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Some Biological Characteristics of *Luciobarbus esocinus* Heckel, 1843 Living in Keban Reservoir

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Abstract

This study was carried out in *Luciobarbus esocinus* obtained from Keban Reservoir (Elazığ) between March 2008 and October 2009. During the research, it was determined that the percentage of male, female and undefined individuals from 187 *L. esocinus* were 45.455%, 37.433% and 17.112% respectively. The ages of population were distributed between I and XVII. The lengths of the individuals ranged from 23.0 to 112.4 cm and the weight of them ranged from 118 to 18042 g. The length and weight equation for population was determined as $W_{\text{all individuals}} = 0.0057TL^{3.2187}$ (n= 187, r= 0.98). The highest GSI values of both sexed were obtained in March and these values were decreased rapidly after this month. It was determined that the condition factor increased until age 5 and then, it decreased respectively.

Keywords: *Luciobarbus esocinus*, growth, GSI, length-weight relationship, condition factor.

Keban Baraj Gölünde Yaşayan *Luciobarbus esocinus* Heckel, 1843'ün Bazı Biyolojik Özellikleri

Özet

Bu çalışma, Mart 2008-Ekim 2009 tarihleri arasında Elazığ Keban Baraj Gölü'nden yakalanan *Luciobarbus esocinus* bireyleriyle gerçekleştirilmiştir. Çalışma süresince yakalanan 187 adet *L. esocinus* bireyinin % 17,112'sini eşeyi belirsiz, % 45,455'ini erkek, %37,433'ünü ise dişi bireylerin oluşturduğu ve populasyonun I-XVII yaş grupları arasında dağılım gösterdiği tespit edilmiştir. Populasyon genelinde total boy değerlerinin 23,0-112,4 cm arasında, ağırlık değerlerinin de 118-18042 g arasında değiştiği belirlenmiştir. Populasyon genelinde boy-ağırlık arasındaki ilişkiyi açıklayan denklem $W_{\text{tüm bireyler}} = 0{,}0057TL^{3{,}2187}$ olarak saptanmıştır (n= 187, r = 0,98). GSİ değerlerinin her iki eşeyde de mart ayında en üst seviyeye çıktığı bu aydan itibaren ise hızla düşüş gösterdiği belirlenmiştir. Kondisyon faktörü değerlerinin de 5. yaşa kadar arttığı, bu yaştan sonra ise düşmeye başladığı saptanmıştır.

Anahtar Kelimeler: *Luciobarbus esocinus*, büyüme, GSI, uzunluk-ağırlık ilişkisi, kondisyon faktörü.

Introduction

Luciobarbus esocinus is a cyprinid which is found along the Euphrates and Tigris Rivers in Turkey, Syria, Iran and Iraq (Kuru, 1979; Coad, 2011). Its size can be over 100 kg and is very delicious and its economic value is quite high (Geldiay and Balık, 2007). *Luciobarbus esocinus* is a benthoplagic species living large rivers and dams but details of environmental requirements unknown. In some literatures, maximum length and weight of *L. esocinus* were reported as 230 cm and 140 kg (Stone, 2007; Coad, 2011; Fishbase, 2011). The species known as *Barbus esocinus* until 2007 was revised as *Luciobarbus esocinus* from 2007 (Fricke *et al.*, 2007).

Keban Reservoir is one of the important areas where this species lives and it was reported that nearly 8.7% of the fish caught from Keban Reservoir consisted of *L. esocinus* (Celayir *et al.*, 2006). This can be evaluated as a low rate, but it is the most valuable fish caught from Keban Reservoir. So this rate is an important economical measurement.

Various biological studies have been conducted about the population of *L. esocinus* (*B. esocinus*) living in Keban Reservoir (Girgin and Şen, 1995; Şen *et al.*, 1996; Şen and Duman, 1999; Şen *et al.*, 2001; Gürel İnanlı *et al*., 2006). However these studies were restricted with small sample size and they were

investigated the population combined instead of gender. The aim of this study is to determine some biological features such as growth parameters and reproduction biology of *L. esocinus*. The results of the study will be able to overcome a lack about this species and they can be used for fisheries management in the reservoir.

Materials and Methods

Fish samples were caught from Keban Reservoir (Elazığ) between March 2008 and October 2009, monthly (Figure 1). All fish specimens were caught using gill nets with various mesh size (40, 50, 60, 70, 90 and 110 mm).

