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BIOLOGICAL CHARACTERISTICS OF EUROPEAN PERCH (*Perca fluviatilis* L., 1758) INHABITING LAKE LADIK (SAMSUN, TURKEY)

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ABSTRACT

The aim of this study was to determine the growth features of European perch (*Perca fluviatilis* L., 1758) inhabiting Lake Ladik. A total of 858 individuals were caught. The total length and weight ranged from 8.2 to 27.5 cm and from 7.16 to 365.20 g, respectively. The age of the females ranged between 1 and 7 years and the age of the males ranged from 1 to 5 years. The female to male ratio was 1:0.19. The von Bertalanffy growth equation parameters were determined as L_∞=41.27 cm, W_∞=1251.40 g, K=0.10 (year^{-1}), t_0 (year)=-1.98 for all samples. Length-weight relationship was calculated as W=0.0047$TL^{3.358}$ for all specimens. Length-length relationships (total length-standard length, total length-fork length, standard length- fork length) were highly significant (r^2>0.98). The mean condition factor value was obtained as 1.28 for all fish. Condition factor showed statistically significant increase according to length classes.

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INTRODUCTION

European perch is the most common and widely distributed member of the perch family, and is important both commercially and for sport fishing. It is widespread throughout Europe and Asia and has been successfully introduced in other parts of the world, mainly South Africa, Australia and New Zealand (Thorpe, 1977). European perch is one of the economically important freshwater fishes inhabiting Lake Ladik (Yilmaz et al., 2013).
Biological features of fish should be well-known in fishing and aquaculture research as well as in research about population dynamics and fish biology. There are studies about growth, reproduction, diet and otolith morphometry of European perch (Copp and Kováč, 2003; Polat et al., 2004; Ilhan et al., 2009; Begburs, 2010; Čech et al., 2010; Ceccuzzi et al., 2011; Giannetto et al., 2012; Sabetian et al., 2014; Yilmaz et al., 2014; Banda, 2015; Komsari et al., 2015; Tamás et al., 2015). However, there are no studies about growth characteristics of European perch inhabiting Lake Ladik. Growth features of bream *Abramis brama* (Erbaşaran 2012), northern pike *Esox lucius* (Yazıcıoğlu 2014), rudd *Scardinius erythrophthalmus* (Yazici et al. 2015) were determined in Lake Ladik. Although European perch is a predator fish species, it is an important prey for the top predator northern pike inhabiting Lake Ladik.

Growth features of European perch should be investigated extensively since it is an economically important species which is invasive for some waters and it holds an important place in the food chain. Therefore, the present work is focused on the growth properties of European perch living in this lake.

MATERIALS AND METHODS

Lake Ladik (35°40'-36°05' E -40°50'-41°00' N) is one of the few lakes with floating islands in the world. The lake has a length of 5 km, width of 2 km, depth of 2.5-6 m and altitude of 867 m. This lake, which is a wetland with eutrophic character, has a surface area of 10 km^2 (Yilmaz et al., 2013). The sampling was carried out monthly between November 2009 and October 2010 in different parts of Lake Ladik, using gillnets with meshes of 25x25, 30x30, 35x35, 40x40 mm, 100 m long and 20x20 mm 50 m long. Networks were left in the lake during evening hours and collected the next morning (about 12 hours of exposition). Total length (*TL*, ±0.1 cm) and weight (*W*, ± 0.01 g) of each specimen were recorded. The ages of European perch inhabiting Lake Ladik were determined by using their vertebrae as reliable bony structures by Saygin et al., 2015. Their sexes were determined with macroscopic examination of gonads. The Chi-square test (Zar, 1999) was used to determine whether the sex ratio was different from the expected 1:1 ratio for the entire sample.

The mean total length and weight values of the females and males were compared with the Mann-Whitney U test (α=0.05) (Zar, 1999). The length and weight frequency distributions according to sexes were also compared with the Kolmogorov-Smirnov Z test (α=0.05) (Zar, 1999).

