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Some Biological Characteristics of *Silurus triostegus* Heckel, 1843 from Atatürk Dam Lake (Turkey)

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Abstract: In this study, some biological characteristics such as age and sex composition, growth in length and weight, age-length, age-weight and length-weight relationships, condition factor spawning time, age of sexual maturity, and fecundity of *Silurus triostegus* in Atatürk Dam lake were investigated. The percentage of females was 48.3% and that of males 57.7% out of 623 specimens belonging to age groups I-XI. Isometric growth patterns were proved from the length-weight relationships. It was estimated that the females had higher L_{∞} (202.85 cm) and lower K (0.046871) values than males (L_{∞} 113.98 cm and $K = 0.101972$). Mean condition factors of females and males were calculated to be 0.99055 and 0.95625 respectively. The highest condition factor values were found in April, and the lowest in December. The age of sexual maturity IV in females and age III in males. The diameter of the egg was smallest in July, with a mean of 1.035 mm, while the mean egg diameter in May was greatest, at 1.937 mm. The fecundity ranged from 6.800 to 120.300. Fecundity was significantly correlated with fish length, fish weight and gonad weight.

Key Words: *Silurus triostegus*, growth, condition factor, reproduction, Atatürk Dam Lake.

Atatürk Baraj Gölü'ndeki *Silurus triostegus* Heckel, 1843' un Bazı Biyolojik Özellikleri

Özet: Bu çalışmada Atatürk Baraj Gölü'ndeki *Silurus triostegus*'un yaş ve eşey kompozisyonu, boyca ve ağırlıkça büyüme, yaş-boy, yaş-ağırlık ve boy-ağırlık ilişkileri, kondüsyon faktörü, üreme zamanı, eşeyssel olgunlaşma yaşı ve yumurta verimi gibi bazı biyolojik özellikleri incelenmiştir. I-XI yaş arasında değişen 623 örneğin % 48,3'ü dişi, % 51,7'si erkek bireylerden oluşmuştur. İzometrik büyüme değeri boy-ağırlık ilişkisinden elde edilmiştir. Dişilerde L_{∞} (202.85 cm) değeri yüksek, K (0.046871) değeri düşük, erkeklerde ise L_{∞} (113.98 cm) değeri düşük, K (0.101972) değeri yüksek bulunmuştur. Dişi ve erkeklerde ortalama kondüsyon faktörü sırasıyla 0,99055 ve 0,95625 olarak hesaplanmıştır. En yüksek kondüsyon faktörü değeri Nisan, en düşük ise Aralık ayında bulunmuştur. Eşeyssel olgunlaşma yaşı dişilerde IV, erkeklerde III yaş olarak belirlenmiştir. Ortalama yumurta çapı 1,035 mm ile Temmuz ayında en düşük, 1, 937 mm ile mayıs ayında en yüksek, yumurta sayısı ise 6800 ile 120300 arasında belirlenmiştir. Yumurta verimi ile balığın boyu, ağırlığı ve gonad ağırlığı arasındaki ilişki anlamlı bulunmuştur.

Anahtar Sözcükler: *Silurus triostegus*, büyüme, kondüsyon faktörü, üreme, Atatürk Baraj Gölü.

Introduction

Atatürk Dam Lake, on the Euphrates River, is the largest dam lake in Turkey, and is used for irrigation and electrical energy production. The surface areas and total water deposits of the dam lake are, respectively, about 81700 hectares and 48.700.000.000 m³. There are 28 species and subspecies belonging to 8 families living in the Euphrates River (1,2,3). Some species and subspecies of

these populations have economic value: *Silurus triostegus*, *Acanthobrama marmid*, *Aspius vorax*, *Barbus rajanorum mystaceus*, *Barbus xanthopterus*, *Capoeta capoeta umbla*, *Capoeta trutta*, *Carasobarbus luteus*, *Chalcalburnus mossulensis*, *Chondrostoma regium*, *Leuciscus cephalus orientalis*, *Leuciscus lepidus*, *Tor grypus* and *Liza abu*. In addition, the dam lake has been stocked with mirror carp (*Cyprinus carpio*).

Silurus triostegus has great economic value. Heckel (1843) was the first investigator to describe *S. triostegus* in the Tigris River near Musul. Gruvel (4) and Beckman (5) in Syria, and Mahdi (6) from Iraq gave information about this species. This species was recorded in Turkey from Karakaya and Atatürk Dam Lakes, which was investigated morphologically and meristically by Ünlü and Bozkurt, (4). There are no records of the biological characters of *S. triostegus* in Turkey; however, there are two investigation from Syria (5,8) and from Iraq (9,10) on some haematological characters and the relationship between the diameter of eye lens and fish age.

The aim of this study was to determine some biological characteristics such as age and sex composition, growth in length and weight, age-length, age weight and weight relationships, condition factor, spawning time, age of sexual maturity and fecundity of *S. triostegus* in the dam lake under consideration.

