ARAŞTIRMA MAKALESİ | **RESEARCH PAPER**

Age, Growth, Length-Weight Relationship and Condition Factor of Beysehir Dace (*Squalius anatolicus* Bogutskaya, 1997) in Oymapınar Dam Lake (Antalya), Turkey

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Abstract: This study aimed to determine some biological parameters such as age, growth condition factor, length-weight relationship, and sex ratio of Beysehir daces (*Squalius anatolicus*) sampled from Oymapınar dam lake between March 2016 and February 2017. A total of 422 Beysehir daces were sampled using 100 m long and 2,5 m depth monofilament gillnets (20, 30, 40, 50 mm mesh size) from the Oymapınar dam lake. The ages of the Beysehir daces ranged between II and VIII. The oldest age for females was VIII and VII for males. The sex composition of the sampled fish showed that 47.39 % of the samples were females and 52.61% were males. It was determined that the fork lengths of the females varied between 20.0 cm and 55.1 cm and the weights varied between 93.37 g and 2307.88 g. Von Bertalanffy growth parameters for all individuals were determined as $L_\infty = 60.57$ cm, $W_\infty = 3260.79$ g, $k = 0.160$ and $t_0 = -0.877$ The b values of the length-weight relationship for females, males and all individuals were 3.202, 3.185 and 3.194, respectively. The average condition factor (C_F) for all individuals was calculated as 1.278 ± 0.006. The findings of this study will aid in the development and implementation of long-term management plans for the Beysehir dams in this lake, as well as serve as the foundation for future research on the biological parameters of fish living in this lake.

Keywords: Age, growth, oymapınar dam lake, *Squalius anatolicus.*

Oymapınar Baraj Gölü'ndeki (Antalya, Türkiye) Beyşehir Tatlısu Kefalinin *(Squalius anatolicus* Bogutskaya, 1997*)* Yaş, Büyüme, Boy-Ağırlık İlişkisi ve Kondisyon Faktörü

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Öz: Bu çalışmada; Oymapınar Baraj Gölü'nden Mart 2016 - Şubat 2017 tarihleri arasında örneklenen Beyşehir tatlısu kefali (*S. anatolicus*)'nin yaş, büyüme, kondisyon faktörü, boy-ağırlık ilişkisi ve cinsiyet oranı gibi bazı biyolojik parametrelerin belirlenmesi amaçlanmıştır. Oymapınar Baraj Gölü'nden örneklenen 422 Beyşehir tatlısu kefalinin yaşları II-VIII arasında dağılım göstermiş, örneklerin % 47,39'nu dişiler, % 52,61'ini erkekler oluşturmuştur. Dişilerin çatal boylarının 20,0 cm ile 55,1 cm arasında, ağırlıklarının ise 93,37 g ile 2307,88 g arasında değiştiği saptanmıştır. Tüm bireyler için Von Bertalanffy büyüme parametreleri $L_\infty = 60,57$ cm, $W_\infty = 3260,79$ g, $k = 0,160$ ve $t_0 = -0,877$ olarak belirlenmiştir. Bu çalışmada balıklar için elde edilen b değerleri, izometrik b değerinden (3,0) istatistiki olarak önemli bulunmuştur. Yakalanan en büyük dişi VIII., erkek VII. yaşındadır. Tüm bireyler için ortalama kondisyon faktörü (KF) $1,278 \pm 0,006$ olarak hesaplanmıştır. Bu çalışmanın sonuçları, göldeki beyşehir tatlısu kefali için sürdürülebilir yönetim planlarının oluşturulması ve uygulanmasına yardımcı olacak ve gölde yaşayan balıkların biyolojik parametreleri ile ilgili gelecekte yapılacak çalışmalara temel oluşturacaktır.

Anahtar kelimeler: Büyüme, oymapınar baraj gölü, *Squalius anatolicus*, yaş.

INTRODUCTION

Squalius anatolicus (Bogutskaya, 1997) is a member of the Leuciscidae family and is commonly known as "Central Anatolian Pike Chub or Beysehir dace", which is endemic to Turkey (Freyhof, 2014; Çiçek, 2018, Bayçelebi et al., 2020). The population of the Beyşehir dace is limited in distribution and is predominantly found in the Beyşehir lake, Saltlake, and Manavgat river basins (Özuluğ & Freyhof, 2011, Çiçek, et al., 2018). *S. anatolicus* is nutritious and appreciated by many people as a source of animal protein.

