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Morphometric Characteristics of Freshwater Crayfish (*Pontastacus leptodactylus* Eschscholtz, 1823) Caught in Sapanca Lake, Türkiye

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ABSTRACT

This is the first study providing information on some morphometric parameters for *Pontastacus leptodactylus* from Sapanca Lake (Sakarya), Türkiye. This study was conducted from June - 2016 to October - 2017 and a total of 264 crayfish were caught, being 146 females and 118 males. The results revealed that the average total length for the population was 91.89±15.68 mm (*TL*±SD) (94.75±15.91 mm for females, 88.36±14.72 mm for males), and the average total weight for the total population was 27.27±16.84 g (*TW*±SD) (29.02±17.54 g for females, 25.09±15.74g for males). The sex ratio was computed as 1.24:1 (female to male). A strong positive statistical relationship was determined between the total length and total weight of females, males, and both sexes (r^2: 0.90 – 0.95). This statistically strong relationship was also valid between other body parts, such as carapace length, width, and weight. The regression analyses for total length-total weight relationships also revealed that the whole population exhibited positive allometric growth (b=3.186) regardless of sex, and the condition factor for all sex groups was computed to be over 3 (*K*=3.23±0.60 SE).

Keywords: *Pontastacus leptodactylus*, morphometric characteristics, Sapanca Lake

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Sapanca Gölü'nde (Türkiye) Yakalanan Tatlısu Kerevitlerinin (*Pontastacus leptodactylus* Eschscholtz, 1823) Morfometrik Özellikleri

Öz: Bu çalışma, Sapanca Gölü (Sakarya, Türkiye) tatlısu kerevitlerinin *(Pontastacus leptodactylus*) bazı morfometrik parametreleri hakkında bilgi sağlayan ilk çalışmadır. Çalışma Haziran 2016-Ekim 2017 tarihleri arasında gerçekleştirilmiş, 146 dişi ve 118 erkek olmak üzere toplam 264 kerevit yakalanmıştır. Sonuçlar, popülasyonun ortalama toplam uzunluğunun (*TL*±SD) 91,89±15,68 mm (dişiler için 94,75±15,91 mm, erkekler için 88,36±14,72 mm) ve ortalama ağırlığının (*TW*±SD) 27,27±16,84 g (dişiler için 29,02±17,54 g ve erkekler için 25,09±15,74 g) olduğunu ortaya koymuştur. Cinsiyet oranı 1.24:1 (dişi:erkek) olarak bulunmuştur. Dişi, erkek kerevitler ve her iki cinsiyetin total boy ve total ağırlığı arasında istatistiksel olarak güçlü bir pozitif ilişki belirlenmiştir (r^2: 0.90 – 0.95, P<0.05). Bu istatistiksel güçlü ilişkinin, diğer morfometrik parametreler, özellikle kabuk uzunluğu, genişliği ve ağırlığı arasında da geçerli olduğu tespit edilmiştir. Toplam boy-toplam ağırlık ilişkileri için yapılan regresyon analizleri de cinsiyetten bağımsız olarak tüm popülasyonun pozitif allometrik büyüme gösterdiğini (b=3.186) ve tüm cinsiyet grupları için kondisyon faktörünün 3'ün üzerinde (*K*=3.23±0.60 SE) olduğunu ortaya koymuştur

Anahtar kelimeler: *Pontastacus leptodactylus*, morfometrik özellikler, Sapanca Gölü

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Introduction

Crayfish are distributed in tropical and subtropical latitudes and are habituated in rivers, streams and lakes, dam lakes, marshes areas, freshwater caves and springs, and terrestrial burrows (Richman et al. 2015). More than 640 freshwater crayfish species are distributed around the globe in various water resources, except Indian and Antarctica

continental (Crandall and Buhay 2008; Reynolds 2011). Although the number of species is high, the number of crayfish species of commercial importance does not exceed seven species (FAO 2022). *Pontastacus leptodactylus* is the indigenous freshwater crayfish species that are widely spread in Türkiye's inland waters and it is also a commercially important inland water species nowadays. Although Türkiye's crayfish fishing started in 1961 from Sapanca Lake at first (Bolat 2001), official catch data was not recorded until 1977. It was the most important inland water product, especially between 1977 and 1985. However, there was a dramatic decrease in its population due to the crayfish plague, which was recorded in Türkiye in 1984 (Furst 1988; Baran and Soylu 1989; Rahe and Soylu 1989; Aydın et al. 2015). After 1985, despite increased crayfish stocks, the amount of harvested crayfish has not reached the levels of previous years in Türkiye. In Türkiye, the average amount of year of crayfish harvested between 2008 and 2017 was 650 tons (TÜİK 2022). According to the data of the Turkish Statistical Institute, 60 tons of crayfish were caught in 1977, 50 tons in 1982, 56 tons in 1985, 7 tons in 1986, 6.5 tons in 1987 and 17 tons in 1988 in Sakarya province (TÜİK 1977,1982,1985,1986,1987,1988). From these data for the years 1977 to 1988, commercial crayfish fishing in Sakarya province was carried out only in Sapanca Lake, and it was assumed that the amount of crayfish caught belonged only to this lake. The adverse effects of the crayfish plague have been severe and long-lasting in some water sources, while in some water sources, it has been lighter and shorter in Türkiye. Sapanca Lake has been one of the water sources where crayfish disease has a heavy impact in Türkiye. Sapanca Lake was one of the important water sources in Türkiye for crayfish harvesting until 1980, but after 1984 the crayfish stock in the lake collapsed considerably due to crayfish plague (*Aphanomyces astaci*).