Materials and Methods

The study was carried out on 623 specimens (301 females and 322 males) of *S. triostegus* captured in Atatürk Dam Lake from October 1996 to July 1998 (Figure 1). The sampling was performed by using gill nets of various mesh sizes (18x18, 25x25, 32x32, 40x40 and 55x55mm).

The standard length (SL) of each specimen was measured in mm, and body weight (W) was determined in g. The ages of the specimens were calculated by checking the vertebrae. For this purpose, beginning from the 5th vertebra of the fish column, 3-5 vertebrae were taken, cleaned and counted under binocular stereo microscope (11,12,13). Sex was determined by examination of the gonads either visually in the larger samples or with the aid of a binocular stereo microscope in the smaller.

Length and weight class intervals were statistically determined (14). The number of classes were estimated from the formula $Max_d - Min_d / C_i$, where Max_d = maximum length or weight values, Min_d = minimum length or weight values and C_i = number of intervals 5 to 20 classes. The formulas $L_t = L_{\infty} [1 - e^{-k(t-t_0)}]$ and $W_t = W_s [1 - e^{-k(t-t_0)}]^3$ were used to determine the age-length and age-weight relationships, respectively (15). The length-weight regression equation was carried out by the least squares method on logarithmic transformed data by the equation $W = aL^b$ (16). Analyses of variance (ANOVA) were carried out to determine the statistical significant in the length-weight relationships. The condition factors were determined by using the formula $K = W \times 10^5 / L^3$ (15,17). One-way ANOVA was used to test for differences in condition index between months. Statistical differences between females and males in condition index were determined using Student's t-test (18). The least significant difference was $P < 0.05$. The gonads were removed and weighed to the nearest 0.01g. The monthly gonado-somatic index (GSI) was calculated as follows (19): $GSI = \text{Gonad Weight}(g) / \text{Body Weight}(g) \times 100$.

The number of eggs was estimated by the gravimetric method using ovaries which had been preserved in 4% formalin solution (20) in order to enumerate the total number of eggs in the particular ovary (absolute fecundity). From each ovary twenty ova were selected randomly and measured by means of a micrometer eye-piece, and then the mean egg diameter was computed for all of the samples. The relationship between body weight (W) and gonad weight was calculated by linear regression.

Fecundity (F) - length (FL), fecundity - body weight (W), and fecundity - gonad weight (GW) relationships were calculated on the basis of the formula suggested by Pantulu, (19) and Pitcher and MacDonald (21).

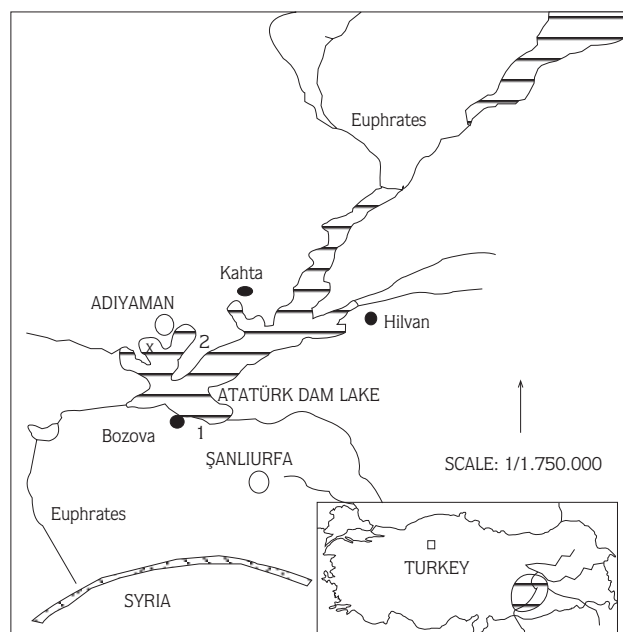


Figure 1. Sampling area

$\text{Log } F = \text{Log } a + b$, $\text{Log } F = \text{Log } a + b \text{ Log } W$, $\text{Log } F = \text{Log } a + b \text{ Log } GW$

Results

Age and sex composition

The age and sex composition of the fish samples is given in Table 1.

Table 1. The age and sex ratio of *S. triostegus* from Atatürk Dam Lake during the study period Nov. 1996 - Jun. 1998

Age Groups	Female		Male		Combined sexes	
	N	%	N	%	N	%
I	5	0.8	3	0.5	8	1.3
II	35	5.6	36	5.8	71	11.4
III	19	3	20	3.2	39	6.3
IV	18	2.9	29	4.7	47	7.5
V	43	6.9	98	15.7	141	22.6
VI	51	8.2	72	11.6	123	19.7
VII	42	6.7	30	4.8	72	11.6
VIII	41	6.6	16	2.6	57	9.1
IX	28	4.5	12	1.9	40	6.4
X	12	1.9	6	1	18	2.9
XI	7	1.1			7	1.1
Total	301	48.3	322	51.7	623	100

Age groups ranged from I to XI. The majority of the specimens were in age groups V and VI (42.3%). As seen in Table I, 48.3% of the samples were female and 51.7%

male. The sex ratio was 0.93 females for 1 male. The sex ratio was not significantly different from 1:1 (χ^2 , $P > 0.05$) in the samples observed.