Studies on fish population are very important in resolving the management of fishing related issues (Polat et al., 1999). It forms the basis for calculations leading to knowledge of the growth, mortality, recruitment, and other fundamental parameters of fish populations. Growth is one of the most critical measurable characteristics of individuals, stocks, and species, and it is fundamental to our understanding of the life histories, demographics, ecosystem dynamics, and sustainability of fisheries (Pardo et al., 2013). Thus, knowledge of biological parameters such as the age, condition factor, growth parameters, length – weight relations and sex ratios of fish are important in understanding, the present and future status of the species due to environmental changes and the appropriate stock management measures to be taken (Wang et al., 2017).

There are some biological studies on *S. anatolicus* in Turkey (Aydogdu et al., 2015, Bayçelebi et al., 2020). But there is no previous study on the biological characteristics of *S. anatolicus* living in the Oymapınar dam lake.

In this study, the age, length and weight distribution, age-length, age-weight and length-weight relationships, sex distribution, growth parameters and condition factor of *S. anatolicus* were investigated to reveal the growth characteristics of the population. The results from this study will help in planning and implementing sustainable management plans for the Beyşehir daces in this lake and will also act as the base for future studies on the biological parameters of fishes living in this lake.

MATERIALS AND METHODS

Study Area: This research was conducted at the Oymapnar Dam Lake in Antalya. Oymapınar Dam is located 76 km from the centre of Antalya province. It is a dam built on the Manavgat river from 1977 to 1984 for electric energy generation (Anonymous, 2021). The lake lies between latitude 36.908628°N and longitude 31.531694°E in the Antalya province of Turkey. Fish samples were collected from seven stations spread across different parts of the dam lake. Fish samples were collected from seven (7) sampling stations. The sampling stations were located at the points where the various sources of water enter the Oymapınar Dam Lake. The sampling point coordinates are presented in Table 1 and the sampling locations are shown in Figure 1.

Table 1. Sampling point coordinates.

Sampling Point	Latitude (°N)	Longitude (°E)
Power plant (1)	36.909	31.532
Kızlıca Stream (2)	36.917	31.534
Tepekli Stream (3)	36.923	31.537
Manavgat River (4)	36.921	31.549
Karpuz Stream (5)	36.908	31.57
Köprü Stream (6)	36.907	31.576
Aygir Stream (7)	36.903	31.576
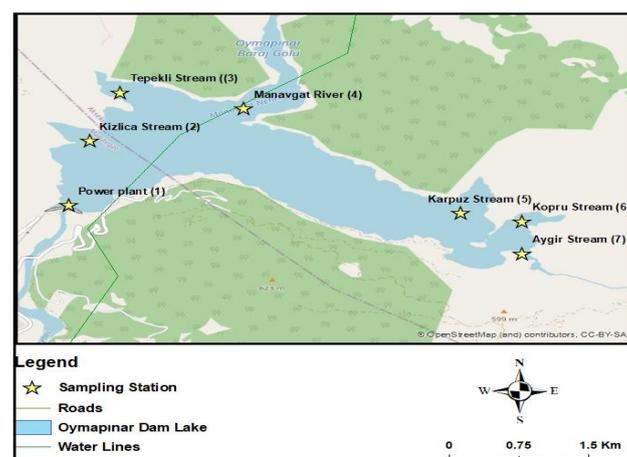
Figure 1. Oymapınar Dam Lake map showing sampling stations.

Fish Sampling and Measurements of Length and Weight: This study was conducted between March 2016 and February 2017. A total of 422 Beysehir daces were sampled using 100 m long and 2.5 m depth monofilament gillnets (20, 30, 40, 50 mm mesh size) from the Oymapınar dam lake. Beysehir dace was collected through random sampling from various points that could represent the lake. The nets were collected the next day after being thrown. The fork lengths (FL) of the samples were measured to the centimetre (0.1 cm) by placing them on the measuring board. Body weights were weighed with an electronic scale with an accuracy of 0.1 g.

Determination of Growth Parameters
Age Determination: The scales of the Beysehir dace samples were used in age determinations according to the method specified in Lagler (1966) and Nikolsky (1963). Scales of fish were collected using dissecting scissors and forceps. The scale samples were cleaned and stored in small envelopes. The age of fish was determined from the scale using the profile projector tool at a 17.5X magnification.

Absolute and Proportional Growth: Growth was determined in terms of length and weight by sex, absolute and proportional growth. Fish samples were grouped

according to their age, average length, and weight (Çetinkaya et al., 1989). Absolute growth is determined as the length and weight attained at any age, and proportional growth is the growth in a certain period, the percentage of length or weight at the beginning of the period (Erkoyuncu, 1995).