For the protection of crayfish populations, the size and the characteristics of the population must be known. There is no study about the crayfish population inhabiting Sapanca Lake. Therefore, this study was the first report on the morphometric structure, growth characteristics, and the status of crayfish (*P. leptodactylus* Eschscholtz, 1823) population of the Sapanca Lake.

Materials and Methods

Study Area

Sapanca Lake is located in the eastern region of Marmara, Türkiye. Half of the lake is located in the province of Sakarya and the other half is located within the boundaries of Kocaeli. It's surface area varies between 46 and 60 km^2 depending on the amount of water entering the basin of the lake. The length of the lake is 16 km and the widest part is 6 km and the north and south are surrounded by mountains. The average depth of the lake is 29 m and its deepest point is 52 - 54 m (Uzunay and Soylu 2006).

Field Sampling and Data Collection

The crayfish samples were collected monthly from Sapanca Lake between June 2016 and October 2017. In order to catch crayfish samples, a total of 80 nets of single-entrance fyke nets (each with a 34 mm mesh size) were used. Before starting the research, 4 different areas of the lake (front of the Eşme Beach, Seka Camp area, Arifiye Gölbaşı and Kurtköy Creek) 3 times were used fyke nets in May 2016 and June 2016. As a result of these preliminary searches, the front of Eşme Beach has been selected as the sampling area because the highest number of crayfish is harvested in the coastal region. Fyke nets were located in water along 50 m of shore and harvested 2 days later. Fishing trials have been performed 14 times monthly between June 2016 and October 2017. Caught live crayfish were put into styrofoam boxes and carried the same day to Istanbul University Sapanca Inland Water Research and Application Unit. All crayfish were counted and separated by sex. The sex of the crayfish was determined by morphologically, checking the presets of the copulatory swimmerets. After this, each crayfish was weighed with a digital scale (0.001 g sensitivity). Total length (TL), carapace length (CL) (from the tip of the rostrum to the posterior median edge of the cephalothorax), carapace width (CW), abdomen length (AL), rostrum length (RL), head length (HL), and areola length (ARL) were measured with a digital calliper (to the nearest 0.01 mm). For measuring the body parts, the methods of Rhodes and Holdich (1984) were used. During the study, in the sampling area, the water surface temperature, oxygen and pH values were measured with a multiparameter (YSI, USA).

Data Analysis

Freshwater crayfish, as in fish, has a nonlinear relationship between length and weight that can be expressed as $W = aL^b$ (Froese 2006), where W = weight of the samples in g, L = length of the samples in cm, *a* and *b* are constant parameters of the regression equation; b is the slope value of the line in the regression equation giving information about the body shape of fish, and a is the intersection point of the regression equation giving information on the food capacity of the environment. To determine whether the weight increase of the freshwater crayfish population analyzed was isometric or

allometric, the length and weight values underwent regression analysis, and coefficients a and b were calculated by the least-squares method (Ricker 1975; Pauly 1984). The condition factor (K) was calculated from the equation, $K = 100W/TL^3$, where W is observed total body weight (g) and TL (cm) is body total length (Ricker 1975).

The Catch per unit effort (CPUE) was calculated as follows for each harvest: $CPUE= \Sigma N_c / \Sigma N_{fn}$ where ΣN_c is the sum of a number of crayfish in harvest and ΣN_{fn} is the sum of fyke-net set during the study (Bolat et al. 2011; GFCM 2018).

Sex ratios were calculated for caught *P. leptodactylus* each month. The chi-square test (χ^2) was used to test for differences in the male-female ratio, with a significance level of p=0.05. The t-test was used to determine if there were potential and meaningful differences between the acquired *b* values and cubic growth. For this process, the standard error of the *b* values was first calculated, and its relationship with the value in the t distribution table of 95% confidence interval was analyzed (Sokal and Rohlf 1987). The calculated r (correlation value) shows the relationship between the independent variable (e.g. length) and the dependent variable (e.g. weight) (Romaire et al. 1977; Harlıoğlu 1999). Differences in length class distributions of crayfish among males and females were assessed by the Kolmogorov-Smirnov two-sample test. In order to test any statistically significant differences for slopes and elevation between both sexes analysis of covariance (ANCOVA) was performed at the significance level of P<0.05.

Based on sexes for harvested crayfish, the CPUE values were calculated both for below (<100 mm TL) and above (≥100 mm TL) minimum landing size (MLS) according to months. We compared mean catch per unit effort (CPUE; number of crayfish/trap/hour) of legal and sub-legal *P. leptodactylus* among months using one-way analysis of variance (ANOVA; a p 0.05) or with the Kruskal–Wallis H-test when the ANOVA assumption could not be satisfied. All the analyses were performed using the statistical programs Microsoft Excel 2007 and SSPS 16 for Windows. In statistically evaluating the data acquired from the research, the significance tests were done based on the p=0.05 confidence limits (Ricker 1973).