Length and weight composition

The length distribution was from 142 to 990 mm, and the majority were 500-800 mm (Figure 2). The weight of *S. triostegus* samples ranged between 30.5 and 8500 g, and the majority weighed 100-4000 g (Figure 3). Of the captured fishes, 3.21% weighed less than 100 g, and 6.09% weighed more than 4000 g.

Growth

Growth in length

The lengths in the different age groups of *S. triostegus* with their absolute growth in length are given in Table 2.

Table 2 shows that the mean lengths between females and males were different in all age groups except age group III. The differences in length are statistically significant between females and males of age groups VIII, IX and X ($P < 0.05$), while in the other age groups the differences are not statistically significant ($P > 0.05$).

The age-length equations of *S. triostegus* according to von Bertalanffy were calculated for females, males and combined sexes separately as follows:

$$\text{Females } L_t = 202.85 [1 - e^{-0.046871(t+2.0515)}]$$

$$\text{Males } L_t = 113.98 [1 - e^{-0.101972(t+1.6876)}]$$

$$\text{Combined sexes } L_t = 133.37 [1 - e^{-0.08165(t+1.6926)}]$$

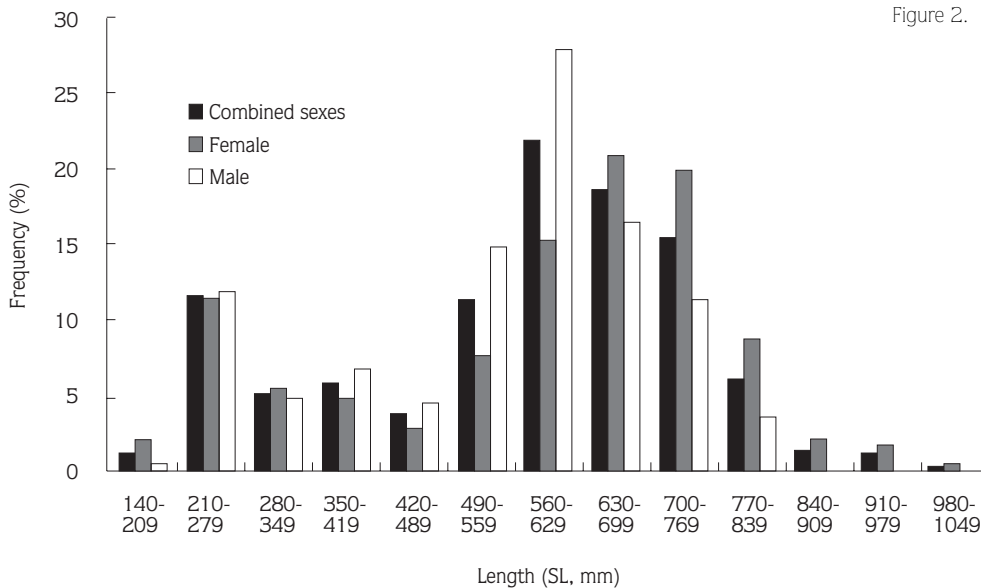


Figure 2. Distribution of length of *S. triostegus* from Atatürk Dam Lake during the study period Nov. 1996 - Jun. 1998.

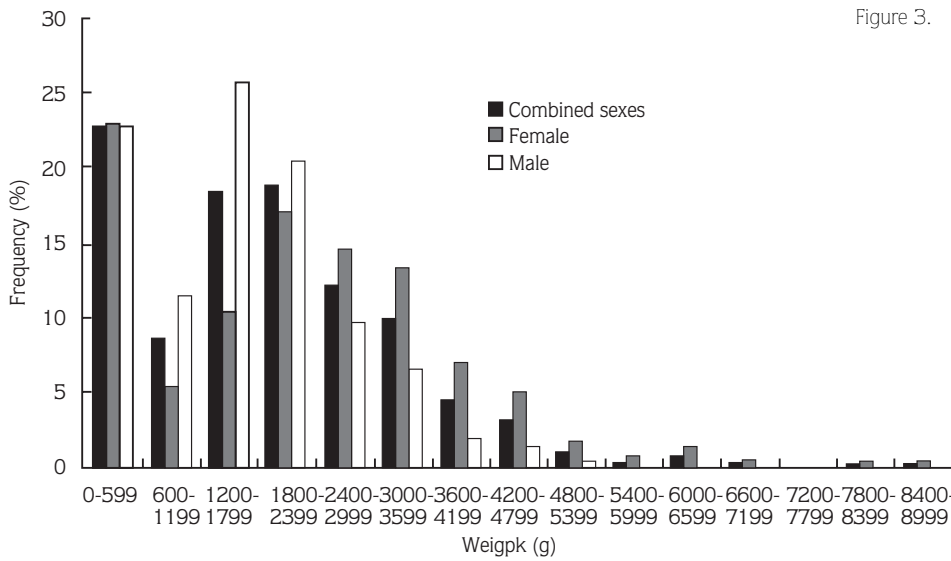


Figure 3. Distribution of weight of *S. triostegus* from Atatürk Dam Lake during the study period Nov. 1996 - Jun. 1998.