The absolute length increase (AFL) and absolute weight increase (AW) were calculated as follows:

$$AFL = (L_t - L_{t-1}) \text{ and } AW = (W_t - W_{t-1})$$

While proportional length increase (PFL) and proportional weight increase (PW) values were calculated using the equations suggested by Chugunova, (1963):

$$PFL = [(L_t - L_{t-1}) / L_t] * 100 \text{ and } PW = [(W_t - W_{t-1}) / W_{t-1}] * 100.$$

In the equations, "L_t" is the average absolute length (cm) at any age, "L_{t-1}" is the average absolute length (cm) in the previous year, "W_t" is the average absolute weight (g) at any age, while "W_{t-1}" is the average absolute weight (g) in the previous year.

Age-Length and Age-Weight Relationships: The age-length and age-weight relationships were determined by the von Bertalanffy Growth (VBBD) model (Beverton and Holt, 1957). For age-length and age-weight growth equations were used; $Lt = L_\infty{}^* (1-e^{-k(t-to)})$ and $Wt = W_\infty{}^* (1-e^{-k(t-to)})^b$, respectively (Lugart et al., 2016). In the equations, "Lt" is the expected length (cm) at a given time (t), "t" is the age, "Wt" (g) is the weight at a given time (t), "L_∞" is the asymptotic length (cm) of the fish, "W_∞" is the asymptotic weight (g) of the fish, "k" is the growth coefficient, "t_0" is the age at which the fish's length is theoretically zero, and "b" is the slope of the weight/length relationship.

Length–Weight Relationship: The length-weight relationship was calculated according to Le Cren's (1951) equation, $W = aL^b$, by using the measured length and weight values of every individual. In this relationship, if the logarithms of both sides are taken to base 10, the relationship becomes a linear (logW= loga + b.logL) equation, where "W" is the fish weight (g), "L" is the fork length (cm), "a and b" are the regression coefficients.

Condition Factor: Lagler's (1966) isometric growth equation was used to calculate the condition factor (C_F), known as the nutritional coefficient of individuals.
$C_F = (W/L^3) * 100$ where C_F = Condition factor, W = weight (g), L represents length (fork length, cm) (Nikolsky 1963; Çetinkaya 1989).

Sex ratio: The sex ratio is defined as being the proportion of male or female individuals compared to the total number of individuals. It also gives an idea regarding the balance of the sexes within the population. The sex ratio is calculated as follows:
SR = F/ (M + F) x 100 where F= number of females, M = number of males.

Statistical Analysis: The data were subjected to statistical analysis using the computer package programs Microsoft Office Excel, and the IBM Statistical Package for Social Science (SPSS) version 21. All statistical analyses were considered significant at P < 0.05 and, all means are given with ± standard errors (SE).

The Chi-square (χ^2) test was used to compare sex ratios in age groups. The paired t-test was used to compare the mean lengths, weights, and condition factors of the female and male fish in age groups, and the paired t-test was used to compare the measured lengths and weights and the lengths and weights obtained by calculation (Kaptan, 1995). The student's t-test was used to test the statistical deviation of the obtained b values from the isometric range of 3.0 for fish.

RESULTS

Population Structure
Age, Length and Sex Distribution: The results of the age and sex distribution show that of the 422 Beysehir daces that were sampled from Oymapınar dam lake, 47.39% (200) were female and 52.61% (222) were male and the ages ranged from age groups II to VIII. The fork lengths of the 422 Beysehir daces sampled from the Oymapınar dam lake were measured and the lengths varied from 20 cm to 55.1 cm. Individuals in the 26 cm and 30 cm length groups were found to have the highest proportion with 47.16% of the population (Table 2). The fork lengths of the female fish varied between 20 cm and 55.1 cm, and the fork lengths of the male fish ranged from 20 cm to 51 cm. The female-to-male sex ratio was 0.90: 1.00. It was observed from the results that the most dominant age group in the population for both sexes was age group II. Sex distributions according to age groups are given in Table 2. The Chi-square (χ^2) test showed the differences between all age groups and, the sex ratio of Beysehir daces in total were not statistically significant (P ≥ 0.05) Table 2.