Age-length and age-weight relationships were determined using the growth equations developed by von Bertalanffy (Sparre and Venema, 1998):

$L_t=L_\infty[1-e^{-K(t-t0)}]$

$W_t=W_\infty[1-e^{-K(t-t0)}]^b$

where L_t is the total length at age *t*, L_∞ is the asymptotic length (cm), *K* is the coefficient of growth (year^{-1}), *t* is age (year), t_0 is the hypothetical age at length 0, W_t is the weight at age (g), W_∞ is the asymptotic weight (g), *b* is the regression coefficient in the length-weight relationship (Sparre and Venema, 1998). Parameters of L_∞, *K* and t_0 were calculated by the FISAT II software package (Gayalino et al., 2005), and W_∞ and *b* were calculated from the length-weight relationship.

The growth performance index was determined by the equation of Munro and Pauly (1983):

$\Phi' = log (K) + 2 log (L_\infty)$

Φ' value was obtained in FISAT II software package (Gayalino et al., 2005).

The length-weight relationship was calculated by the formula (Ricker, 1975):

$W = aTL^b$

where *W* is the body weight (g), *TL* is the total length (cm), *a* and *b* are the parameters of the relationship. Whether the *b* parameter was different from 3 was tested by the t-test (Zar, 1999). The relationships between different length types (total length-standard length, total length-fork length, standard length-fork length) were detected using linear regression analysis for the females, males and the entire sample.

Fulton's condition factor was calculated:

$CF= (W/L^3)x100$

where *W* is the fish weight (g), *L* is the total length (cm) (Ricker, 1975). The difference was tested by the t-test (α=0.05) in terms of condition factor values between females and males.

RESULTS

Growth

The total length and weight ranged from 8.2 to 27.5 cm and from 7.16 to 365.20 g for the entire population, respectively. When the average values of the total length and weight were compared for the female and male samples, it was found that the difference was statistically significant (Mann-Whitney U test, P<0.001). The female individuals were bigger than the males in terms of both length and weight. The female to male ratio was estimated as 1:0.19 and the sex ratio was different from 1:1 ratio (X^2=403.005, df=1, P<0.001; Table 1.). It was observed that the length-frequency distribution (Figure 1, 2) (Kolmogorov-Smirnov test, Z=5.121, P<0.001) and the weight-frequency distribution (Figure 3 and 4) (Kolmogorov-Smirnov test, Z=5.280, P<0.001) were different between females and males.
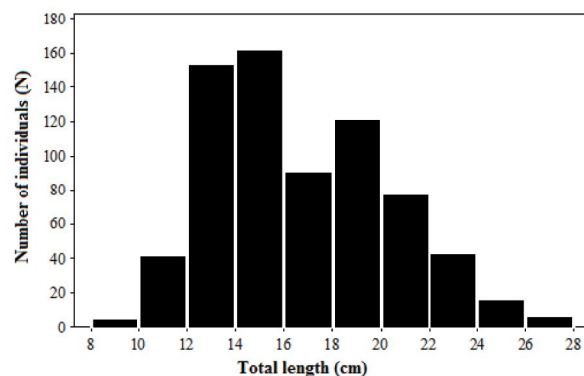

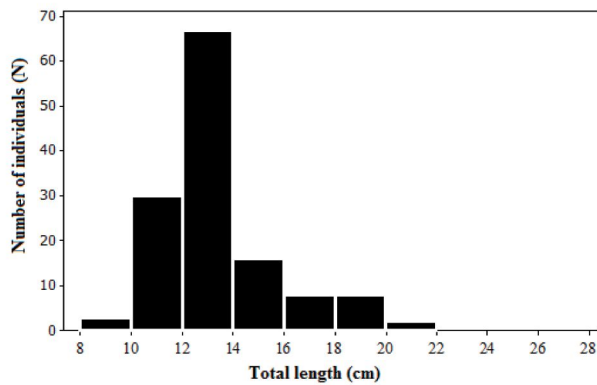**Fig 1.** Length-frequency distribution for the females of European perch