Results

The results estimated in the current study aimed to demonstrate the length-weight relationships, condition factor and CPUE for 34 mm mesh size on commercial fyke net fishery for *P. leptodactylus* first time in the Sapanca Lake. A total of 264 crayfish were caught of 146 females (55.30%) and 118 males (44.70%) from Sapanca Lake during the study. The crayfish total length (*TL*) caught ranged in size from 63.70 to 133.43 mm and in total weight (*TW*) from 8.00 to 87.10 g. Total body length ranged from 63.70 -133.43 mm for males and from 68.81 - 132.13 mm for females, with a total weight between 8.00-87.10 g for males and 9.80 to 73.60 g for females. The average total length for the population was estimated as 91.89±15.68 mm (*TL*±SD) (94.75±15.91 mm (*TL*±SD) for females, 88.36±14.72 mm (*TL*±SD) for males), and the average total weight for the population was estimated as 27.27±16.84 g (*TW*±SD) (29.02±17.54 g (*TW*±SD) for females, 25.09±15.74 g (*TW*±SD) for males) (Table 1). The dominant total length classes were 75 - 90 mm for both sexes (Figure 1). While female individuals were bigger than male individuals in terms of average total length and total weight, the mean total length and the mean total weight were not significantly different in the sexes (t=3.402, p=0.06; t:1.894, p=0.059, respectively).

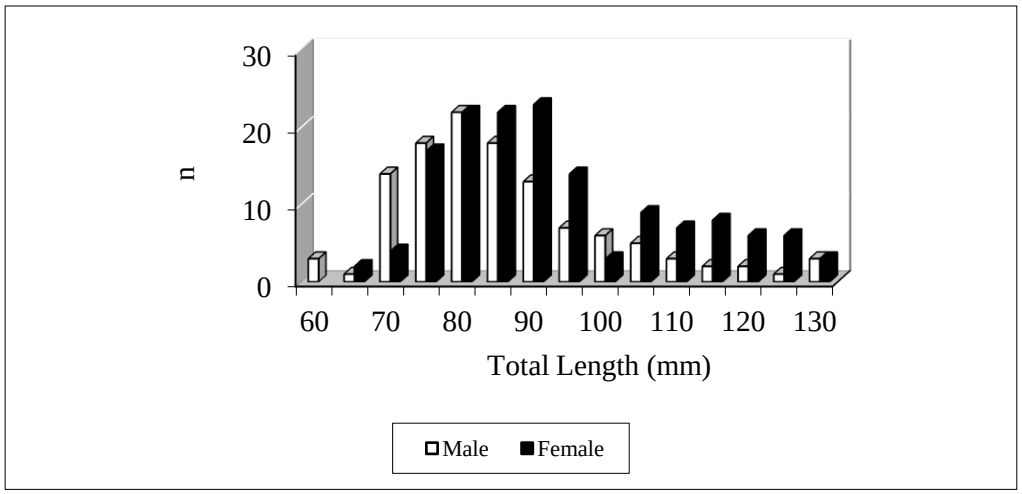

Figure 1. Length frequency distribution by sex for *P. leptodactylus* in the Sapanca Lake

Table 1. Descriptive statistics of various morphometric measurements of *P. leptodactylus*. (*TL*: total length (mm); *CL*: carapace length (mm); *CW*: carapace width (mm); *AL*: abdomen length (mm); *RL*: rostrum length (mm); *ARL*: areola length (mm); *HL*: head length (mm); *AW*: abdomen width (mm); *TW*: total weight (g))

	Sex	Min-Max	Mean±Sx	t-student test
TL	F	68.81-132.13	94.75±15.91	
	M	63.70-133.43	88.36±14.72	t:0.000
	M + F	63.70-133.43	91.89±15.68	P>0.05
CL	F	31.96-67.85	47.20±8.36	
	M	30.76-69.19	44.83±7.86	t:0.018
	M + F	30.76-69.16	46.14±8.20	P>0.05
CW	F	15.23-33.70	22.82±4.40	
	M	14.50-36.83	22.16±4.69	t:0.185
	M + F	14.50-36.83	22.53±4.54	P>0.05
AL	F	28.96-69.42	48.44±8.59	
	M	29.08-65.85	43.63±7.26	t:0.000
	Total	28.96-69.42	46.31±8.36	P>0.05
RL	F	8.75-21.50	14.07±2.54	
	M	9.64-19.14	13.38±2.12	t:0.011
	M + F	8.75-21.50	13.76±2.38	P>0.05
ARL	F	10.26-21.64	14.83±2.71	
	M	10.18-22.24	14.53±2.51	t:0.251
	M + F	10.18-22.24	14.70±2.62	P>0.05
HL	F	18.84-47.42	31.90±5.72	
	M	21.62-47.72	30.57±5.29	t:0.046
	M + F	18.84-47.72	31.31±5.56	P>0.05
TW	F	9.80-73.60	29.02±17.54	
	M	8.00-87.10	25.09±15.74	t:0.056
	M + F	8.00-87.10	27.27±16.84	P>0.05

F: female; M: male

Although size-frequency distributions show a size predominance over females, in length-frequency distributions, females and males show almost the same size, with mean female size exceeding that of males, and the *K-S* test revealed the existence of significant differences in size distributions of total length and abdomen length (Kolmogorov-Smirnov two-sample test: nm=118, nf=146, D=0.185; D=0.253; D=0.185; P<0.05, respectively), and there is no difference between male and female individuals in other measured length distributions (P>0.05).

Even though the sex ratio for the whole population was 1.24:1 in favor of the females, the $\chi 2$ analysis showed significant differences from the ratio of 1:1 ($\chi 2$ = 30.254, P = 0.0043). According to months, sex rates have changed and the number of caught crayfish was high in winter but decreased in summer. Male individuals were caught at most (30 individuals) in February and at least (1 individual) in November. Female individuals were caught at most in March 2016 (26 individuals) and at least (1 individual) in August and November 2016 (Table 2).