Distributions of Weight Among Sampled Species: The weight of the 422 Beysehir daces examined varied between 93.37 g and 2307.88 g. Females weighed between 101.95 g and 2307.88 g while the weight of the males varied between 93.37 g and 2010.99 g. As shown in Table 3, the predominant weight class in the sampled population for female and male was 300 g with a rate of 15.88% for females and 21.33% for males. When females and males were mixed, the 300 g weight class had a rate of 37.20%, followed by the 100 g, 500 g and 900 g weight classes at 27.3%, 17.30%, and 5.69% respectively (Table 3).

Growth in Length: The average length, annual absolute length, and proportional length increase values of Beysehir daces in each age group sampled between March 2016 and February 2017 are presented in Table 4. The fastest growth rate in both sex groups occurred in age class

II. The proportional increase in length of male fish was greater than that of females (Table 5). The "t" test analysis showed that there was a significant difference between the average length of male and female fish in age class VI (P ≤ 0.05).

Population growth: The growth of Beysehir dace was mathematically examined using the VBBD model and the growth parameters and growth equation obtained are presented in Table 5. The calculated Length values for both sex and age groups according to VBBD are shown in Table 4. In sex groups, it was observed that the difference between the measured length and the length obtained by calculation was not statistically significant according to the t-test analysis (P ≥ 0.05).

Table 2. Sex distribution of Beysehir daces by age group

Age	Female		Male		χ² test	Female + Male	
	N	N (%)	N	N (%)		N	N (%)
II	71	16.82	85	20.14	0.891 (P>0.05)	156	36.97
III	44	10.43	60	14.22	0.371 (P>0.05)	104	24.64
IV	40	9.48	51	12.09	0.254 (P>0.05)	91	21.56
V	10	2.37	11	2.61	0.329 (P>0.05)	21	4.98
VI	7	1.66	13	3.08	0.130 (P>0.05)	20	4.74
VII	22	5.21	2	0.47	0.293 (P>0.05)	24	5.69
VIII	6	1.42	-	-	-	6	1.42
Total	200	47.39	222	52.61	0.700 (P>0.05)	422	100.00

Table 3. Dstribution of Beysehir daces by sex and weight classes

Weight Classes (g)	Female		Male		Female + Male	
	N	N%	N	N%	N	N%
100	55	13.03	62	14.69	117	27.73
300	67	15.88	90	21.33	157	37.20
500	36	8.53	37	8.77	73	17.30
700	8	1.90	12	2.84	20	4.74
900	13	3.08	11	2.61	24	5.69
1100	6	1.42	5	1.18	11	2.61
1300	7	1.66	3	0.71	10	2.37
1500	3	0.71	1	0.24	4	0.95
1700	1	0.24	0	0.00	1	0.24
1900	1	0.24	0	0.00	1	0.24
2100	2	0.47	1	0.24	3	0.71
2300	1	0.24	0	0.00	1	0.24
Total	200	47.39	222	52.61	422	100.00

Table 5. Growth Parameters and Equations of von Bertalanffy Calculated in terms of Length with Respect to Sexes of Beysehir daces.

Growth Parameters				
Sex	L_∞	K	t_0	Growth Equations
Female	66.18	0.140	-0.984	$L_t = 66.18 [1- e^{-0.140 (t+0.984)}]$
Male	57.15	0.170	-0.837	$L_t = 57.15 [1- e^{-0.170 (t+0.837)}]$
Female + Male	60.57	0.160	-0.877	$L_t = 60.57 [1- e^{-0.160 (t+0.877)}]$

L_∞ = asymptotic length, k = growth coefficient, t_0 = hypothetical age

Table 4. Average fork lengths (FL, cm), Standard Errors (SE), Minimum and Maximum Length Values, Annual Absolute (AFL) and Proportional Length Increase (PFL) Values in Beysehir daces by Sex and Age Groups