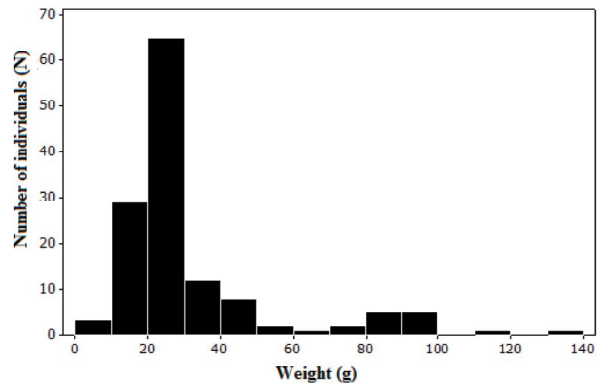**Fig 2.** Length-frequency distribution for the males of European perch

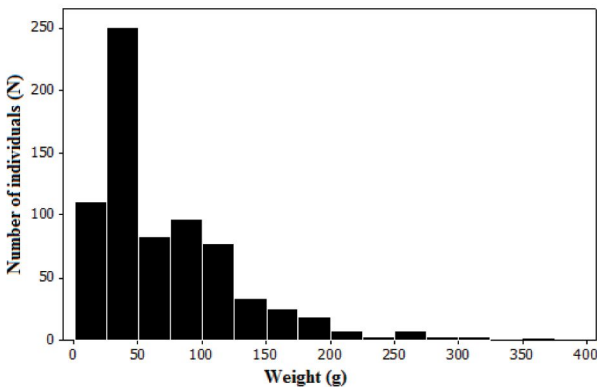**Fig 3.** Weight-frequency distribution for the females of European perch

Fig 4. Weight-frequency distribution for the males of European perch

Age ranged from 1-7 years for the females and 1-5 years for the males. The age groups II and III were dominant with the values of 25.52% and 25.06%, respectively. The mean total length was statistically different between females and males in the same age groups, except for the age group V (t- test, P<0.05). The mean weight was statistically different between females and males for the age groups I-IV (t-test, P<0.05).

L_∞ was calculated as 43.72 cm for female, 23.55 cm for male (Table 2).

Length-weight relationships

The length-weight relationships were $W = 0.0047 \times TL^{3.364}$ for the females and $W = 0.0054 \times TL^{3.301}$ for the males. The graph of the length-weight relationship for all individuals is

Table 1. Descriptive statistics of total length and weight of European perch in Lake Ladik

Sex	Total Length (cm)					Weight (g)			
	N	Mean	Sd	Min	Max	Mean	Sd	Min	Max
Female	721	16.61	3.65	8.5	27.5	72.02	56.36	7.16	365.20
Male	134	13.35	2.32	8.7	20.6	32.04	23.45	7.74	131.08
Undetermined	3	8.47	0.23	8.2	8.6	7.38	0.25	7.22	7.67
All	858	16.08	3.69	8.2	27.5	65.55	54.56	7.16	365.20

N: Number of individuals, Sd: Standard deviation, Min: Minimum, Max: Maximum

Table 2. The von Bertalanffy growth parameters and growth performance index values in the length and weight for European perch

Sex	L_∞ (cm)	W_∞ (g)	K (year^{-1})	t_0 (year)	b	Φ'
Female	43.72	1553.62	0.09	-2.15	3.364	2.236
Male	23.55	182.53	0.18	-2.26	3.301	1.999
All	41.27	1251.40	0.10	-1.98	3.358	2.231

presented in Figure 5. It was found that all *b* values were significantly different from 3 (t-test, P<0.05), and this finding showed that the growth was positively allometric.
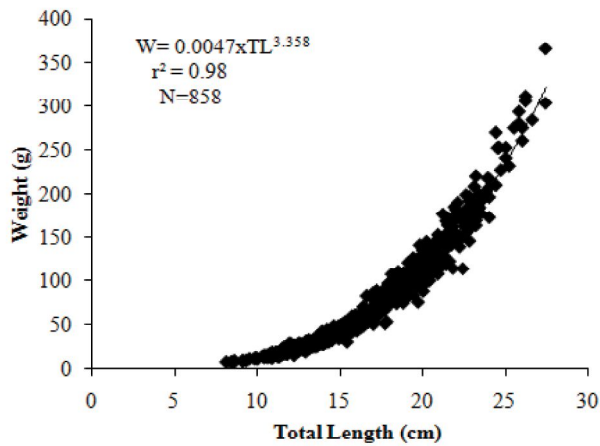

