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Select biological characteristics of the mossul bleak *Alburnus mossulensis* Heckel, 1843 (Actinopterygii: Cyprinidae) in the Ataturk Dam Lake, Turkey

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ABSTRACT

Maturity, growth and reproductive characteristics of the mossul bleak *Alburnus mossulensis*, from Ataturk Dam Lake (Euphrates) were assessed. Maturity composition of the analysed samples varied between age groups I and VII. The ratio of females to males was 1.047:1. Fork length of the samples varied between 40-198 mm and weights were in the range of 0.45-68 g. The regression equations derived for the length-weight relationship was Log W = -5.5531+3.2958 Log FL (r2=0.9593) for females and Log W=-5.3695+3.2112 Log FL (r2=0.9487) for males. Mean condition factor was determined as 1.069 for females and 1.062 for males. Absolute fecundity was established to be between 288 and 3380. The age of sexual maturity was 3 years in females and 2 years in males.

Keywords: *Alburnus mossulensis,* Ataturk Dam Lake, Euphrates River, Growth, Maturity, Mossul bleak

Introduction

The mossul bleak *Alburnus mossulensis* Heckel, 1843 (Family: Cyprinideae) is widely distributed throughout Tigris and Euphrates river basins, Turkey and Syria (Kuru, 1979; Bogutskaya, 1997; Coad, 2010) and it is one of the commercially significant freshwater fish species in Ataturk Dam Lake (Oymak, 2000; Duman and Celik, 2001; Bayhan and Gocer, 2012). This species is found both in lentic and lotic environments (Unlu, 2014).

Despite being a small fish, *A. mossulensis* is commercially important in the region. Since it is a fast growing fish and an indiscriminate feeder (Coad, 2010), it can be a good source of inexpensive animal protein. This fish also has the potential to be used as a source of fish feed in aquaculture. Several studies have been done on the biology of *A. mossulensis* in Iraq (Barak, 1978; Jawad, 2004), Iran (Esmaeili and Ebrahimi, 2006; Parsa *et al*., 2011; Mousavi-Sabet *et al*., 2013) and Turkey (Ergene, 1993; Ozdemir *et al*., 1993; Turkmen and Akyurt, 2000; Yıldırım *et al*., 2003; Basusta and Cicek, 2006; Yildirim *et al*., 2007; Uckun and Gokce, 2014). However, there is not much documentation on the biological characteristics of this species in the Atatürk Dam Lake.

The aim of this study was to provide information about age, growth and condition factor, age at sexual maturity, spawning period and fecundity of this species from the Atatürk Dam Lake, which is one of the biggest dam lakes in the world.

Materials and methods

Ataturk Dam, with its 84.5 million m^3 fill volume and 169 m height above the foundation, is the sixth largest dam in the world in terms of fill volüme (Agan, 2016). It is located on the Euphrates River in south-east Anatolia, Turkey (Fig. 1). About 35 species constantly dwell the dam lake (Bozkurt, 1994). *Alburnus mossulensis* (Heckel, 1843); *Cyprinus carpio* (Linnaeus, 1758); *Acanthobrama marmid* (Heckel, 1843); *Liza abu* (Heckel, 1843); *Chondrostoma regium* (Heckel, 1843); *Capoetta trutta* (Heckel, 1843); *Carasobarbus luteus* (Heckel, 1843); *Mastacembelus mastacembelus* (Banks andSolander, 1794); *Cyprinion macrostomus* (Heckel, 1843); *Arabibarbus grypus* (Heckel, 1843) and *Luciobarbus mystaceus* (Pallas, 1814) are the main commercial fishes in the dam lake (Bozkurt, 1994; Oymak, 2000).

A total of 301 specimens were caught between October 2008 and September 2009 using sinking horizontal gillnets (100 m long, 2 m high and mesh size of 12 and 24 mm). Specimens were immediately transported to the laboratory in a portable icebox. Fish were identified