Age	Female				Male				T-test	Female + Male			
	N	FL±SE (min − max)	AFL	PFL %	N	FL±SE (min − max)	AFL	PFL %		N	FL±SE (min − max)	SFL	PFL %
II	71	23.67±0.18 (20-26.4)	-	-	85	23.68±0.17 (20-27.3)	-	-	0.395 P > 0.05	156	23.67±0.12 (20-27.3)	-	-
III	44	28.61±0.23 (26.1-31.8)	4.94	20.87	60	28.77±0.20 (26.2-32.4)	5.09	21.49	0.156 P > 0.05	104	28.70±0.15 (26.1-32.4)	5.03	21.25
IV	40	32.84±0.24 (29.8-35.5)	4.23	14.79	51	33.32±0.31 (29.5-37.8)	4.55	15.82	1.000 P > 0.05	91	33.11±0.20 (29.5-37.8)	4.41	15.37
V	10	36.36±0.24 (35.3-37.5)	3.52	10.72	11	38.37±0.27 (36.7-39.5)	5.05	15.16	0.344 P > 0.05	21	37.41±0.28 (35.3-39.5)	4.3	12.99
VI	7	39.05±0.19 (38.2-39.6)	2.69	7.40	13	42.49±0.48 (39.9-44.7)	4.12	10.74	0.037 P < 0.05	20	41.29±0.49 (38.2-44.7)	3.88	10.37
VII	22	42.99±0.50 (40-46.7)	3.94	10.09	2	49.55±1.44 (48.1-51)	7.06	16.62	0.142 P > 0.05	24	45.53±0.59 (40-51)	4.24	10.27
VIII	6	51.68±1.14 (48.5-55.1)	8.69	20.21	-	-	-	-	-	6	51.68±1.14 (48.5-55.1)	6.15	13.51

FL = Fork Length, SE = Standard Error, Min = Minimum, Max = Maximum, AFL = Absolute Fork Length and PFL = Proportional Fork Length

Growth in Weight: The average weight (g), absolute weight (AW) and proportional weight increase (PW) of the Beysehir daces, which were examined according to age and sex groups, are shown in Table 8. The "t" test analysis showed that the difference between the average weights of female and male fish in age class III and IV was statistically significant (P ≤ 0.05).

The calculated von Bertalanffy weight growth parameters and equations are given in Table 6. The b values of 3.200, 3.186 and 3.195 obtained for female, male and female + male respectively was statistically different from the isometric b value range of 3 (P ≤ 0.05). The calculated largest obtainable weight (W_∞) value for females (4294.08 g) is larger than that of males (2692.69 g), but the k value for the female is lower than that of the male. The measured weights (g) of the Beysehir dace and calculated weight using von the Bertalanffy growth equation are shown in Table 7. In the sex groups, it was observed that the differences between the measured weights and the calculated average weights statistically insignificant (P ≥ 0.05).

Table 6. Calculated von Bertalanffy weight growth parameters and equations based on sex in Beysehir dace.

					Growth Parameters	
Sex	W_∞	k	t_0	b	t-test	Growth Equations
Female	4294.08	0.140	-0.984	3.200	0.000, P < 0.05	$W_t = 4294.08 [1- e^{0.140 (t+ 0.984)}]^{3.200}$
Male	2692.69	0.170	-0.837	3.186	0.001, P < 0.05	$W_t = 2816.17 [1- e^{0.170 (t+ 0.837)}]^{3.186}$
Female + Male	3260.79	0.160	-0.877	3.195	0.000, P < 0.05	$W_t = 5303.27 [1- e^{0.160 (t+ 0.877)}]^{3.195}$

W_∞ = asymptotic weight, k = growth coefficient, t_0 = hypothetical age, b = is the slope of the weight/length relationship

Table 7. Measured weights (g) and calculated weights of the Beysehir dace using von Bertalanffy growth equation.

| Age	Female			Male			Female + Male		
	N	Weighed (W)	Calculated (W)	N	Weighed (W)	Calculated (W)	N	Weighed (W)	Calculated (W)
II	71	166.12	137.91	85	167.70	126.25	156	166.93	134.94
III	44	297.11	283.05	60	301.77	258.44	104	299.80	277.25
IV	40	455.49	474.16	51	481.45	426.07	91	470.04	460.29
V	10	648.43	699.99	11	793.17	615.74	21	724.24	670.66
VI	7	843.39	948.63	13	1088.44	815.23	20	1002.67	895.46
VII	22	1130.20	1209.13	2	1725.96	1014.77	24	1179.84	1123.93
VIII	6	1951.63	1472.35	-	-	-	6	1951.63	-

Table 8. Average weight (W, g), standard errors (SE), minimum and maximum weight values of Beysehir dace based on age groups and sexes, annual absolute weight increase (AW) and proportional weight increase (PW) values.