Fig 5. The length-weight relationship of European perch sampled in Lake Ladik (N: number of individuals)

Length-length relationships

The relationships of the total-fork length, fork-standard length, standard-total length were calculated to reveal length conversions (Table 3.) and it was found that there were strong relationships between different length types (P<0.001, r²>0.98).

Condition factor

The values of the condition factor for the females, males and all specimens were calculated as 1.30, 1.18 and 1.28, respectively (Table 4). When the condition factors of the females and males in the same age groups were compared, the differences were statistically significant for the age groups II and III (t-test, P<0.05). Similarly, the condition factors were also different between the females and males in the whole sample (t-test, P<0.05). The females had higher condition factors than the males in every comparison that had significant differences.

Table 3. The length-length relationships of European perch

Sex	N	Equations	*a*	*b*	*r²*
Female	721	TL= a+b FL	0.0037	1.06	0.99
		FL= a+b SL	0.465	1.08	0.99
		SL= a+b TL	-0.315	0.87	0.99
Male	134	TL= a+b FL	0.172	1.04	0.99
		FL= a+b SL	0.308	1.09	0.99
		SL= a+b TL	-0.242	0.87	0.99
All	858	TL= a+b FL	0.0073	1.06	0.99
		FL= a+b SL	0.399	1.08	0.99
		SL= a+b TL	-0.264	0.87	0.99

(TL: Total Length, FL: Fork Length, SL: Standard Length)

Table 4. The values of the condition factors for European perch according to age

	Female		Male		All	
Age	N	CF±Se (Min-Max)	N	CF±Se (Min-Max)	N	CF±Se (Min-Max)
I	63	1.16±0.01 (0.94-1.37)	29	1.18±0.02 (0.91-1.41)	95	1.17±0.01 (0.91-1.41)
II	173	1.19±0.01 (0.80-1.58)	46	1.14±0.02 (0.79-1.33)	219	1.18±0.01 (0.79-1.58)
III	176	1.24±0.01 (0.98-1.76)	39	1.15±0.02 (0.97-1.58)	215	1.23±0.01 (0.97-1.76)
IV	150	1.37±0.01 (0.90-1.77)	16	1.37±0.05 (1.00-1.71)	166	1.36±0.01 (0.90-1.77)
V	114	1.42±0.02 (0.99-1.82)	4	1.36±0.11 (1.07-1.56)	118	1.42±0.01 (0.99-1.82)
VI	31	1.47±0.03 (1.23-1.73)	-	-	31	1.47±0.03 (1.23-1.73)
VII	14	1.60±0.03 (1.46-1.83)	-	-	14	1.60±0.03 (1.46-1.83)
All	721	1.30±0.01 (0.80-1.83)	134	1.18±0.01 (0.79-1.71)	858	1.28±0.01 (0.79-1.83)

DISCUSSION

The growth of fish varies widely among water bodies and such growth variations have been linked to both biotic and abiotic factors. The growth of European perch depends on complex interactions with water temperature (Le Cren, 1958; Coble, 1966), pH (Tolonen et al., 2003), population density (Rask, 1983), and food density and availability (Craig, 1978).