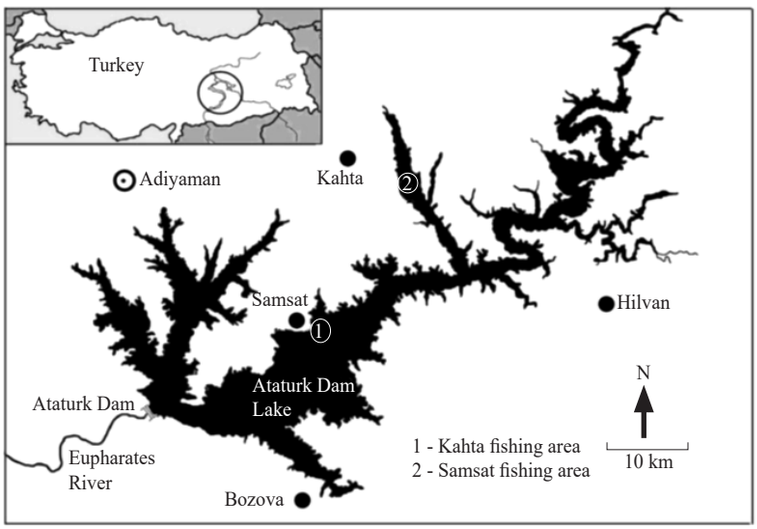

Fig. 1. Map of the study area (Oymak *et al.,* 2011)

to species level with the identification keys given by Kuru (1980).

Fork length (FL), weight (W) and gonad weight (GW) were measured to an accuracy of 1 mm, 1 g and 0.01 g, respectively. Sex in mature specimens was determined by visul examination of gonads, but microscopic examination was used for differentiating sex in juveniles (Unlu, 1991). The statistical significance of the sex ratio results was established by Chi-squared test (χ^2). Differences were considered statistically significant at $p<0.05$. Age was determined from scales (Ekingen and Polat, 1987). For this purpose, approximately 10 scales from each fish were mounted between two glass microscope slides and they were assessed by Kindermann microfiche reader. Maturity of samples was determined monthly by internal examination.

The formula $L_t = L\infty[1-e^{-k(t-to)}]$ was used to describe the age-length relationship. Length-weight regression was carried out by the least squares method on logarithmic converted data by the equation $W=aL^b$ (Le Cren, 1951; Tesch, 1968; Ricker, 1968). Analyses of variance (ANOVA) was done to detect the statistical significance between the length-weight relationship of male and female. Condition factor was assessed using the formula K=Wx105/L3 (Tesch, 1968). One-way ANOVA was used to test the similarity in condition index between months. Statistical differences between females and males in condition index was sudied using Student's t-test. The average age at which 50% of fishes mature was taken to be the age at first maturity (Oymak *et al*., 2011) and the length corresponding to this age was taken as the length at first maturity.

The monthly gonado-somatic index (GSI) was calculated using the formula given by Tesch (1968) to identify the spawning period:

GSI=*GW* x 100 / *W-GW*

where *W* = body weight, *GW* = gonad weight.

Absolute fecundity was estimated gravimetrically (Laevastu, 1965) from samples drawn from mature ovaries during the spawning season (April and May). Regression equations describing relationships between fecundity (F) and fork length (FL), fecundity and body weight (W) and fecundity and gonad weight (GW) were calculated using the following formula:

Log F = log a + b log FL; Log *F* = log a + b log W; Log F = log a + b log GW;

where F = number of eggs, L = fork length (mm), W= body length (g) and GW= gonad weight (g) (Unlu *et al*., 1994; Oymak *et al*., 2011).

Results and discussion

Age and sex composition

In this study, 154 females and 147 males (301 in total) were examined. The overall ratio of females to males was found to be 1.05:1 and χ^2 analysis showed that this was not statistically significant ($\chi^2 = 0.162$, $p>0.05$).

Age of the fish ranged from 1 to 7 years. Age group IV was the dominant age group for both sexes (Table 1). In two separate studies, in the Karasu River, the age groups were defined to be I-V and I-VII for *Chalcalburnus mossulensis*, a synonym of the species *A. mossulensis* (Turkmen and Akyurt, 2000; Yildirim *et al*., 2003) and in Karakaya Dam Lake, age groups of 0-IV (Uckun and Gokce, 2014) were established for *A. mossulensis*.

Table 1. Age distribution of *A. mossulensis* from Ataturk Dam Lake, Turkey (N=number of specimens)

Age Groups	Female		Male		Total	
	N	%	N	%	N	%
I	1	0.33	4	1.33	5	1.66
II	0	0	26	8.64	26	8.64
III	10	3.32	28	9.3	38	12.62
IV	95	31.56	74	24.59	169	56.15
V	35	11.63	13	4.32	48	15.95
VI	11	3.65	2	0.66	13	4.32
VII	2	0.66	0	0	2	0.66
Total	154	51.15	147	48.85	301	100

Length and weight composition

The length distribution of the species was 40-198 mm and the majority of the fishes measured 150-175 mm (Fig. 2). Weight of *A. mossulensis* samples ranged between 0.45 and 68 g and the majority weighed 30-50 g (Fig. 2).