| Age	Female				Male			t-test	Female + Male			
	N	W±SE (min – max)	AW	PW (%)	N	W±SE (min – max)	AW	PW (%)		N	W±SE (min – max)	AW	PW (%)
II	71	166.12±4.64 101.95-248.76	-	-	85	167.70±4.37 93.37-247.45	-	-	0.058 (P > 0.05)	156	166.93±3.17 93.37-248.78	-	-
III	44	297.11±8.81 203.4- 435.74	130.99	78.85	60	301.77±7.36 219.51-465.37	134.07	79.95	0.034 (P < 0.05)	104	299.80±5.58 203.4-465.37	132.87	79.60
IV	40	455.49±12.47 302.3-647.56	158.38	53.31	51	481.45±15.22 284.94-836.17	179.68	59.54	0.001 (P < 0.05)	91	470.04±10.18 284.94-836.17	170.24	56.78
V	10	648.43±30.67 520.54-776.31	192.94	42.36	11	793.17±22.08 659.09-945.77	311.72	64.75	0.126 (P > 0.05)	21	724.24±24.30 520.54-945.77	254.2	54.08
VI	7	843.39±22.42 773.46-956.43	194.96	30.07	13	1088.44±35.20 956.38-1289.15	295.27	37.23	0.070 (P > 0.05)	20	1002.67±35.82 773.46-1289.15	278.43	38.44
VII	22	1130.20±41.00 873.9-1477.17	286.81	34.01	2	1725.96±285.02 1440.94-2010.99	637.52	58.57	0.194 (P > 0.05)	24	1179.84±53.67 873.9-2010.99	177.17	17.67
VIII	6	1951.63±123.70 1535.22-2307.88	821.43	72.68	-	-	-	-	-	6	1951.63±123.70 1535.22-2307.88	821.43	72.68

W = Weight, SE = Standard Error, Min = Minimum, Max = Maximum, AW = Absolute Weight, PW = Proportional Weight

Length – Weight Relationship: The length-weight relationship equation of Beysehir dace sampled from Oymapınar Dam Lake is given as follows; $W= 0.0064 FL^{3.202}$ ($R^2= 0.982$) for females (Figure 2), $W= 0.0068 FL^{3.185}$ ($R^2= 0.981$) (Figure 3) for males and males and $W=0.0066 FL^{3.194}$ ($R^2= 0.982$) for both females and males combined (Figure 4). The b value obtained from the regression equations used to determine the length-weight relationship was close to 3, indicating that there is positive allometric growth in the Beysehir population under study (Ricker 1968). The correlation coefficient in the relationships was found to be as high as 0.98. It was observed that in the first year, the growth in weight was faster than the growth in length in the sampled Beysehir dace population.

Condition Factor (C_F): The calculated average, maximum and minimum condition factors, and standard errors for each age class of the Beysehir dace samples are given in Table 9. In the Beysehir dace population sampled from Oymapınar dam lake, the average C_F values according to age classes and sex groups. The sum of female - male Beysehir daces varied between 1.237 and 1.410 in females. It was observed that the average C_F values generally increases with age. The difference between the average C_F values of Beysehir daces at the age class VII was statistically significant ($P \le 0.05$). The average calculated C_F value of Beysehir dace for female, male and female-male combined was 1.284, 1.273 and 1.278, respectively.
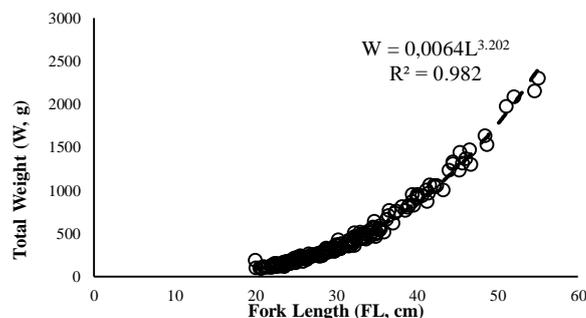
Figure 2. Length – weight relationship in female Beysehir daces.
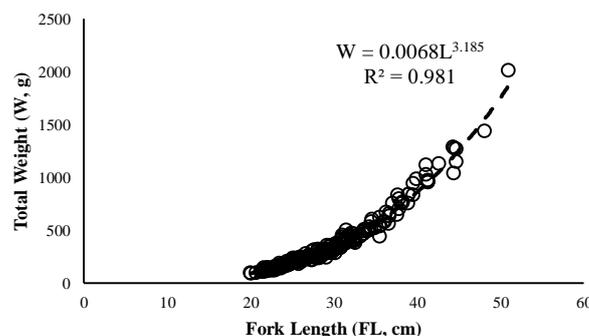
Figure 3. Length – weight relationship in male Beysehir daces.
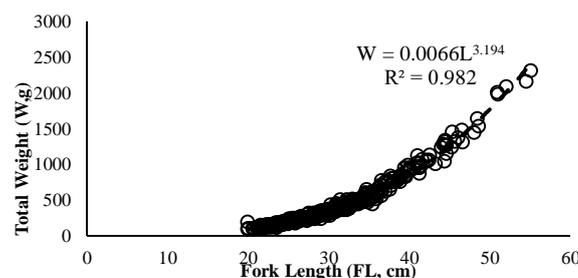
Figure 4. Length – weight relationship in both female and male Beysehir daces combined.