The ages of the fish were determined using dorsal fin rays (Şen and Duman, 1999). Sexes of the fish were determined by opening their abdominal region and examining their gonads macroscopically and if necessary microscopically (Lagler *et al*., 1977). The length-weight relation of the population was investigated by the regression analysis of $W= a.L^b$ and growth was investigated by von Bertalanffy Growth Function; (Sparre and Venema, 1992; Nikolsky, 1969; Kara, 1992).

$L_t = L_\infty * [1-e^{(-k*(t-to))}]$

$W_t = W_\infty * [1-e^{(-k*(t-to))}]^b$

Absolute and rational growth in length and weight was calculated by the following formulas;

Absolute growth: L_2-L_1 and W_2-W_1

Rational growth: $((L_2-L_1)/L_1)*100$ and $((W_2-W_1)/W_1)*100$ (Erkoyuncu, 1995).

In order to determine reproduction period Gonadosomatic Index (GSI) and Condition Factors (CF) were used. These were estimated by the following equations;

GSI= [Gonad weight/(Body weight–Gonad weight)]*100

CF= [(Body weight–Gonad weight)/Fish length^3]*100 (Avşar, 2005).

Data were statistically analysed by using Microsoft Office Excel 2003 and SPSS 12.00 package programmes.

Results

Age and Sex Distribution

A total of 187 *L. esocinus* specimens were caught from Keban Reservoir. Rates of male, female and undefined sex were found as 45.455%, 37.433% and 17.112% respectively. Twelve age groups were recorded from I to XVII and the most individuals are found to be in IV age group for both sexes. The overall sex ratio was 1:0.82 (females/males) and it was not significantly different from the theoretical 1:1 value (X^2= 0.726<$X^2_{(1, 0.05)}$= 3.84; p= 0.228, p>0.05) (Table 1).

Length and Weight Distribution

Total lengths and weights of 187 *L. esocinus*

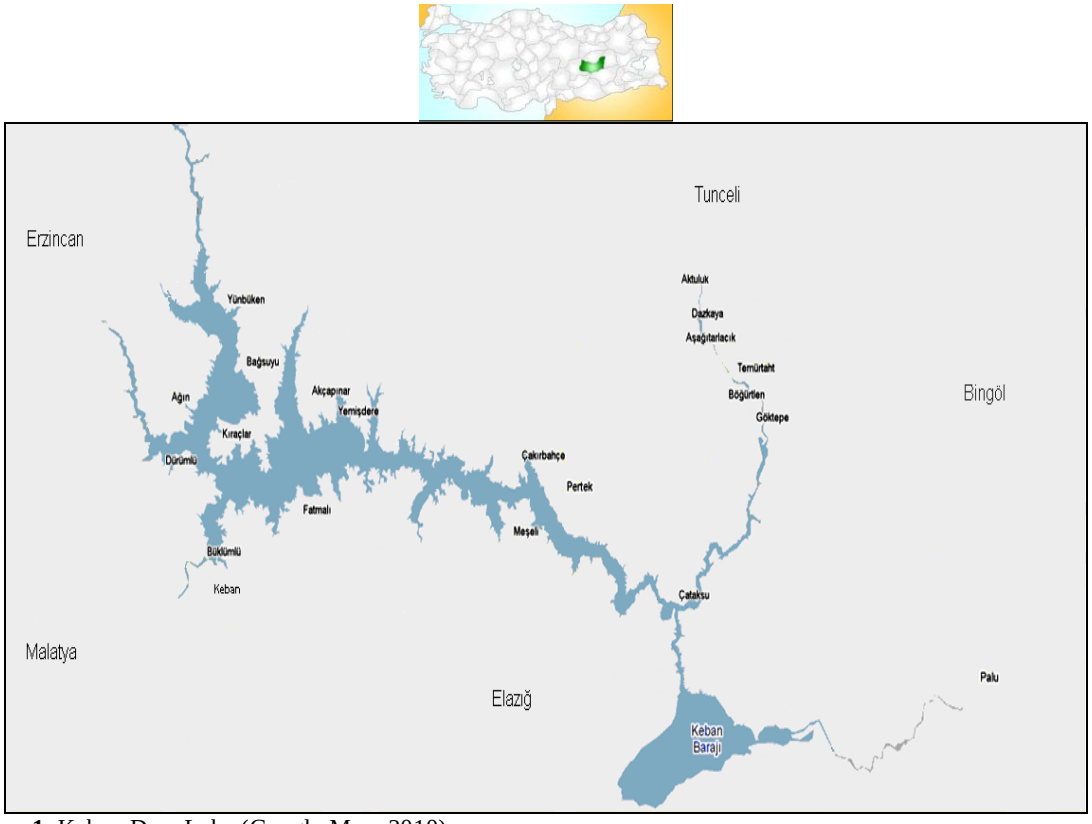

Figure 1. Keban Dam Lake (Google Map, 2010).

were examined for their age and sex groups. The differences among the total length values and among the weight values for each age group were determined using by t-test.