Table 2. Lengths (mm) of the different age groups of *S. triostegus* from Atatürk Dam lake. N: number of fishes; SD: standard deviation; minimum and maximum values are given in parentheses.

Age Groups	N	Female SL±SD (Min.-Max.)	N	Male SL±SD (Min.-Max.)	Student's t-test	N	Combined sexes SL±SD (Min.-Max.)
I	5	203.6±35.557 (42-228)	3	206.33±6.35 (199-210)	P>0.05	8	204.63±27.129 (142-228)
II	35	239.6±24.11 (191-285)	36	247.78±20.83 (210-288)	P>0.05	71	243.75±22.72 (191-288)
III	19	318.16±40.78 (258-410)	20	326.5±39.72 (245-395)	P<0.05	39	322.44±39.93 (245-410)
IV	18	420.39±77.37 (312-570)	29	442.86±76.28 (316-582)	P>0.05	47	434.26±76.65 (312-582)
V	43	557±60.24 (382-630)	98	563.5±47.02 (397-670)	P>0.05	141	561.52±51.28 (382-670)
VI	51	637.65±47.43 (490-718)	72	621.17±65.75 (355-750)	P>0.05	123	628±59.2 (355-750)
VII	42	662.74±51.16 (466-735)	30	668.8±56.23 (531-795)	P>0.05	72	665.26±53.03 (466-795)
VIII	41	723±35.76 (595-828)	16	675.94±115.49 (391-769)	P<0.001 *	57	709.79±70.29 (391-828)
IX	28	769.68±36.1 (675-840)	12	742.92±48.5 (630-815)	P<0.05* *	40	761.65±41.47 (630-840)
X	12	803.25±60.13 (720-920)	6	765±40.87 (710-810)	P<0.05* *	18	790.5±56.34 (710-920)
XI	7	888.14±84.38 (772-990)					

It was estimated that the females had higher L_{∞} (202.85 cm) and lower low K (0.046871) values than males (L_{∞} 113.98 cm and K = 0.101972). The age-length relationship curves of *S. triostegus* are shown in Figure 4.

Growth in weight

The weights in the different age groups of *S. triostegus* with their absolute growth in weight are given Table 3.

The mean weights between females and males were different at all age groups.

The differences in weight were statistically significant between females and males of age groups II, VI, VIII and X (P<0.05), but not in the other age groups (P>0.05).

The age-weight equations of *S. triostegus* according to von Bertalanffy were calculated for females, males and combined sexes separately as follows:

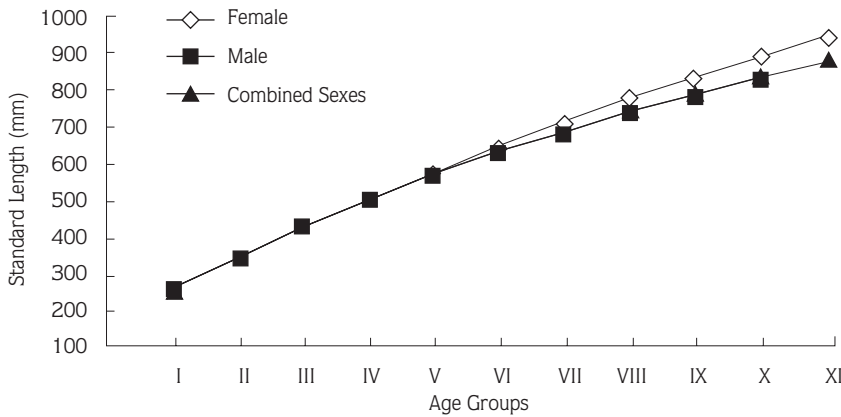


Figure 4. Age-length relationship curves of *S. triostegus* in Atatürk Dam Lake. The curves were obtained from Von Bertalanffy equations.

Table 3. Weights (g) of the different age groups of *S. triostegus* from Atatürk Dam Lake. N: number of fishes; SD: standard deviation; minimum and maximum values are given in parentheses.

Age Groups	N	Female SL±SD (Min.-Max.)	N	Male SL±SD (Min.-Max.)	Student's t-test	N	Combined sexes SL±SD (Min.-Max.)
I	5	77.9±27.7 (30.5-100)	3	69.67±5.51 (64-75)	P>0.05	8	74.81±21.57 (30.5-100)
II	35	124.65±36.90 (45.2-200)	36	142.00±40.68 (80-270)	P<0.05*	71	133.45±39.56 (45.2-270)
III	19	302.68±93.05 (172-550)	20	332.80±112.87 (136-510)	P>0.05	39	318.13±103.46 (136-550)
IV	18	760.44±375.36 (272-1540)	29	810.41±372.40 (285-1652)	P>0.05	47	791.28±370.25 (272-1652)
V	43	1535.30±395.20 (600-2218)	98	1491.03±347.94 (582-2500)	P>0.05	141	1504.53±362.15 (582-2500)
VI	51	2241.08±481.70 (1030-3804)	72	2040.65±565.95 (438-3800)	P<0.05*	123	2123.76±539.75 (438-3804)
VII	42	2573.98±519.57 (905-3530)	30	2475.33±494.13 (1246-3430)	P>0.05	72	2532.88±507.95 (905-3530)
VIII	41	3403.93±503.13 (1780-4540)	16	2652.69±986.92 (433-37809)	P<0.001*	57	3193.05±746.79 (433-4540)
IX	28	3888.50±490.62 (3200-5000)	12	3647.50±423.07 (3150-4300)	P>0.05	40	3816.20±479.21 (3150-5000)
X	12	4990.83±965.22 (3000-6850)	6	4051.67±685.58 (3200-4900)	P<0.05*	18	4677.78±973.96 (3000-6850)
XI	7	6302.86±1384.94 (4700-8500)					