Table 9. The calculated average, minimum and maximum C_F values of Beysehir daces based on age classes and sex.

Age	Female N	Female $C_F \pm SE$ (min - max)	Male N	Male $C_F \pm SE$ (min – max)	t-test	Female + Male N	Female + Male $C_F \pm SE$ (min – max)
II	71	1.237 ± 0.01 (0.902-2.469)	85	1.237 ± 0.01(1.017-1.503)	0.705 P > 0.05	156	1.237 ± 0.01 (0.902-2.469)
III	44	1.254 ± 0.02 (1.095-1.560)	60	1.256 ± 0.01(0.983-1.512)	0.004 P < 0.05	104	1.255 ± 0.01 (0.983-1.560)
IV	40	1.275 ± 0.02 (1.089-1.536)	51	1.284 ± 0.01(0.997-1.616)	0.620 P > 0.05	91	1.280±0.01 (0.997-1.616)
V	10	1.343 ± 0.04(1.115-1.583)	11	1.401 ± 0.04(1.286-1.534)	0.896 P > 0.05	21	1.373±0.03 (1.115-1.583)
VI	7	1.414 ± 0.05 (1.342-1.551)	13	1.417 ± 0.03(1.189-1.613)	0.547 P > 0.05	20	1.416±0.03 (1.189-1.613)
VII	22	1.411 ± 0.02 (1.240-1.550)	2	1.405 ± 0.10(1.294-1.516)	0.000 P < 0.05	24	1.410±0.02(1.240-1.550)
VIII	6	1.405 ± 0.05 (1.325-1.482)	-	-	-	6	1.405±0.05(1.325-1.482)
Total	200	1.284 ± 0.09	222	1.273 ± 0.09	0.228 P > 0.05	422	1.278±0.006

C_F = Condition Factor, SE = Standard Error, Min = Minimum, Max = Maximum

DISCUSSION

The understanding of variation in sex ratio is critical because it is a major factor in population fecundity. Unbalanced sex ratios can drive sexual selection, affect the mating system, and influence population persistence and conservation status, owing to the effect of the sex ratio on effective population size (Clutton-Brock 2007, Wang et al., 2017). The sex ratio of male to female in this study was 0.90:1, which is close to the 1:1 expected for most fish species (Bagenal & Tesch,1978). The ratio of females to males recorded in this study does not agree with the studies of Özcan & Serdar, (2019) that reported 1:0.9, female to male for the chubs living in Lake Yeniçağa, Bolu, Turkey Kılıç & Becer, (2016) also reported a higher female ratio in their studies. However, similar to the report, Benzer (2013) found a higher male to female ratio for chubs living in the Kirmir stream of the Sakarya River in Turkey. Carbonara et al., (2012) stated that differences in sex ratio are due to ethological behaviour responsible for the over-dispersion and segregated distribution of the sexes. Variation in sex ratio could be caused by several factors, such as offspring sex ratio, sex differences in mortality and migratory rates, and differ according to age at maturity (Donald 2007) and even due to environmental factors including temperature and toxicants (Wang et al., 2017).

The age classes of the sampled Beysehir daces varied from II to VIII. Out of the 422 sampled Beysehir daces, 156(36.97%) belong to age class II while age class III and IV followed closely with 104(24.64%) and 91(21.56%). In the studies of Balik et al., (2004), most of the samples were also in age class II for Çildir Lake and Isikli Lake. However, the oldest age class for females in this study was found to be age class VIII and age class VII for males. Kiliç & Becer (2016) reported a similar age range for chubs in Lake Yeniçaa, Bolu, Turkey, but Özcan and Serdar (2019) reported age class VI, the oldest age class for chubs in the Karasu River (East Anatolia, Turkey).

The average fork length of the individuals sampled varied between 23.67 cm and 51.68 cm. Fish lengths were grouped into a class interval of 4 cm, and the predominant length group was found to be 26 cm with 25.12% in the sample. The average length of Beysehir observed in this study is greater than the average length of chubs observed in Keban dam lake by Çolak in 1983 and those observed by Kara and Solak in (2004) from chubs sampled from Sır dam lake. The main reasons for the differences in the average length of Beysehir daces found in the study and studies conducted in other regions might be due to the different environmental conditions of the habitat and the differences in geographical conditions.