Total lengths of *L. esocinus* were found between 23.00-44.00 cm for the undefined sex, 34.80-112.40 cm for males and 31.60-106.40 cm for females. The differences between sexes were not statistically significant (P>0.05) according to age groups (Table 2). Weights of *L. esocinus* varied from 118 to 928 g for the undefined sex, from 340 to 18042 g for males and from 363 to 12506 g for females. The differences between sexes were not statistically significant (P>0.05) according to age groups (Table 3).

Growth

The growth parameters that describe growth in length were found as $L\infty$= 225.621 cm, k= 0.031, t_0= -3.929 for males, $L\infty$= 234.378 cm, k= 0.038, t_0= -2.819 for females and $L\infty$= 229.732 cm, k= 0.035, t_0= -2.891 for all individuals. Using these parameters von Bertalanffy growth models of *L. esocinus* were described as $L_t=225.621*[1-e^{-0.031*(t+3.929)}]$ for males, $L_t=234.378*[1-e^{-0.038.(t+2.819)}]$ for females and $L_t=229.732*[1-e^{-0.035*(t+2.891)}]$ for all individuals. Growth curves using von Bertalanffy equations were

Table 1. Age composition and sex ratios of *Lucioabrbus esocinus* population in Keban Reservoir

Age	Undefined		Male		Female		All individuals		Female/Male	X^2	p
	N	%	N	%	N	%	N	%			
1	4	2.139	-	-	-	-	4	2.139	-	-	-
2	15	8.021	2	1.070	3	1.604	20	10.695	1:1.5	0.100	0.654
3	13	6.952	16	8.556	6	3.209	35	18.717	1:0.4	2.272	0.033*
4	-	-	34	18.182	19	10.160	53	28.342	1:0.6	2.122	0.039*
5	-	-	13	6.952	14	7.487	27	14.439	1:1.1	0.018	0.847
6	-	-	8	4.278	11	5.882	19	10.160	1:1.4	0.237	0.491
7	-	-	5	2.674	7	3.743	12	6.417	1:1.4	0.166	0.564
8	-	-	2	1.070	4	2.139	6	3.209	1:2.0	0.333	0.414
9	-	-	4	2.139	-	-	4	2.139	-	-	-
10	-	-	-	-	4	2.139	4	2.139	-	-	-
14	-	-	-	-	2	1.070	2	1.070	-	-	-
17	-	-	1	0.535	-	-	1	0.535	-	-	-
Total	32	17.112	85	45.455	70	37.433	187	100	1:0.82	0.726	0.228

*Statistically significant

Table 2. The distribution of total lengths (cm) of *Luciobarbus esocinus* population in Keban Reservoir according to age and sex groups

Age	Undefined		Male		Female			All individuals	
	N	$\bar{X}$ ±S.e. (Min-Max)	N	$\bar{X}$ ±S.e. (Min-Max)	N	$\bar{X}$ ±S.e. (Min-Max)	t-test	N	$\bar{X}$ ±S.e. (Min-Max)
1	4	28.42±2.056 (23-33)	-	-	-	-	-	4	28.42±2.056 (23-33)
2	15	34.75±0.689 (30.8-39)	2	37.39±2.550 (34.8-39.9)	3	35.36±2.500 (31.6-40.1)	p>0.05	20	35.84±0.890 (30.8-40.1)
3	13	38.15±1.104 (32.1-44)	16	43.91±1.201 (35-50.6)	6	44.41±2.349 (38.2-52.3)	p>0.05	35	42.16±0.652 (32.1-52.3)
4	-	-	34	50.03±0.862 (36.5-56)	19	51.64±0.946 (38.8-54.5)	p>0.05	53	50.84±0.877 (36.5-56)
5	-	-	13	55.38±1.252 (40.8-57.7)	14	57.77±1.243 (43.7-60.4)	p>0.05	27	56.57±1.559 (40.8-60.4)
6	-	-	8	59.81±2.356 (50.2-69.8)	11	63.40±1.961 (44-65.7)	p>0.05	19	61.61±2.700 (44-69.8)
7	-	-	5	63.82±3.785 (51.3-68.2)	7	68.71±3.884 (45.6-69.4)	p>0.05	12	66.26±3.433 (45.6-68.2)
8	-	-	2	67.67±4.552 (63.4-74.55)	4	72.92±4.132 (51.7-73)	p>0.05	6	70.83±4.381 (51.7-74.55)
9	-	-	4	75.12±3.306 (70.3-85.4)	-	-	-	4	75.12±3.306 (70.3-85.4)
10	-	-	-	-	4	83.87±4.298 (73.9-94.4)	-	4	83.87±4.298 (73.9-94.4)
14	-	-	-	-	2	101.10±5.300 (95.8-106.4)	-	2	101.10±5.300 (95.8-106.4)
17	-	-	1	112.40	-	-	-	1	112.40