In two separate studies from the Karasu River, the fork lengths were in the range 85-185 mm and 94-195 mm (Turkmen and Akyurt, 2000; Yildirim *et al*., 2003), while the total lengths of individual specimens in Ataturk Dam Lake were 83-242 mm (Basusta and Cicek, 2006). Fork lengths of the species reported in Iran were 36-93 mm (Esmaeili and Ebrahimi, 2006) and the total lengths reported from Gamasiab River were 70-155 mm (Mousavi-Sabet *et al*., 2013) while the values in Karakaya Dam Lake were found to be between 108-190 mm (Uckun and Gokce, 2014). The difference in the size range in different localities is attributed to the changes in the biotic and abiotic factors between the environments and fishing periods (Emmrich *et al*., 2014). In our study, the weight of the individual specimens ranged between 0.45-68 g. In studies from different localities, including two separate studies in the Karasu River, the values recorded were 3.64-79.5 g and 67.93-86.5 g (Turkmen and Akyurt, 2000; Yildirim *et al*., 2003). The weight of individual specimens in Gamasiab River were between 6.3-54.6 g (Mousavi-Sabet *et al*., 2013). Individual specimens in Karakaya Dam Lake have been identified to vary in weight between 16.87-56.57 g (Uckun and Gokce, 2014).

Growth in length

The length values of *A. mossulensis* calculated for each age group are summarised in Table 2

The lemgth-at-age equations of *A. mossulensis* calculated according to von Bertalanffy, for females, males and sexes combined were:

Female : $L_t = 235.69\ [1\text{-}e^{-0.21742(t-(-1.4271))}]$

Male : $L_t = 205.293\ [1\text{-}e^{-0.47692(t-0.3757)}]$

Sexes pooled : $L_t = 207.544\ [1\text{-}e^{-0.3966(t-(-0,0078))}]$

It was estimated that the females had higher L∞ (235.69 mm) and lower low K (0.21742) values than males (L∞= 205.293 mm and K = 0.47692). The age-length relationship curve of *A. mossulensis* is shown in Fig. 3.