Table 2. Sex ratios of *P. leptodactylus* caught by months in the Sapanca Lake

	Female	Male	Sex ratio (F:M)	Chi-square	p-value
June 2016	16	2	8:1	9.3596*	0.0022
July 2016	4	3	1.33:1	0.1335	0.7148
August 2016	1	2	0.5:1	0.3237	0.5694
September 2016	5	4	1.25:1	0.1019	0.7495
November 2016	1	1	1:1	0.0000	1.000
January 2017	9	15	0.6:1	1.2125	0.2708
February 2017	12	30	0.4:1	5.5213*	0.0188
March 2017	26	11	2.36:1	4.4926*	0.0340
April 2017	25	14	1.79:1	2.2461	0.1339

May 20117	19	19	1:1	0.0000	1.000

Table 2. Continue

June 2017	7	5	1.4:1	0.2977	0.5853
July 2017	14	7	2:1	1.9349	0.1642
August 2017	3	2	1.5:1	0.1905	0.6625
October 2017	4	3	1.33:1	0.1335	0.7148
Total			**1.24:1**	**0.8207**	**0.3649**
< 100 mm	**104**	**96**	**1.08:1**	**0.1067**	**0.7439**
≥ 100 mm	**42**	**22**	**1.91:1**	**3.8685***	**0.0492**

∗Significant

The highest level of female: male ratio was determined at 8:1 in June 2016. The lowest level of female:male ratio was observed at 0.4:1 in February 2017. There were statistically significant differences in the number of the catch between sexes individuals in the months of sampling in June 2016 and February 2017, respectively (χ^2 = 8.214; X^2 = 12.141; P<0.05, respectively). There was no significant difference between the sexes in other months of sampling (P>0.05). In the study period, water temperature varied between 7.7 and 27.1 °C.

The descriptive statistics and estimated parameters of the length-weight relationship parameters are given in Figure 2, Figure 3, Figure 4, Table 3 and Table 4.

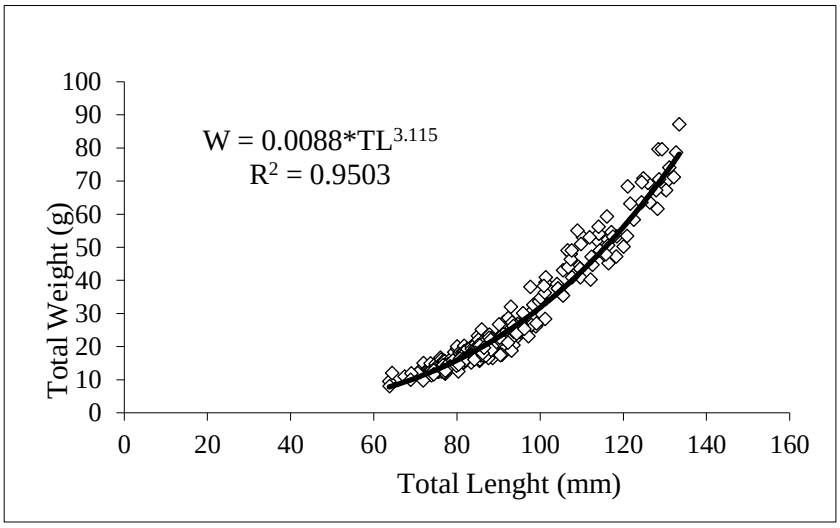

Figure 2. Total length-total weight relationships of crayfish population in Sapanca Lake

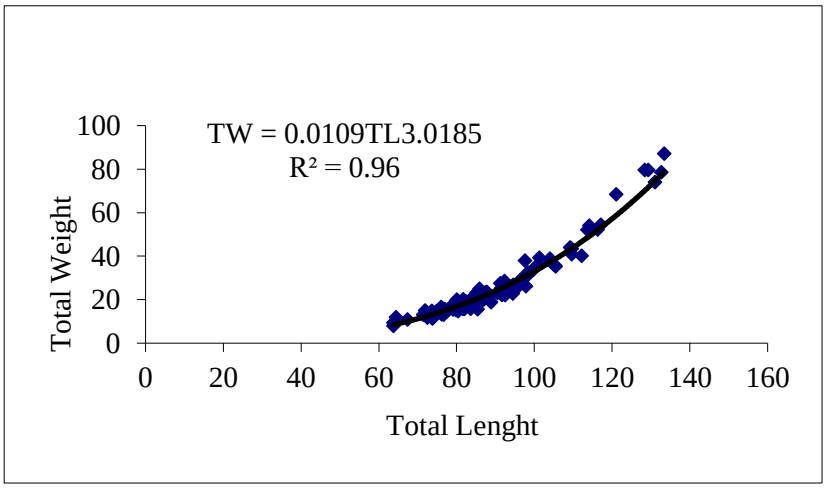

Figure 3. Total length-total weight relationships of male crayfish in Sapanca Lake