formed for males, females and all individuals as in Figure 2. From the length-weight relationships and the estimated L∞, the asymptotic weights (W∞) were calculated as 154729 g, 234978 g and 226954 g, respectively, for males, females and all individuals.

It is determined that relative and absolute growths of length and weight were faster for early ages and it slowed when they get older (Table 4 and 5). While estimating absolute and relative growth rates, after the age group X were not taken into account because of the absence of serial age group and lack of samples number.

Length and Weight Relationship

The length-weight relationships of the *L. esocinus* were estimated using 85 males and 70 females. The *b* values for males, females and all individuals were estimated as b= 3.098 and b= 3.282 and b= 3.218, respectively. The results indicated that the *b* value of the both sexes was higher than 3, meaning positive allometry in the both sexes. The resulting equations for males, females and all individuals are given below:

$W_{male} = 0.0079TL^{3.0985}$; n= 85; r = 0.97

Table 3. The distribution of weights (g) of *Luciobarbus esocinus* population in Keban Reservoir according to age and sex groups.

Age	Undefined		Male		Female		t-test	All individuals	
	N	$\bar{x}$ ±S.e. (Min-Max)	N	$\bar{x}$ ±S.e. (Min-Max)	N	$\bar{x}$ ±S.e. (Min-Max)		N	$\bar{x}$ ±S.e. (Min-Max)
1	4	241.25±51.13 (118-368)	-	-	-	-	-	4	241.25±51.132 (118-368)
2	15	436.57±30.16 (250-678)	2	432±92.01 (340-524)	3	467±76.42 (363-616)	p>0.05	20	445.19±25.37 (250-678)
3	13	660±53.64 (356-928)	16	942.43±73.96 (448-1468)	6	997.33±174.34 (536-1604)	p>0.05	35	866.63±52.31 (356-1604)
4	-	-	34	1555.13±74.72 (612-2256)	19	1561.26±73.17 (646-1780)	p>0.05	53	1558.19±54.96 (612-2256)
5	-	-	13	2156.29±136.40 (710-2396)	14	2077.78±126.04 (986-2604)	p>0.05	27	2117.03±92.52 (710-2604)
6	-	-	8	2734.65±379.82 (1726-4708)	11	2586.45±218.00 (1034-2762)	p>0.05	19	2660.55±207.97 (1034-4708)
7	-	-	5	3162.76±608.53 (1430-4352)	7	3026.85±484.60 (1274-4487)	p>0.05	12	3094.80±366.89 (1274-4487)
8	-	-	2	3588.19±1133.33 (2246-5022)	4	3416.25±953.81 (1635-5291)	p>0.05	6	3502.22±703.3 (1635-5291)
9	-	-	4	6743.5±745.70 (5505-8824)	-	-	-	4	6743.5±745.70 (5505-8824)
10	-	-	-	-	4	7307±1079.00 (4271-9026)	-	4	7307±1079.00 (4271-9026)
14	-	-	-	-	2	12232±274.04 (11958-12506)	-	2	12232±274.04 (11958-12506)
17	-	-	1	18042	-	-	-	1	18042