In the determination of the age – length relation of the Beysehir dace population in Oymapınar dam lake Beysehir dace, the calculated maximum theoretical length (L_∞) value was found to be 66.18 cm and 57.15 cm for females and males, respectively. When the females and males were combined, the calculated theoretical maximum length was found to be 60.57 cm. The values for the asymptotic length (L_∞) in this study are lower than the values obtained by Çolak (1983) for the same species in Keban dam lake and those obtained by Kara & Solak (2004) in Sır dam lake. While the L_∞ values obtained in this study is close to the L_∞ values reported by Tümgelir et al., (2007) for Beyşehir lake, they tend to be higher than the L_∞ values reported by Şaşı & Balık (2003), Balık et al., (2004), and Kılıç, (2011) for studies carried out for *Squalius anatolicus* in Topçam dam lake, Işıklı lake, and Yeniçağa lake, respectively. The higher L_∞ values obtained in this study may be due to better environmental conditions, water quality or diets available to the lake *Squalius anatolicus* population in the Oymapınar dam lake (Muchlisin et al., 2017).

The average weights recorded in this study for *S. anatolicus* population in Oymapınar dam lake are close to those reported by Tümgelir et al., (2007) for *Squalius anatolicus* population in Beyşehir Lake until age class V but lower than the average weights reported in Sır dam lake by Kara & Solak, (2004). From the reports of Kara & Solak, (2004), the chub population of Sır dam lake has a better growth performance than the Beysehir dace population in the Oymapınar Dam Lake. The average weight values reported on Topçam dam lake (Şaşı & Balık, 2003), Işıklı lake (Balık et al., 2004), Yeniçağal lake (Kılıç, 2011) and Keban dam lake (Aydın et al., 2015), are lower than the average weights recorded in this study. According to Kırankaya & Ekmekçi, (2007), besides climatic and geographical differences, the fact that the dam lakes are in different ontogenic stages, and the natural lakes and artificial lakes undergo different ontogenic developmental

processes might contribute to the different growth rates in the populations of different water bodies.

The asymptotic weight (W_∞) of the Beysehir dace population in Oymapınar dam lake from this study was 4294.08 g, 2692.69 g and 3260.79 g for females, males, and all individuals, respectively. The W_∞ values reported for female chubs in Sır Dam Lake by Kara and Solak, (2004) were higher than the values recorded in this study. The slope coefficient "b" of the regression in the length-weight relationship of Beysehir daces sampled from Oymapınar dam lake was found to be 3.195 for total individuals. The "b" values obtained in this study deviated statistically from the isometric b value range of 3.0 for fish. The "b" values obtained in this study are in agreement with the "b" values obtained by previous studies by other researchers from other lakes. It can be stated that the *S. anatolicus* population has a positive allometric growth between length and weight (Ricker 1968).

The condition factor is a useful index for the monitoring of feeding intensity and growth rates in fish (Oni et al. 1983). It is strongly influenced by both biotic and abiotic conditions and can therefore be used as an index to assess the status of the aquatic ecosystem in which fish live (Anene 2005). The average "C_F" value of female, male, and combined female and male Beysehir daces were calculated as 1.284, 1.273, and 1.278, respectively. The "C_F" values obtained in this study are lower than those reported by Benzer, (2013), and Kılıç & Becer, (2016). From the condition factors obtained in this study, it can be said that Oymapınar dam lake has a good nutrition level for the survival of fish. When the condition factor value is close to 1.00 and 1.00 above, it indicates that the nutritional level of the fish is good (Ünver & Tanyolaç 1999).

CONCLUSION

This study carried out on Oymapınar dam lake contains extremely important information about this species, which has been renamed within the framework of taxonomic regulations. It is seen that the information required to determine the protection and management strategies of Beysehir dace is very limited and no biological studies have been carried out for the Beysehir dace population in Oymapınar dam lake. This study is important in that it is the first research done on the growth characteristics of *S. anatolicus* in Oymapınar dam lake. A long-term study of the growth and reproductive biology of local fish species living in the reservoir environments is important in terms of monitoring the changes in the growth of these species and determining the best stock management system based on the results obtained. Also, it is believed that soon, pollutants will affect the life of aquatic creatures in this lake and contribute to future

studies, as the water inputs into the dam lake are from streams close to settlements and agricultural areas.

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