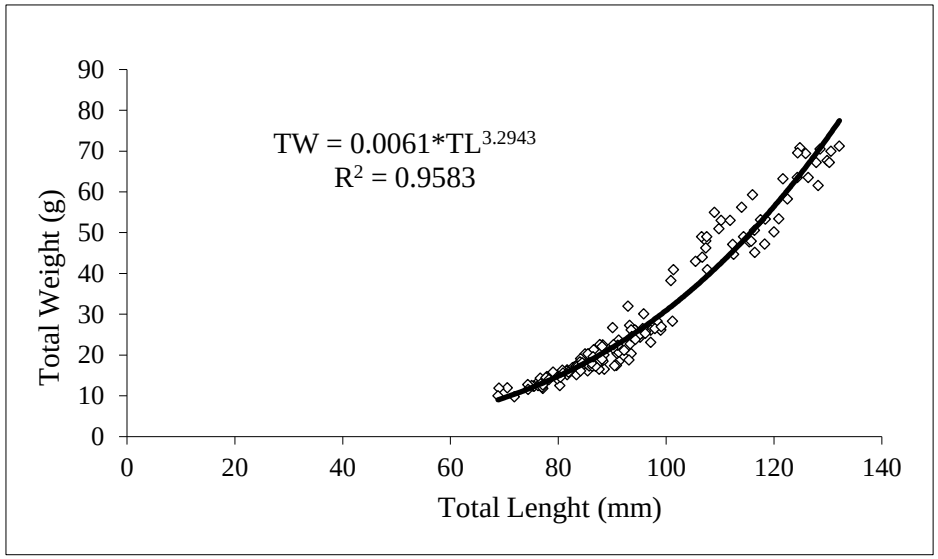

Figure 4. Total length-total weight relationships of female crayfish in Sapanca Lake

Table 3. Descriptive statistics and length-weight relationship parameters for *P. leptodactylus* in the Sapanca Lake (*TW*, total weight (g); *TL*, total length (mm); *CL*, carapace length (mm); *SE*(b)., standard error of the slope b; *CL*(b), 95% confidence limits of slope b; r^2, is the coefficient of determination; *A*-, negative allometry; *A*+, positive allometry; *I*, isometry growth)

Relation	Sex	W = a Lb	SE(b)	CL(b)	r^2	Type of growth	Ancova	F (DF)	P
TL - TW	M	$TW = 0.0109\ TL^{3.018}$	0.057	2.961-3.076	0.960	I			
	F	$TW=0.006108\ TL^{3,294}$	0.057	3.237-3.352	0.958	A+	Slope	1.573	0.211
	M + F	$TW = 0.00002\ TL^{3.115}$	0.044	3.071-3.159	0.950	A+	Intercept	21.44	0.000
CL - TW	M	$TW = 0.0002\ CL^{3.021}$	0.069	2.952-3.090	0.943	I			
	F	$TW = 0.0001\ CL^{3.134}$	0.066	3.069-3.200	0.940	A+	Slope	4.391	0.037
	M + F	$TW = 0.0002\ CL^{3.062}$	0.048	3.014-3.111	0.939	I	Intercept	640.7	0.000

Table 4. Morphometric relationships between length and lengths for *P. leptodactylus* caught in the Sapanca Lake (*TL*, total length (mm); *CL*, carapace length (mm); *CW*, carapace width (mm); *AL*, abdomen length; *RL*, rostrums length; *HL*, head length and *ARL*, areola length; *SE*(*b*)., standard error of the slope b; *CL(b)*, 95% confidence limits of slope b; r^2, is the coefficient of determination; *I*, isometry growth)

	Sex	**Log *W* = Log a +b Log *L***	**SE(b)**	**CL(b)**	**r^2**	**Type of growth**	**Ancova**	**F (DF)**	**P**
TL - CL	M	LogCL= - 0.4868 + 0.5123 LogTL	0.010	0.503-0.522	0.960	I			
	F	LogCL= - 0.4867 + 0.5012 LogTL	0.009	0.492-0.510	0.956	I	Slope	0.509	0.476
	M + F	LogCL = 0.1135 + 0.4994 LogTL	0.007	0.493-0.506	0.954	I	Intercept	19.569	0.000
TL - CW	M	LogCW = -3.837 + 0.291 LogTL	0.006	0.285-0.297	0.949	I			
	F	LogCW = -2.8718 +0.2725 LogTL	0.006	0.267-0.278	0.942	I	Slope	0.390	0.533
	M + F	LogCW =- 2.8708+ 0.2758 LogTL	0.004	0.271-0.280	0.938	I	Intercept	258.4	0.000
TL - AL	M	LogAL = -1.6607+ 0.5149 LogTL	0.010	0.505-0.525	0.958	I			
	F	LogAL = -5.301+ 0.5767 LogTL	0.011	0.565-0.588	0.948	I	Slope	0.700	0.193
	M + F	LogAL = - 4.906+ 0.5635 LogTL	0.008	0.555-0.572	0.942	I	Intercept	41.208	0.000
TL - ARL	M	LogARL =- 0.1630+ 0.167 LogTL	0.004	0.163-0.171	0.926	I			
	F	LogARL = -0.8222+0.1673LogTL	0.004	0.164-0.171	0.937	I	Slope	0.002	0.961
	M + F	LogARL = - 0.1601-0.1632LogTL	0.003	0.159-0.166	0.918	I	Intercept	53.719	0.000
TL - HL	M	LogHL = -0.3977 + 0.3525LogTL	0.007	0.345-0.359	0.951	I			
	F	LogHL = 1.065 + 0.3305 LogTL	0006	0.324-0.336	0.955	I	Slope	5. 424	0.021
	M + F	LogHL = 0.736 + 0.336 LogTL	0005	0.331-0.341	0.951	I	Intercept	13.520	0.000
TL - RL	M	LogRL = 0.3905 + 0.1528 LogTL	0.005	0.148-0.158	0.888	I			
	F	LogRL = 0.5708 + 0.1438LogTL	0.004	0.139-0.149	0.852	I	Slope	1.534	0.217
	M + F	LogRL = 0.8694 + 0.1435 LogTL	0.004	0.139-0.147	0.851	I	Intercept	32.800	0.000