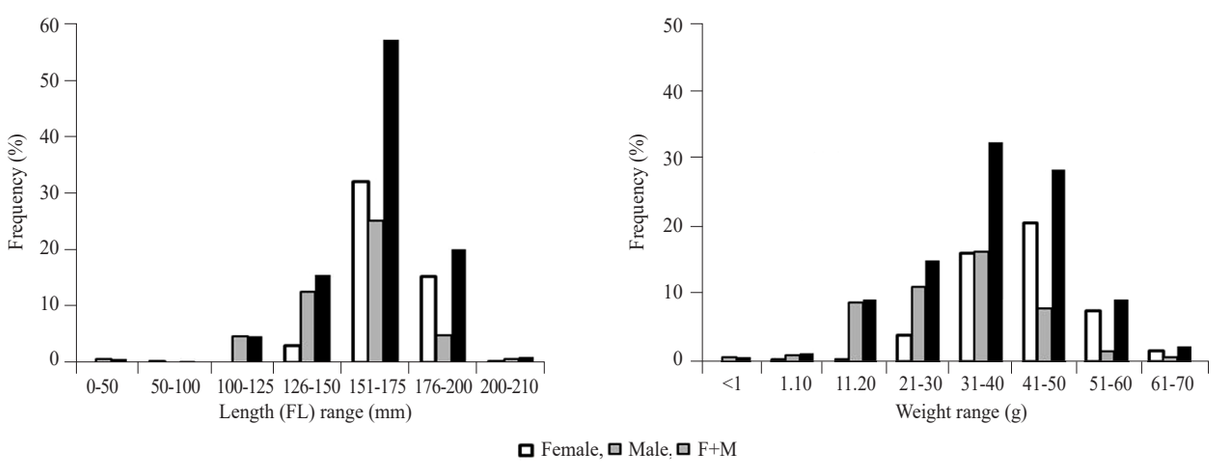

Fig. 2. Length and weight composition of *A. mossulensis* from Ataturk Dam Lake

Table 2. Length (mm) of *A. mossulensis* from the Ataturk Dam Lake

Age groups	Female		Male		Statistical differences between sexes	
	N	Mean±SD (min-max)	N	Mean±SD (min-max)	Student's t-test	p
I	1	8	4	73.00±35.29 (40-105)		
II	-	-	26	128.58±10.00 (110-150)		
III	10	149.6±9.92 (140-170)	28	147.86±10.33 (125-162)	0.3812	0.3527
IV	95	165.62±8.81 (150-195)	74	163.74±8.39 (145-182)	1.4041	0.0811
V	35	179.17±7.12 (163-193)	13	187.69±7.33 (175-205)	-3.6566	0.0003*
VI	11	191.5±8.58 (175-205)	2	196.50±12.02 (188-205)	-0.9451	0.1824
VII	2	198	-	-		

*=Significantly different ($p<0.05$)

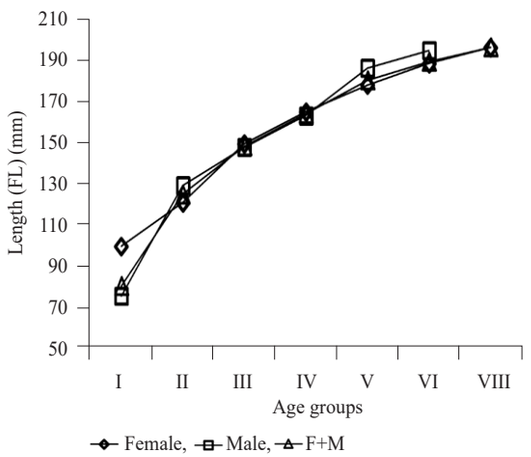

Fig. 3. Age-length relationship curves of *A. mossulensis* in Ataturk Dam Lake

Growth in weight

The weights in the different age groups of *A. mossulensis* with their absolute growth in weight are given in Table 3. The differences in weight are statistically significant between females and males of age group IV ($p<0.001$), while in the other age groups the differences are not statistically significant ($p>0.05$).

Length-weight relationship

The length-weight equations were derived as:

Female : log W = -5.5531 + 3.2958 log FL (r^2=0.9593)
Male : log W = -5.3695 + 3.2112 log FL (r^2=0.9487)
Sexes pooled F+M : log W = -5.4953 + 3.2695 log FL (r^2=0.9563)

The "b" values of both sexes indicated positive allometric growth. The curves of the length-weight relationship obtained from these equations are shown in Fig. 4.

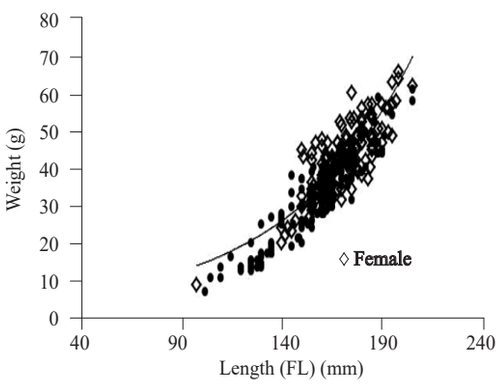

Fig. 4. Length-weight relationship of *A. mossulensis* from Ataturk Dam Lake

Table 3. Weight (g) of *A. mossulensis* from the Ataturk Dam Lake

Age groups	Female		Male		Statistical differences between sexes	
	N	Mean±SD (min-max)	N	Mean±SD (min-max)	Student's t-test	p
I	1	8	4	4.24±4.64 (0.45-10)		
II	-	-	26	15.27±2.81 (10-21)		
III	10	25.90±4.33 (20-35)	28	25.54±3.11(17-30)	0.2862	0.3882
IV	95	39.56±5.70 (30-54)	74	36.70±4.74 (29-48)	3.4723	0.0003*
V	35	50.14±3.15 (45-56)	15	50.62±5.52 (45-63)	-0.3721	0.3558
VI	11	60.09±2.47 (58-65)	2	60.50±0.71 (60-61)	-0.2252	0.4130
VII	2	67±1.41(66-68)	-	-		

*= Significantly different ($p<0.05$)

Condition factor

The condition factor of *A. mossulensis* ranged between 0.4478 and 1.4770 in females and between 0.1866 and 1.4893 in males (Table 4). The differences in condition factor between sexes in the same age group were not statistically significant between the individuals of age groups ($p>0.05$) except age groups IV and V ($p<0.05$).