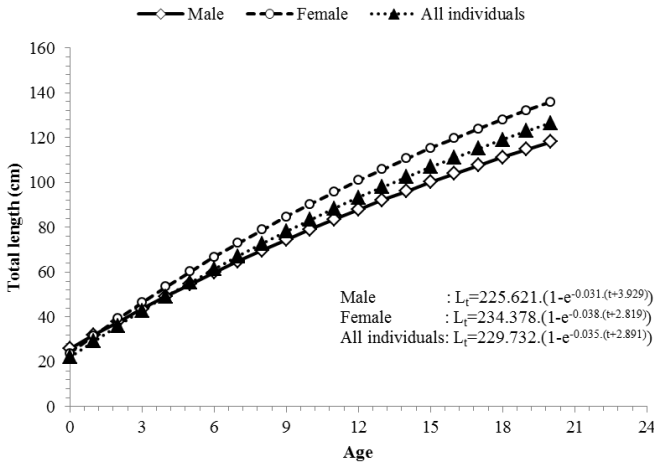

Figure 2. von Bertalanffy growth curves of *Luciobarbus esocinus* population in Keban Reservoir.

$W_{female} = 0.0039TL^{3.2828}$; n= 70; r = 0.98

$W_{all\ individuals} = 0.0057TL^{3.2187}$; n= 187; r = 0.98

The high r-values indicated a very strong relationship between the two dimensions. Length and weight relationship for the whole population was shown in Figure 3.

Gonadosomatic Index and Condition Factor

In order to determine the spawning period of *L. esocinus,* Gonadosomatic Index (GSI) was used for each sex group. It was observed that GSI value was at the highest levels in March and it declined after March (Figure 4). GSI values changed between 0.011%-4.289% for males and 0.010%-0.373% for females.

It was determined that the condition factor (CF) for *L. esocinus* population varied between 0.528-1.706 for males and 0.875-1.863 for females throughout the year. CF values were at the lowest level in January and February just before the reproduction period (Figure 4).

The determination of the spawning season for *L. esocinus* population in Keban Reservoir was

Table 4. Absolute (AL cm) and relative (RL %) length increasings a of *Luciobarbus esocinus* population in Keban Reservoir

Sexes	Growth rates	Age groups								
		I-II	II-III	III-IV	IV-V	V-VI	VI-VII	VII-VIII	VIII-IX	IX-X
Undefined	A.L.	6.33	3.40	-	-	-	-	-	-	-
	R.L.	22.25	9.80	-	-	-	-	-	-	-
♂	A.L.	-	6.52	6.11	5.34	4.43	4.00	3.85	7.44	-
	R.L.	-	17.44	13.93	10.68	8.00	6.70	6.03	11.00	-
♀	A.L.	-	9.05	7.23	6.12	5.63	5.30	4.21	-	10.94
	R.L.	-	25.58	16.27	11.85	9.75	8.36	6.12	-	15.00
All individuals	A.L.	7.41	6.32	8.67	5.73	5.03	4.65	4.56	4.29	8.75
	R.L.	26.07	17.65	20.58	11.27	8.90	7.55	6.88	6.05	11.64

Table 5. Absolute (AW g) and relative (RW %) weight increasing of *Luciobarbus esocinus* population in Keban Reservoir

Sexes	Growth rates	Age groups								
		I-II	II-III	III-IV	IV-V	V-VI	VI-VII	VII-VIII	VIII-IX	IX-X
Undefined	A.W	195.32	223.58	-	-	-	-	-	-	-
	R.W.	80.96	51.21	-	-	-	-	-	-	-
Male	A.W	-	510.43	612.69	601.15	578.36	428.11	425.43	3155.30	-
	R.W.	-	118.15	65.01	38.65	26.82	15.65	13.45	87.93	-
Female	A.W	-	530.33	563.92	516.52	508.67	440.40	389.40	-	3890.75
	R.W.	-	113.56	56.54	33.08	24.48	17.02	12.86	-	113.88
All individuals	A.W	203.94	421.44	691.56	558.84	543.52	434.25	407.42	3241.28	563.50
	R.W.	84.53	94.66	79.79	35.86	25.67	16.32	13.16	92.54	8.35