$$\text{Females } W_t = 59953.87 [1 - e^{-0.046871(t+2.0515)}]^{-2.8824}$$

$$\text{Males } W_t = 12624.72 [1 - e^{-0.101972(t+1.6876)}]^{-2.9589}$$

$$\text{Combined sexes } W_t = 19135.35 [1 - e^{-0.08165(t+1.6926)}]^{-2.9299}$$

Age-weight relationship curves of *S. triostegus* are shown in Figure 5.

Length-Weight Relationship

The equations of length-weight relationships were calculated by using the lengths and weights of the 623 *S. triostegus* samples as follows:

$$\text{Females } \log W = -4.9431 + 2.9589 \log L \quad r = 0.9801$$

$$\text{Males } \log W = -4.7550 + 2.8824 \log L \quad r = 0.9678$$

$$\text{Combined sexes } \log W = -4.8743 + 2.9299 \log L \quad r = 0.9739$$

The "b" values of both sexes showed an isometric growth pattern from the length-weight relationships. The curves of the length-weight relationship obtained from these equations are shown in Figure 5.

Condition Factor

The mean condition factor of *S. triostegus* was found to be 0.99055 in female individuals, and 0.95625 in

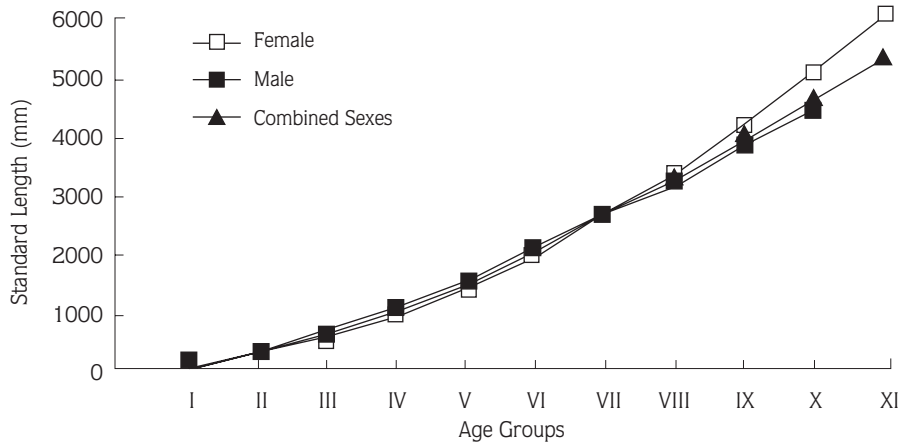


Figure 5. Age-weight relationship curves of *S. triostegus* in Atatürk Dam Lake. The curves were obtained from Von Bertalanffy equations.

males. The mean condition factor of females was higher than that of males except in age group IX (Table 4). The differences in condition factor between sexes in the same age group were statistically significant between the individuals of age groups IV, V, VIII and IX ($P < 0.05$), but not in other age groups. In terms of monthly changes in condition factor, the values were highest in April, and lowest in December (Figure 6).

Reproduction

Age at sexual maturity

The age at sexual maturity of *S. triostegus* samples was determined by observing the gonads beginning from January. As shown in Table 5, the age of sexual maturity was IV in females, and III in males. The mean standard length of mature males was 326 mm and 332.8 mm in

Table 4. Condition factor of the different age groups of *S. triostegus* from Atatürk Dam Lake.