F: female; M: male

Table 5. A comparison of sex distribution and growth characteristics of *P. leptodactylus* populations in some water resources in Turkey (*M*= Male, *F*= Female, Growth type: *I* = isometric growth, *+A* = positive allometric growth, *-A* = negative allometric growth)

Water resources	Sex rate (F : M)	Sex	N	Growth type
Aktaş Lake, CL-W (Aksu and Kurt Kaya, 2017)	0.94 : 1	M	81	A^+
		F	76	A^-
		M + F	157	A^+
Eğirdir Lake, CL-W (Bolat and Kaya, 2016)	0.75 : 1	M	1289	A^-
		F	1719	A^-
		M + F	3008	A^-
Gaga Lake, CL-W (Yılmaz et al., 2011)	0.98 : 1	M	131	A^-
		F	129	A^-
		M + F	260	
Trakya District Lakes (Deniz et al., 2010)	0.56 : 1	M	1558	A^+
		F	880	A^-
		M + F	2438	A^+
Apolyont Lake, CL-W (Berber and Balık, 2009)	0.68 : 1	M	843	I
		F	573	A^-
		M + F	1416	I
Manyas Lake, CL-W (Berber and Balık, 2006)	0.53 : 1	M	731	I
		F	387	A^-
		M + F	1118	A^-
This study (Sapanca Lake)	1.24:1	M	118	I
		F	146	A^+
		M + F	264	A^+

While the TL-TW and CL-TW relationships were observed with positive allometry growth for females and also for pooled data for TL-TW (b>3, t-test, P>0.05), and all remaining length-weight relationships were shown isometry growth for females, males and pooled data (b<3, t-test, P<0.05). Though the student's t-test showed no significant statistical difference between the *b* values of male and female individuals, the all length-weight and length-length relationships were calculated separately for females, males, and all samples (Tables 3 and 4). The slope and intersection of length-weight and length-width relationships were compared among sexes by ANCOVA to test for equality of slope and intersection in data. There was no significant difference between the slope and intersection of male and female groups (ANCOVA; P<0.05).

The condition factors (K) for studied crayfish ranged from 2.52 to 5.16 for males, 2.12 to 5.95 for females and mean condition factors were calculated at 3.33±0.38 for males and 3.15± 0.73 for females.

The catch data from 14 fishing operations was standardized with CPUE by number and biomass. A total of 10107.22 g of crayfish was caught on the 48-trapping/hour during the study period. The mean CPUE for all traps was determined as 0.3929 n/fyke-net/hour and 15.2478 g/fyke-net/hour at the end of the study. The lowest and highest mean CPUE were established 0.0417 n/fyke-net/hour in November 2016 and 0.8750 n/fyke-net/hour in February 2017, respectively (Figure 5). The lowest and highest average CPUE was 1.4021 g/fyke-net/hour in November 2016 and 42.529 g/fyke-net/hour in April 2017 by weight (Figure 6). The mean CPUE values below MLS, according to the highest and lowest number and weight of harvested crayfish were calculated as 0.2976 n/fyke-net/hour and 9.7927 g/fyke-net/hour respectively. The mean CPUE values above MLS, according to the highest and lowest number and weights of harvested crayfish were calculated as 0.0952 n/fyke-net/hour and 5.2478 g/fyke-net/hour, respectively. Although there is a statistically significant difference in terms of individual CPUE values in number when compared to below MLS and above MLS (Hn=3.9213, p=0.4768), there is no statistical difference found according to their weights (Hw=0.0423, p=0.837). There is also no statistical difference observed in terms of CPUE value below MLS and above MLS according to sexes (Hn=0.0007, p=0.97948; Hw=0.3201, p=0.57154; Hn=0.5772, 267 p=0.44741; Hw=0.1746, p=0.67605).