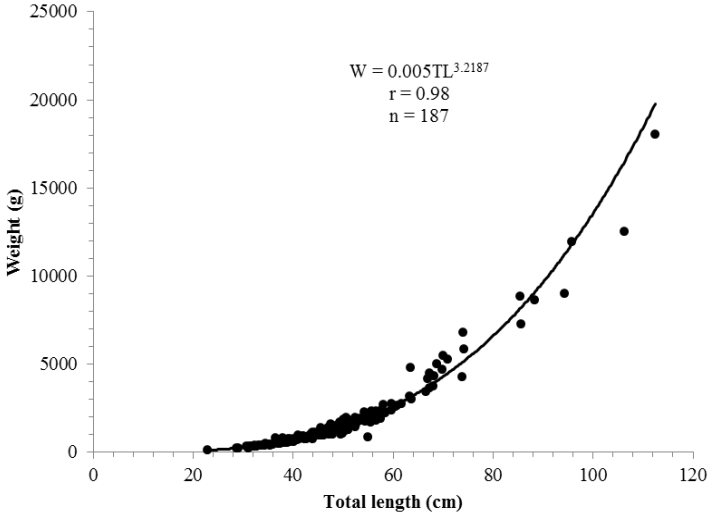

Figure 3. Length-weight relation of *Luciobarbus esocinus* population in Keban Reservoir.

based on the GSI and CF. It can be said that spawning period of *L. esocinus* in Keban Reservoir is between March-April due to the highest GSI values were estimated in March and the lowest CF values were estimated in January and February (Figure 4).

According to the age groups, condition factor increased until age 5 and after that it started to decline. The differences in condition between females and males were statistically significant at the age of 6 and 7; however, they were not significant in the other age groups (Table 6).

Discussion

Luciobarbus esocinus is a relatively large fish but their biological characteristics have not been well studied due to difficulties of its sampling. A total of 187 *L. esocinus* specimens (32 undefined, 85 males

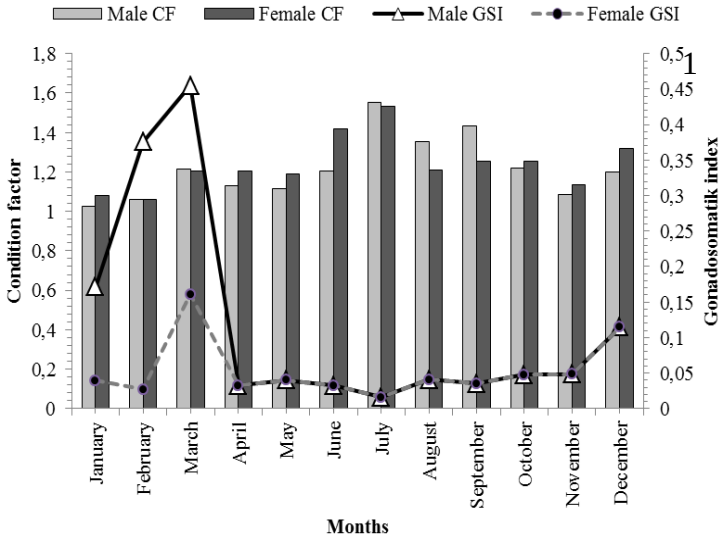

Figure 4. Monthly changes in Gonadosomatic Index (GSI) and Condition Factos of *Luciobarbus esocinus* population in Keban Reservoir according genders.

Table 6. The condition factors of *Luciobarbus esocinus* population in Keban Reservoir according to age and sex groups

Age	Undefined		Male		Female		t-test	All individuals	
	N	$\bar{X}$ ±S.e. (Min-Max)	N	$\bar{X}$ ±S.e. (Min-Max)	N	$\bar{X}$ ±S.e. (Min-Max)		N	$\bar{X}$ ±S.e. (Min-Max)
1	4	0.997±0.022 (0.951-1.044)	-	-	-	-	-	4	0.997±0.022 (0.951-1.044)
2	15	1.007±0.024 (0.822-1.142)	2	0.939±0.022 (0.917-0.962)	3	1.180±0.115 (0.955-1.336)	p>0.05	20	1.026±0.028 (0.822-1.336)
3	13	1.157±0.035 (0.987-1.443)	16	1.101±0.036 (0.867-1.404)	6	1.212±0.085 (0.875-1.456)	p>0.05	35	1.141±0.025 (0.867-1.456)
4	-	-	34	1.195±0.027 (0.855-1.706)	19	1.230±0.036 (0.981-1.762)	p>0.05	53	1.207±0.021 (0.855-1.762)
5	-	-	13	1.161±0.069 (0.528-1.504)	14	1.294±0.370 (0.960-1.863)	p>0.05	27	1.230±0.039 (0.528-1.863)
6	-	-	8	1.124±0.034 (0.988-1.272)	11	1.259±0.035 (0.985-1.371)	p<0.05*	19	1.202±0.029 (0.985-1.371)
7	-	-	5	1.106±0.042 (0.987-1.193)	7	1.238±0.021 (1.170-1.758)	p<0.05*	12	1.183±0.028 (0.987-1.758)
8	-	-	2	1.076±0.056 (1.007-1.145)	4	1.136±0.058 (1.007-1.273)	p>0.05	6	1.116±0.042 (1.007-1.273)
9	-	-	4	1.060±0.020 (1.008-1.105)	-	-	-	4	1.060±0.020 (1.008-1.105)
10	-	-	-	-	4	1.112±0.080 (0.909-1.304)	-	4	1.112±0.080 (0.909-1.304)
14	-	-	-	-	2	1.197±0.160 (1.036-1.358)	-	2	1.197±0.160 (1.036-1.358)
17	-	-	1	0.918	-	-	-	1	0.918