Sex ratio of fish varies according to species, among populations of the same species and from year to year in the same population (Nikolsky, 1963). Similar to the results of our study (1:0.19), females were generally more dominant than males in literature (Ilhan et al., 2009; Ceccuzzi et al., 2011). The female to male ratio of European perch is calculated as 1:0.25 in Lake Pounui (Jellyman, 1980), 1:0.85 in Tahtalı Dam Lake (Ilhan et al., 2009), 1:0.44 in Lake Varesa (Ceccuzzi et al., 2011) and 1:0.62 in the Curonian Lagoon (Troynikov et al., 2011). Jellyman (1980) stated that the overall dominance of females in the population is principally due to a much higher mortality of males than females between age classes 0 and 1. This may be due to selective predation on males similar to those recorded by Alm (1959) who considered that the higher activity of males made them more vulnerable to predation. Northern pike, which is a predator species, fed on European perch in Lake Ladik (Yazıcıoğlu, 2014). Also, gonad maturation takes place earlier in males than females.

In this study, maximum total length and weight values were determined as 27.5 cm and 365.20 g, respectively. The longest perch was sampled from Swedish Lakes

Table 5. The parameters of von Bertalanffy growth equations and the growth performance index in different locations for European perch

Reference	Habitat	Sex	L_∞	W_∞	K	t_0	Φ'
Jellyman (1980)**	Lake Pounui	Female	34.80	625.43[b]	0.19	-2.94	2.39
		Male	24.80	204.46[b]	0.24	-2.58	2.18
Begburs (2010)**	Urkmez Dam Lake	Female	49.98	2872.61	0.21	-0.83	2.72[a]
		Male	49.62	2624.05	0.20	-0.83	2.70[a]
		All	51.16	3013.12	0.19	-0.86	2.71[a]
Ceccuzzi et al. (2011)*	Lake Varese	Female	35.52	664.31[b]	0.18	-1.71	2.37
		Male	32.85	422.22[b]	0.20	-1.56	2.34
		All	33.17	-	0.22	-1.34	2.39
Sabetian et al. (2014)***	Lake Wainamu (2012)	Female	15.9	-	1.88	-	-
		Male	18.6	-	1.48	-	-
		All	17.9	-	1.51	-	-
	Lake Wainamu (2013)	Female	20.3	-	1.36	-	-
		Male	25.7	-	0.91	-	-
		All	24.5	-	0.93	-	-
Banda (2015)***	Warkworth Quarry Lake	Female	21.9	-	0.18	-	1.94
		Male	21.3	-	0.45	-	2.31
		All	25.1	-	0.24	-2.24	2.18
	Lake Rototoa	Female	21.2	-	1.75	-	2.89
		Male	29.4	-	0.84	-	2.86
		All	27.5	-	0.98	-0.08	2.86
Komsari et al. (2015)*	Anzali Wetland	Female	21.00	120.89[b]	0.33	-0.90	2.16[a]
		Male	21.17	141.62[b]	0.31	-0.80	2.14[a]
This study	Lake Ladik	Female	43.72	1553.62	0.09	-2.15	2.23
		Male	23.55	182.53	0.18	-2.26	1.99
		All	41.27	1251.40	0.10	-1.98	2.23

with a total length of 49.5 cm (Holmgren and Appelberg, 2001). The heaviest perch was reported from the lakes of the Aukštaitija National Park with a weight of 2215 g. Kottelat and Freyhof (2007) reported a maximum length of 60 cm for European perch. According to our results, European perch population was composed of mostly young individuals. This resulted from the fact that the fishing activities in the lake were aimed at larger individuals. The highest age was 7 years and this only confirmed our observations. The smallest individuals were at the age of one and there were no individuals at the age of zero in any sexes. This case was thought to have resulted from the mesh size of fishing nets and predation of northern pike on perch in the lake. In literature, the ages of the fish ranged between 0-17 years. Age of Europeran perch was found to be 0-5 years in Lake Pounui (Jellyman, 1980), 1-7 years in Lake Trasimeno (Lorenzoni et al., 1993) and 0-7 years in Lake Varesa (Ceccuzzi et al., 2011). The maximum age was observed under 7 years at many locations. Besides these researches, the maximum age of European perch was determined to be 2 and 17 years in the Aukštaitija National Park (Balkuvien et al., 2003) and 0 and 17 years in Lake Valkea Kotinen (Afolabi, 2011). It appeared that European perch had extensive age distribution.