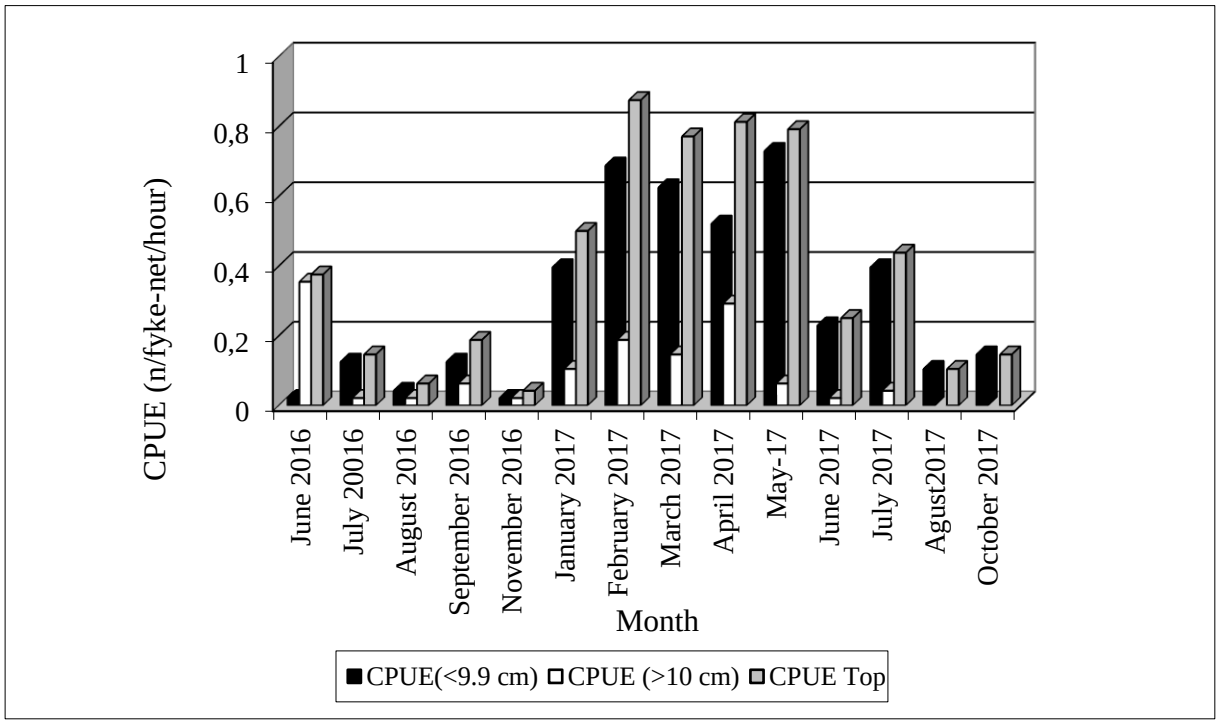

Figure 5. Comparison of catch per unit effort (CPUE) between below-MLS and above-MLS by the number of individuals

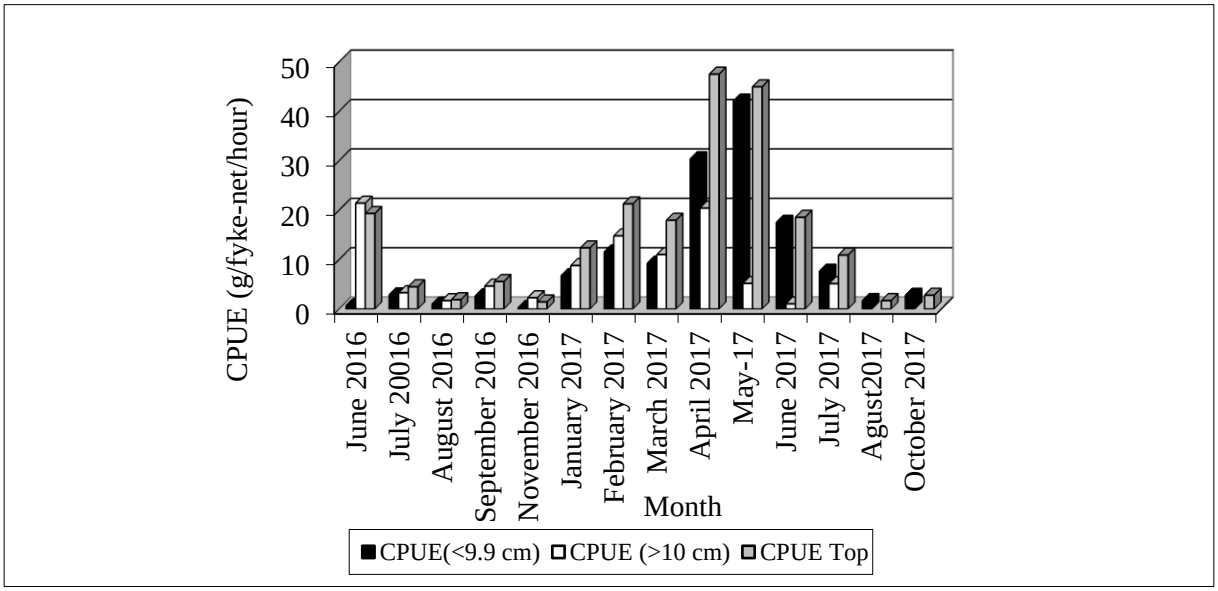

Figure 6. Comparison of catch per unit effort (CPUE) between below-MLS and above-MLS by weight

Discussion

The study is the first scientific report on some morphometric characteristics of freshwater crayfish (*P.leptodactylus*) in Sapanca Lake in Türkiye. The sex ratio, length and weight compositions of crayfish populations were evaluated. Besides, length-weight and length-length relationships, condition factors, and CPUE were calculated for the crayfish population in Sapanca Lake. Although many studies have been performed on the biological and morphological characteristics of *P. leptodactylus* since 1977, there has been no knowledge of this species in Sapanca Lake. Regarding all this, our study reveals important first findings.

Male, female and combined sexes of *P. leptodactylus* were measured and descriptive statistics are given related to them in Table 1. In general, the total weight of the male individuals of crayfish is heavier and longer than females (Romaire et al. 1977; Rhodes and Holdich 1979; Harlıoğlu and Güner 2006). It has been found in most of the studies on *P. leptodactylus* in Türkiye that due to the size of their chela lengths and their weight, male individuals have a greater average length and weight when compared to female individuals (Balık et al. 2005; Büyükçapar et al. 2006; Güner 2008; Aydın et al. 2015). Unlike other water sources in Türkiye, Sapanca Lake female crayfish weight and length is greater than the average male crayfish. It was determined that the mean TL, CL, AL, RL, HL and TW of the female individuals were slightly longer and heavier than those of males. In this study, the average body length and body weight of female crayfish were found to be greater than male individuals. The difference between these morphological characters is due to the predominance of environmental and food sources.