In terms of monthly changes in condition factor, significant differences were seen between the months for both females (ANOVA, F=9.8181, p=0.000) and males (ANOVA, F=17.8585, p=0.000). The values for both sexes were highest in April and lowest in December (Fig. 5).

The mean condition factor of *A. mossulensis* in Karasu River was calculated as 1.047 for females and 1.023 for males (Turkmen and Akyurt, 2000). The condition factor of the same species in the Gamasiab River was between 0.20 to 2.51 for females and 0.32 to 2.01 for males (Mousavi-Sabet *et al*., 2013). Average condition factors in specimens in Karakaya Dam Lake were found to be 0.90 ±0.1 for females and 0.84 ± 0.11 for males (Uckun and Gokce, 2014). The condition factor of *A. mossulensis* species shows significant similarities compared to other species, such as *Alburnus esherichii* (Cetinkaya *et al*., 2015) and *A. alburnus* (Stavrescu-Bedivan *et al*., 2017). The condition factor is an index reflecting interaction between biotic and abiotic factors in the physiological conditions of fishes (Nikolsky, 1963).

In our study, the values of condition factor for both sexes were highest in April, and lowest in December. This value in the Karasu River however, was at its highest level between March and May; it declined in June because of spawning times and was lowest in December (Turkmen and Akyurt, 2000). In the Gamasiab River it was highest in May and lowest in August (Mousavi-Sabet *et al*., 2013); in the Karakay Dam Lake it was identified to be highest in May and lowest in September (Uckun and Gokce, 2014). Condition factor values showed a parallel increase with progressive gonad development and positively correlated with increase in gonad weight.

Age and size at first maturity

The age at sexual maturity of *A. mossulensis* was 2+ in males (Table 5). Due to lack of female specimens in the 2+ age group, the age at sexual maturity in female *A. mossulensis* could not be assessed. However, all samples at age 3 and over were found to be mature. The mean fork length of mature males was 128.6 mm and 149.6 mm in females. The mean weight of males was 15.27 g and 25.90 g in females.

Table 4. Condition factor of the different age groups of *A. mossulensis* from Ataturk Dam Lake

Age groups	Female		Male		Differences between female and male	
	N	Mean±SD (min-max)	N	Mean±SD (min-max)	Student's t test	p
I	1	0.8499	4	0.5583±0.2633 (0.1866-0.7815)	0.5237	0.3464
II	-	-	26	0.7237±0.1716 (0.2791-1.2021)		
III	10	0.6381±0.1365 (0.4478-0.8017)	28	0.8363±0.1617 (0.6445-1.2800)	-0.6428	0.2621
IV	95	0.9210±0.3726 (0.5107-4.2499)	74	0.8416±0.1475 (0.4316-1.2793)	1.6871	0.0467*
V	35	0.8974±0.1563 (0.6998-1.4770)	13	0.8146±0.1006 (0.6707-1.0000)	3.5043	0.0005*
VI	11	0.9498±0.1603 (0.7429-1.2009)	2	1.0929±0.5606 (0.6965-1.4893)	0.8160	0.2159
VII	2	0.8211±0.0777 (0.7661-0.8760)	-	-		

*= Significantly different ($p<0.05$)