Age Groups	N	Female SL±SD (Min.-Max.)	N	Male SL±SD (Min.-Max.)	Student's t-test	N	Combined sexes SL±SD (Min.-Max.)
I	5	0.91372±0.10243 (0.81079-1.06521)	3	0.79261±0.03185 (0.75586-0.81212)	$P > 0.05$	8	0.85752±0.09694 (0.75586-1.06521)
II	35	0.86678±0.12787 (0.61906-1.09568)	36	0.91631±0.14349 (0.68297-1.57219)	$P > 0.05$	71	0.89089±0.13707 (0.61906-1.57219)
III	19	0.94513±0.21321 (0.55653-1.34728)	20	0.92486±0.07955 (0.82752-1.05736)	$P > 0.05$	39	0.935±0.15906 (0.55653-1.34728)
IV	18	0.96615±0.11173 (0.83156-1.22265)	29	0.8852±0.10338 (0.73211-1.13220)	$P < 0.01$	47	0.9162±0.11478 (0.73211-1.22265)
V	43	0.87386±0.09352 (0.74646-1.07637)	98	0.82566±0.10774 (0.45562-1.07807)	$P < 0.01$	141	0.84036±0.10565 (0.45562-1.07807)
VI	51	0.85423±0.0794 (0.62555-1.02770)	72	0.83136±0.09745 (0.64815-1.05803)	$P > 0.05$	123	0.84085±0.09077 (0.62555-1.05803)
VII	42	0.87351±0.07757 (0.70013-0.99632)	30	0.82917±0.13936 (0.57716-1.29030)	$P > 0.05$	72	0.85503±0.10905 (0.57716-1.29030)
VIII	41	0.89816±0.09236 (0.71075-1.04488)	16	0.80163±0.09604 (0.62289-0.97231)	$P < 0.001$	57	0.89816±0.09236 (0.71075-1.04488)
IX	28	0.85381±0.09072 (0.67667-1.05545)	12	0.89832±0.14353 (0.77479-1.31975)	$P < 0.001$	40	0.83484±0.09503 (0.62289-1.05545)
X	12	0.96116±0.13266 (0.72553-1.17884)	6	0.90115±0.09527 (0.82259-1.07331)	$P > 0.05$	18	0.92402±0.13041 (0.72553-1.31975)
XI	7	0.89907±0.11801 (0.73442-1.09107)					

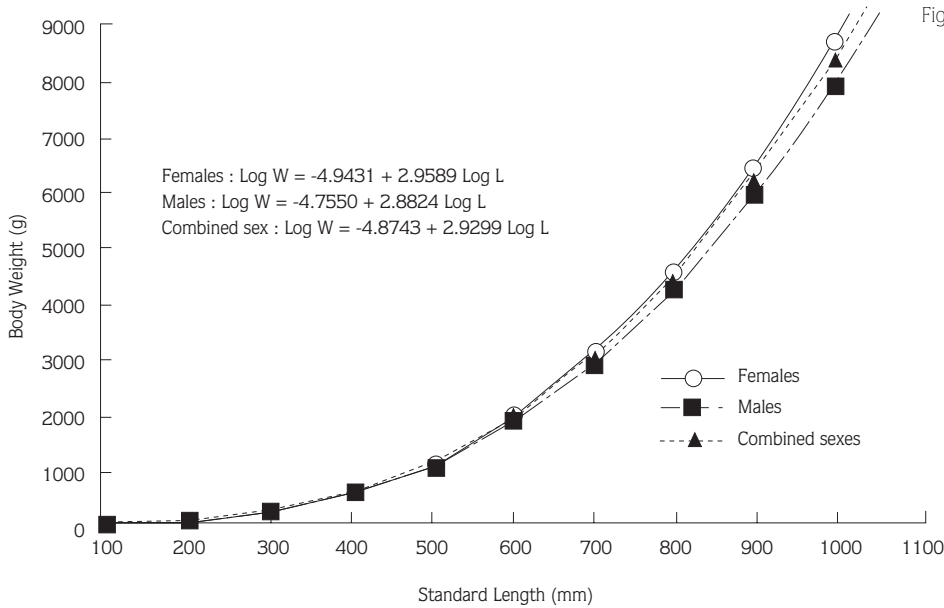


Figure 6. Weight - length relationship of *S. triostegus* from Atatürk Dam Lake

Table 5. The age of maturity of females and males of *S. triostegus* from Atatürk Dam Lake.

		I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Female	Immature	4	8	12	4	-	-	-	-	-	-	-
	%	100	100	100	36.4	0	0	0	0	0	0	0
	Mature	0	0	0	7	30	39	31	34	18	6	2
	%	0	0	0	63.6	100	100	100	100	100	100	100
Male	Immature	5	5	2	-	-	-	-	-	-	-	-
	%	100	100	50	0	0	0	0	0	0	0	0
	Mature	-	-	2	11	72	48	21	7	5	2	6
	%	0	0	50	100	100	100	100	100	100	100	100

females, and the mean weight of males was 760.4 g and 420.4 g in females.

Spawning time

The determination of the spawning time of the *S. triostegus* population in Atatürk Dam Lake was based on the gonado-somatic index values, analysis of development in mean egg diameter, and direct observation of the gonads (Figure 7). As can be seen in Figure 7, there was marked individual variation in the pattern of monthly GSI values.

According to average GSI, the highest values were observed in the samples caught in May. There was a decrease in the mean GSI values of August samples

because almost all individuals spawned. Most individuals spawned in May and June. There was found to be a decrease in the mean GSI values from October until the new spawning season. The mean egg diameter, measured monthly from October 1996 to July 1998 (Figure 7) was greatest in May, and smallest in July, when the ovaries contain only oocytes which will develop the following year. The diameter of the egg was smallest in July, with a mean of 1.035 mm, while the mean egg diameter in May was 1.937 mm.