In Lake Ladik, similar to the reports for other European perch populations in literature (Jellyman, 1980, Ceccuzzi et al., 2011), males grew faster and lived shorter than females according to the von Bertalanffy parameters (Table 5). In Lake Ladik, the comparison between sexes showed that females were larger than males; furthermore, females had higher L_∞ than males. This is probably due to the fact that gonad maturation takes place earlier in males than females; thus, the latter have more time to utilize the energy for somatic growth. Similar results were also obtained from different research (Jellyman, 1980; Heibo and Magnhagen, 2005; Ceccuzzi et al., 2011). The growth performance index calculated in different locations for *P. fluviatilis* was similar. The parameters of length-weight relationship showed that the growth of European perch inhabiting Lake Ladik was positive allometric. The parameters of length-weight relationship found in this study were similar to the results of the researches completed in different locations (Lorenzoni et al., 1993; Begburs, 2010; Ceccuzzi et al., 2011). These parameters of fish may change according to habitat, season, stomach occupancy rate, sex, gonad maturity and length distributions (Wootton, 1998).

In this study, the females have higher condition factors than the males. Condition factor values obtained from different investigations are given in Table 6. Our results showed similarity with those of the Curonian Lagoon (Ložys, 2004), Lake Varesa (Ceccuzzi et al., 2011) and Lithuanian coastal waters of the Baltic Sea populations (Ložys, 2004). The condition factors of fish change according to sex, age composition, habitat, season. Condition factors of *P.fluviatilis* increased with age in Lake Ladik. The condition factors of fish change also according to measured length types. Standard or total lengths are used to determine condition factors in different research.

Consequently, considering the length-weight distribution, growth parameters, length-weight relationships and condition factors of European perch in the lake, this species shows a good development in Lake Ladik.

This study is the first comprehensive research determining the growth features of European perch inhabiting Lake Ladik. The results obtained from this study may be useful for future research concerned with European perch.

Table 6. The values of the condition factors of European perch in different locations

Reference	Habitat	Sex	*CF*
Lorenzoni et al. (1993)**	Lake Trasimeno	Female	1.68
		Male	1.61
Szypuła (1994)**	Lake Dabie	All	1.84
	Szczecin Lagoon	All	2.24
Ceccuzzi et al. (2011)*	Lake Varese	Female	1.24
		Male	1.14
This study*	Lake Ladik	Female	1.30
		Male	1.18
		All	1.28

*Total length, ** standard length

Sadržaj

BIOLOŠKA OBILJEŽJA GRGEČA (*Perca fluviatilis* L., 1758) KOJI NASTANJUJE JEZERO LADIK (SAMSUN, TURSKA)

Cilj ovog istraživanja je utvrditi parametre rasta grgeča (*Perca fluviatilis* L., 1758) koji nastanjuje jezero Ladik. Ukupno je ulovljeno 858 jedinki. Ukupna dužina i težina su u rasponu od 8,2 do 27,5 cm, odnosno od 7,16 do 365,2 g. Dob ženki kretala se u rasponu od 1 do 7 godina, a dob mužjaka u rasponu od 1 do 5 godina. Odnos ženki i mužjaka bio je 1: 0,19. Parametri von Bertalanffijeve jednadžbe su određeni kao L_∞ = 41,27 cm, W_∞ = 1251,40 g, K = 0,10 (godina^{-1}), t_0 (godina) = - 1,98 za sve uzorke. Dužinsko-maseni odnosi su izračunati kao W = 0,0047TL^{3,358} za sve uzorke. Dužinsko-dužinski odnosi (totalna dužina-standardna dužina, totalna dužina-dužina vilice, standardna dužina-dužina vilice) bili su veoma značajni (r^2> 0,98). Prosječna vrijednost faktora kondicije je utvrđena kao 1,28 za sve ribe. Faktor kondicije ukazuje na statistički značajan porast prema dužinskim razredima.

Ključne riječi: parametri rasta, dužinsko-maseni odnosi, faktor kondicije, dužinsko-dužinski odnosi

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