In the research period, 14 times sampling was made and a total of 264 specimens consisting of 146 females (55.3%) and 118 males (44.7%) with the sex ratio of 1.24:1 (female to male) were analyzed. But it was found that a sex ratio change occurs in *P. leptodactylus* caught in different months in the Sapanca Lake. Chi-squared test analysis showed significant differences from the ratio of 1:1. It has been reported that in a natural population, the female to male ratio will vary between 1:1 and 1:1.3 (Avşar 1998). The pooled data values acquire for our study were in the reasonable range expected for a natural population. Some researchers have also reported similar results in their studies in different inland waters in Türkiye (Erdemli 1982; Karabatak and Tüzün 1989, Köksal 1980, Kuşat and Bolat 1995). All these studies taken into consideration, it can be said that the sex ratio is also an important factor in stock evaluations since the reproductive equilibrium and the process of renewal of species are directly affected by the sex ratio in the ecosystem.

In the present results, the males, females, and both sexes of length-weight relationships showed the ideal value and little more than that of 3. While the Student t-test showed isometric growth and the slope of males, females, and both sexes did not exhibit significant interaction, the b value of the TL-W and CL-W relationships were significantly different for females and pooled data (TL-W) (Table 3). In this study, an isometric growth for CL-W of males and

pooled data and positive allometry of females was detected for crayfish, which is in apparent contradiction with some studies in other geographical areas (Table 5). The overall results indicate that *P. leptodactylus* showed an isometric pattern of growth in the studied habitat and the present conditions that exist in the collection site are conducible for the feeding and optimum growth of crayfish.

The determination coefficients (r^2) ranged from 0.851 to 0.960. Similar results were found for *P. leptodactylus* caught from Iznik Lake and Manyas Lake (Aydın et al. 2015; Berber and Mazlum 2009), Keban Dam Lake (Yüksel and Duman 2012), and Terkos Lake (Güner 2006).

The length-weight relationship and the condition factor are considered to be valid not only for fish but also for the evaluation of shellfish. The difference in growth types and condition factors of crayfish among locations may be a reflection of a number of factors, including population density, food abundance, photoperiod, water level fluctuations, and water quality (Weya et al. 2017). The mean condition factor of the crayfish population of Sapanca Lake was 3.23±0.60 (a minimum of 2.12 - a maximum of 5.95). Unlike other water sources in Türkiye, Sapanca Lake female crayfish's weight and length is greater than the average male crayfish, and female and pooled data crayfish are both showing positive allometric growth and condition factor greater than 3. These differences are thought to be due to factors such as the water characteristics, nutrition, and low crayfish density in the Sapanca Lake. The rate of disease symptoms in crayfish caught from Lake İznik was determined as 5.27% (Aydin et al. 2015). İn this research, however, crayfish plaque signs were observed in approximately 11% of the total crayfish caught. According to these results, it was observed that the effect of the plague disease still continues in Sapanca Lake and it has a negative effect on the development of the crayfish stock.

As seen in Figures 5 and Figure 6, CPUE values below MLS were the lowest in November and the highest in May 2017 according to the individual number and weight of the crayfish harvested by months. Depending on the crayfish harvested by months, while the number of individuals, CPUE values above MLS were the lowest in November 2016 and by weight in June 2017. However, the highest CPUE values in June 2016 were determined both by number and weight. Variation of individual numbers of crayfish monthly, CPUE indicated that catches increased considerably from February to May, while it was seen to increase significantly from April to June in terms of weight. Previously, Balık et al. (2002) determined the average CPUE value as 1.10 crayfish/fykenet/night for the lengths above MLS and reported that the CPUE of the caught crayfish in June and July was quite low compared to other months and increased gradually from June to December in Iznik Lake. Additionally, Demirol and Yüksel (2014) calculated the CPUE value per fyke net as 5.74 g/day for the lengths above MLS for 2012 in the Keban Dam Lake. In our case, there is a gradual increase observed in CPUE values for crayfish caught above MLS from January 2017 until April 2017. It was determined that the CPUE values of the crayfish caught in Sapanca Lake were very low compared to these lakes. CPUE value and size distributions of catch crayfish can be affected by the timing of trapping and associated environmental variables such as temperature, aquatic plants, etc. In addition, it is influenced by the density of fyke nets or traps.

Based on these findings in our presented study, it can be concluded the fact that the sampled crayfish are mostly caught below the MLS. The observed highest catch amount in winter and spring can be explained that the place where the traps are set and the catch is made, is covered with high water plants, as well as the high temperature of the summer months so the crayfish do not enter the traps as a result of hiding among the plants due to molting. Taking into consideration the above mentioned, calculating CPUE is very important to evaluate stock and provide information management engagements for the future and studies on sustainable developments.

Although numerous studies have been carried out on biological and morphological traits of *P. leptodactylus* since 1980 in Türkiye water bodies, there was no study of this species in the Sapanca Lake as yet. Considering all this, our study brings out important initial findings for the literature.

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