-35.2	0,0243	2.578	Karakulak *et al.* 2006
Saros Bay, Turkey	All	1025	15.0-37.0	0,00366	3.202	İsmen *et al.* 2007
Mediterranean, Turkey	All	54	9–20	0,0052	3.090	Sangun *et al.* 2007
Mediterranean Sea, Turkey	All	2	20,6	0,0064	2.997	Gökçe *et al.* 2010
Aegean Sea, Turkey	All Female Male	94 52 36	15.3-36.6 - -	0,005 0,004 0,004	3.137 3.138 3.211	Kınacigil *et al.* 2008
Black Sea	All Female Male	336 306 319	5-25.8 10-25.8 5-22.5	0,0069 0,0064 0,0079	3.005 3.033 2.952	This study

The sex ratio of this greater weever population (m:f = 1.04:1) was always in favour of males and this has been mentioned previously by Bagge (2004). However, Kınacigil *et al.* (2008) did not suggest any significant sex ratio differences in samples of greater weever in the Aegean Sea.

Both sexes mature already at the age of 1^{+}.Bagge (2004), however, mentioned that female greater weever attain their sexual maturity at 14 cm standard length in the Kattegat (Denmark). This difference may be due to the fact that the sexual maturity is a function of the size and may be influenced by abundance and seasonal availability of food, temperature, photoperiod and by other environmental factors in different localities (King 1995).

Doğu Karadeniz sahillerinde Trakonya balığının (*Trachinus draco* L., 1758) büyüme ve üreme özellikleri

Özet

Doğu Karadeniz'de dip trolü ile aylık olarak yakalanan 636 adet Trakonya (*Trachinus draco*) balığının cinsiyet oranı, olgunlaşma safhası, ilk üreme boyu, üreme zamanı, ilk üreme yaşı, boy ağırlık ilişkisi, kondisyon faktörü gibi büyüme ve üreme özellikleri çalışılmıştır. Örneklerin %48.11 I dişi, %50.15'I erkek ve %1.72'si cinsiyeti belirlenemeyen bireylerden oluşmuştur. Dişi erkek oranı 1:1.04 (x^2: 0.27, $x^2_{0.05,1}$=3.84; P>0.05)'dır. Gonadosomatik Indeks (GSI) ve yumurta çaplarına göre üreme Temmuz ve Ağustos aylarında meydana gelmektedir. İlk üreme 1 yaşın sonunda ve dişiler için ilk üreme boyu 12.1 cm'dir. Olgunlaşmış yumurtaların ortalama çapı 0.91 ± 0.265 mm'dir. Kondisyon faktörünün aylık değişimi cinsiyetlere göre önemsiz bulunmuştur (P>0.01). Von Bertalanffy büyüme denklemleri dişi ve erkek bireyler için sırasıyla $L\infty$ = 32.62 cm, K = 0.18 y^{-1}, to = −1.74 yıl, ve $W\infty$ = 232.54 g, ve $L\infty$ = 29.31 cm, K = 0.17 y^{-1}, to = −2.28 yıl, ve $W\infty$ = 232.54 g. Büyüme performans indeksi dişi, erkek ve tüm bireyler için sırasıyla (Φ) 2.29, 2.17 ve 2.36 olarak hesaplanmıştır. Maksimum yaş dişiler için 6+ yıl ve erkekler için 5+ yıl olarak bulunmuştur.

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