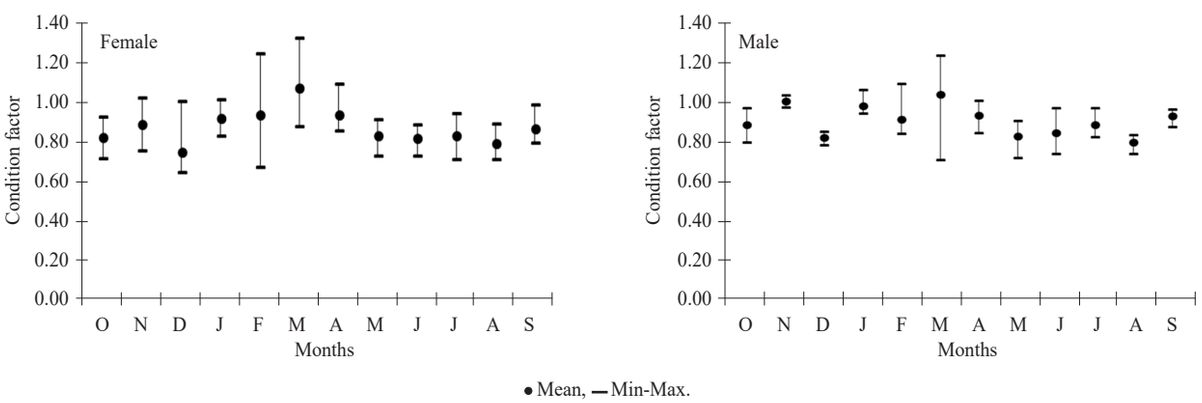

Fig. 5. Annual cycle of condition factor of *A. mossulensis* from Ataturk Dam Lake between October 2008 and September 2009

Table 5. The age at maturity of females and males of *A. mossulensis* from Ataturk Dam Lake

		I	II	III	IV	V	VI	VII
Female	Immature	1	-	0	0	0	0	0
	%	100	-	0	0	0	0	0
	Mature	-	-	10	95	35	11	2
	%	0	-	100	100	100	100	100
Male	Immature	4	1	0	0	0	0	0
	%	100	3.85	0	0	0	0	0
	Mature	-	25	28	74	13	2	2
	%	-	96.15	100	100	100	100	100

Spawning season

Identification of the spawning season of *A. mossulensis* population in Ataturk Dam Lake was done based on the gonado-somatic index (GSI) values, analysis of development in mean egg diameter and direct observation of the gonads (Fig. 6). There was marked individual variation in the pattern of monthly GSI values; high values were observed in the samples caught in the spring months*, i.e.,* March, April and May, while in June, there was a decrease in the GSI values since most of the individuls spawned in May. In Karakaya Dam Lake, GSI values were found to be highest in May, with the lowest value in October for males and December for females (Uckun and Gokce, 2014).

The mean egg diameter was highest in April and lowest in August, when the ovaries comprised only developing oocytes (Fig. 6). Based on these observations it was concluded that the species is ready for reproductive activity from April and peak spawning period of *A. mossulensis* population in Ataturk Dam Lake was in May.

Fecundity

Absolute fecundity in *A. mossulensis* was found to be low and ranged from 288 to 3380. A positive correlation was determined between fecundity and fish length, fish weight and gonad weight, and the regression equations derived are given below:

$\log F = -0.103 + 1.771 \log FL$ $r^2=0.467$ $p>0.05$
$\log F = -2.539 + 0.668 \log W$ $r^2=0.524$ $p<0.05$
$\log F = -4.516 + 0.215 \log GW$ $r^2=0.265$ $p<0.05$

It is well known that fecundity is affected by age, size, feeding, season and environmental conditions (Hanson,

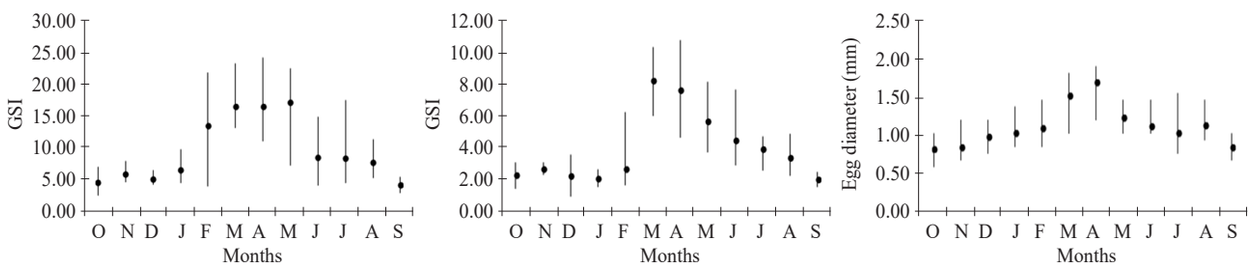

Fig. 6. Annual GSI (a: Female, b: Male) and egg diameter (c) of *A. mossulensis* from Ataturk Dam Lake between October 2008 and September 2009

2009). Fecundity recorded in the present study was much lower than that reported by Yildirim *et al.* (2007) in Karasu River (3000-11000) and by Keivany *et al.* (2017b) in Bibi-Sayyedan River in Iran (2000-10000).

Acknowledgements

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