According to the GSI values, seasonal development in ova size, and direct observation of the gonad, it was determined that the spawning took place in May and continued until late June in the *S. triostegus* population.

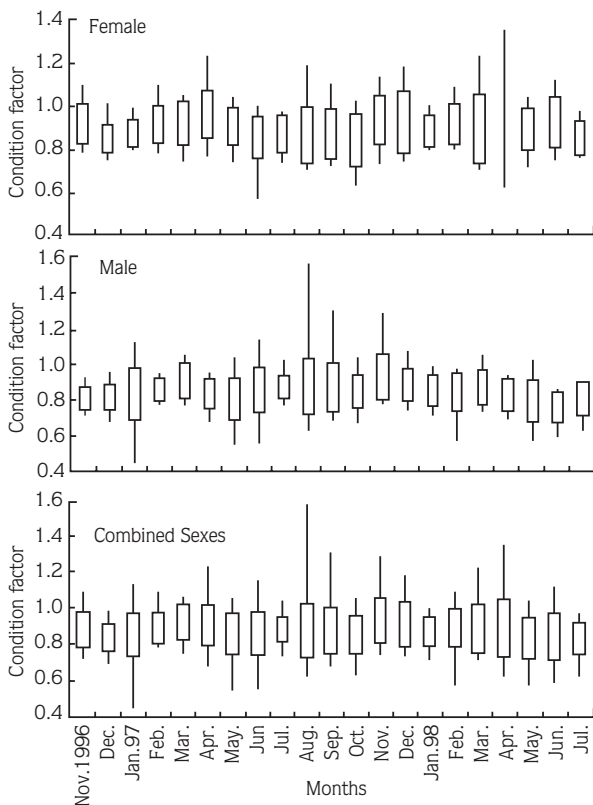


Figure 7. Monthly fluctuation in the condition factors of *S. triostegus* from Atatürk Dam Lake.

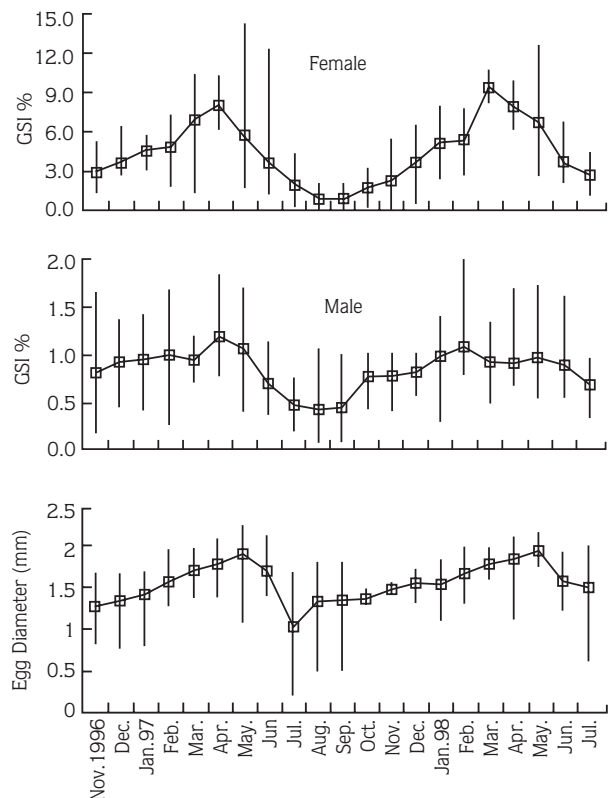


Figure 8. Monthly GSI and egg diameter of *S. triostegus* from Atatürk Dam Lake.

Fecundity

Fecundity was estimated in 301 females captured just prior to spawning. The number of eggs ranged from 6.800 to 120.300. A positive correlation was found between fish length, fish weight and gonad weight versus fecundity (Figure 8), and the relationships are given below:

$$\log F = 0.1823 + 1.5357 \log L \quad r = 0.318$$

$$\log F = 2.5843 + 0.5672 \log W \quad r = 0.351$$

$$\log F = 3.2019 + 0.6674 \log GW \quad r = 0.793$$

Discussion

The 623 specimens of *S. triostegus* captured from Atatürk Dam Lake ranged from age group I to XI. To our knowledge, there is no information about the maximum age of *S. triostegus* for comparison. The majority of the specimens were in age groups V and VI. The sex ratio was 0.93 females for 1 male and not significantly different from the expected ratio, 1:1.

The maximum standard length of samples examined during the study was 990 mm, for a female in age group XI. Beckman (5) has stated that the length of *S. triostegus* is about 1 m in the Euphrates in Syria. A study of the Euphrates in Iraq has shown the length of the fish to be about 50 cm (6). It has been determined that the mean lengths between females and males are different in all age groups except age group III.

The L_{∞} and W_{∞} values of females were higher than those of males, because males reach sexual maturity earlier (22).

The mean weight of *S. triostegus* in age group I was 74.81 g, while in age group XI it was 6302.86 g. The "b" value in the length and weight of males was lower than that of females. The "b" values in fish differ according to species, sex, age, season and feeding (15).