*Statistically significant

and 70 females) were investigated throughout the sampling period. Age group IV was dominant age group for both sexes. Similar finding was reported by Şen *et al*, (1996). The age groups were reported as from I to X (87 individuals and the most individuals are found to be in age group III) by Girgin and Şen (1995) and as from I to VII (81 individuals) by Şen *et al*. (1996). These differences may be due to fishing methods, sample size and different years (Nikolsky, 1980; Ünlü *et al*., 2000).

The distribution of the length ranged from 23 to 112.40 cm. The weight of the samples ranged from 118 g to 18042 g and the majority of individuals were between 1001-2000 g for both sexes. According the age groups, statistical differences between sexes were not determined for total lengths and weights ($p>0.05$). It was also determined that absolute and relative total length and weight growths were more for the young individuals and it declined in older individuals. Girgin and Şen (1995) reported that total lengths were between 215-1120 mm and weights were between 82-23200 g. Şen *et al*. (1996) determined that the average total lengths were between 15.30-52.88 cm and the average weights were between 26.23-1765.55 g.

In the present study, the exponent (*b*) in the length-weight relationships for males, females and all individuals (*b*= 3.098 for males, *b*= 3.282 for females and *b*= 3.218 for all individuals) indicated that growth in weight of *L. esocinus* was positive allometry. In previous study, *b* value was reported as *b*= 3.071 in Keban Reservoir (Girgin and Şen, 1995); *b*= 3.287 in Keban Reservoir (Şen *et al*, 1996); *b*= 3.017 in Lake Habbaniya and *b*= 3.085 in Lake Tharthar (Szypula *et al*., 2001). Our results about b coefficient is similar with the other studies results above, however, *b* value may vary the different stages in the ontogenetic development, and differences in age, maturity, sex and species (Türkmen *et al*., 2002; Alp *et al*., 2005).

In this study, maximum values of GSI in both sexes were observed in March, and GSI values rapidly decreased in April. Spawning period of *L. esocinus* in Keban Reservoir was determined in March-April and this species has a short spawning period. In previous studies, spawning period of *L. esocinus* were reported in April-May in Keban Dam Lake-Turkey (Şen *et al*., 1996); in March in the Turkish Tigris River (Ünlü, 2006); in April-May in Iraq (Al-Rudainy, 2008); in March in Iran and Iraq (Coad, 2011). Ünlü (2006) reported that *B. esocinus* individuals were lentic organisms and eggs between the big rocks and stones at the bottom of the rivers. While Al-Rudainy (2008) given sexual maturity as 10 years in Iraq, Ünlü (2006) given age at first maturity as 4 years in the Turkish Tigris River. Present study, with other studies were similarity in terms of findings of the spawning period.

The condition factor (CF) for *L. esocinus* in Keban Reservoir varied from 0.528 to 1.863 (Table 6). The lowest CF values for both sexes were estimated in January and February. According to age groups, CF increased until the age 5 and showed a decline after this age. Increase of CF until the age group V may result from this species late maturation. There was a strong relationship between the amount of germ cells produced in gonads and nutrition reserves in the muscles. As the gonadosomatic index values increases in a stock, their condition factor values declines (Avşar, 2005). Average CF values reported as between 0.813-1.019 by Girgin and Şen (1995); between 0.883-1.442 by Şen *et al*. (1996). Condition factor values change according to nutrition condition of the environment, fish age and stress condition and the reproduction activity of the fish (Korkut *et al*., 2007).

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