The condition factors of the *S. triostegus* population ranged between 0.455 and 1.572. The condition factor of females was found higher than that of males for all age groups except age group IX. With regard to monthly

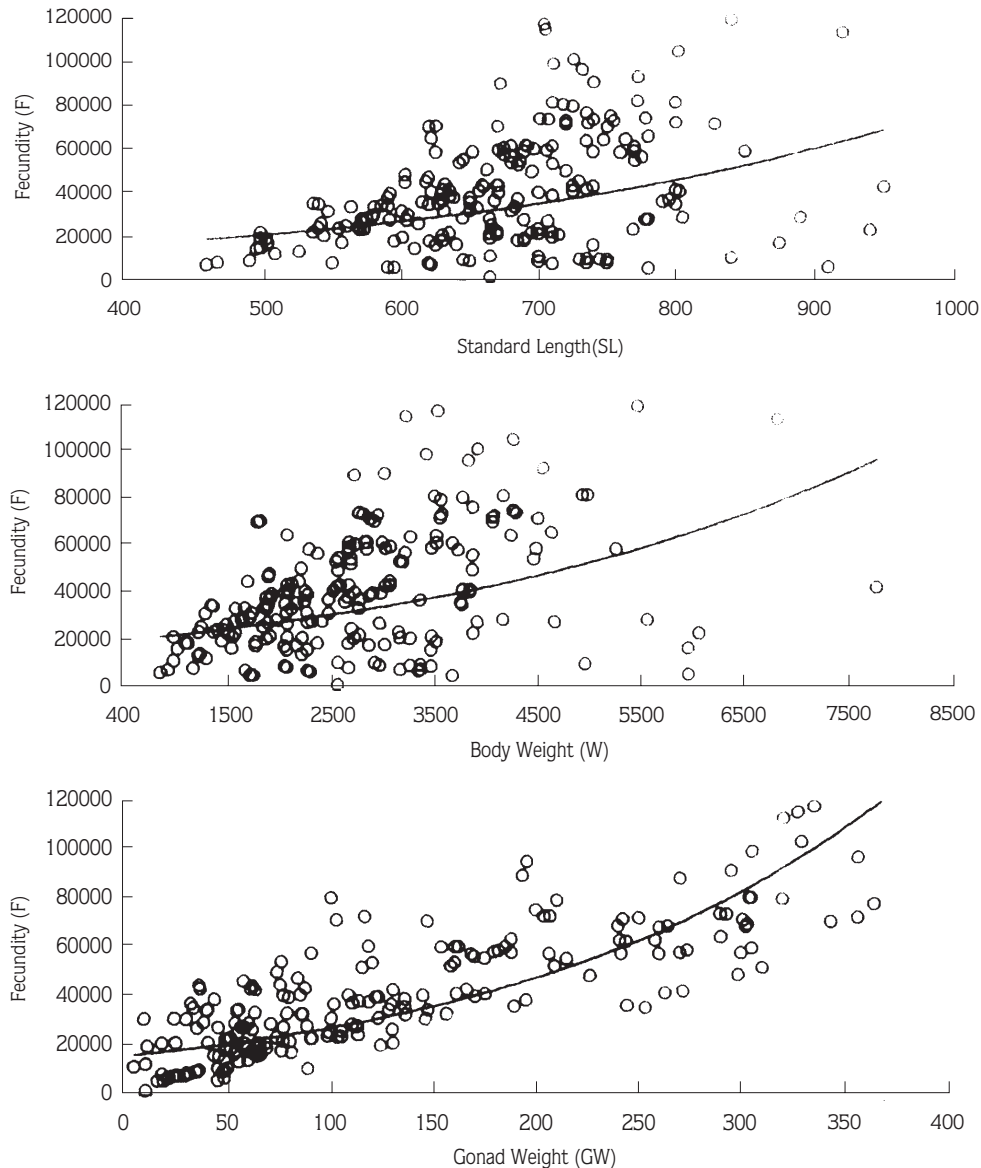


Figure 9. The relationships between fecundity and fish length, fish weight and gonad weight of *S. triostegus* from Atatürk Dam Lake.

changes in condition factor, the values were highest in April, and lowest in December. The condition factor varied according to growth and season (17).

The sexual maturity of males and females was reached in groups III and IV, when they reached a standard length of about 326 mm and 332.8 mm respectively. No investigation has been carried out on the sexual maturity of *S. triostegus*.

The greatest egg diameter, 2.250 mm, was determined in samples caught in May. According to the gonosomatic index, egg diameter and gonad developing phase, spawning started in May, increasing in speed from June to July. Van den Eelart (8) stated that the spawning of *S. triostegus* started in March in the Euphrates in Syria. The differences between the two spawning times, may be due to the higher temperature of Euphrates water in Syria in March than that of Euphrates water in Turkey.

The fecundity of *S. triostegus* varied from 6800 to 120300. It was correlated significantly with fish length,

weight and gonad weight. Fecundity is affected by age, size, species, feeding and environmental conditions (36).

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