Age and growth of *Alburnus mossulensis* (Cyprinidae) in Bibi-Sayyedan River of Isfahan Province

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Abstract

Population structure and growth of Mossul bleak, *Alburnus mossulensis*, a native species of cyprinids in Bibi-Sayyedan River of Semirom, Isfahan, were investigated by monthly sampling during December 2010 to December 2011. For this purpose, 543 speciments (353 females, 159 males and 31 immature) were caught using seine net (5 mm mesh size) and a cast net. Age groups of males and females were 0^+ to 5^+. The most frequent age group was 2^+ in both sexes. The sex ratio was 1M:2.2F (p<0.01). Males outnumbered the females in younger age classes and females outnumbered the males in older age groups. The highest condition factor was observed in April for males and in March for females. The mean condition factor (CF) was not significantly different between the sexes among all fish during different months (p>0.05). The largest female was 16.80 cm in total length and 49.12 g in weight, while the largest male was 14.10 cm in total length and 28.19 g in body weight. The length-weight relationship was calculated as $W = 0.0169L^{3.0355}$ (r^2=0.95) for males, $W=0.0061L^{3.1751}$ (r^2=0.98) for females and $W=0.0066L^{3.139}$ (r^2=0.99) for all fish (males, females and immature). Regression coefficient (b) based on Pauly test, was significantly different from 3 in females, but not in males (p<0.05), indicating an isometric growth pattern in males and a positive allometric growth pattern in females and all fish.

Keywords: Age, Growth patern, Length-weight relationship, Sex ratio

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Introduction

The Mossul bleak or Shah-kuli Jonobi (in Farsi) is a cyprinid fish (Nelson *et al*., 2016) widely distributed in Iran and its adjacent countries. This species is found in the Tigris (Karun and Karkheh river basins), Fars, Bushehr and Hormuz basins in Iran (Keivany *et al.* 2016b; Coad, 2017; Esmaeili *et al.* 2017), however, the biology of this species is not well documented in Iran and other countries, partly because this fish is not of commercial importance due to its slow growth rate and small size. Nevertheless, it is used as an edible fish on a local scale and hence, there is no information on its landings.

Ergene (1993) studied the reproduction and growth of this species in the Euphrates Basin of Turkey. Turkmen and Akyurt (2000) studied the population structure and growth properties of the species in Karasu River. Epler *et al*. (2001) and Hussain *et al.* (2001) studied this species in Iraq. Yildırım *et al.* (2003) studied the population structure and growth properties of the species in Karasu River. Başusta and Çiçek (2006) studied the length-weight relationships for this fish in Ataturk Dam Lake in southeastern Anatolia, Turkey. Yildirim *et al.* (2007) studied the reproduction and growth of this species in the Euphrates Basin of Turkey. Jawad *et al*. (2009) studied the relationship between opercular girth, maximum girth and total length of this fish in the estuarine and lower river sections of Shatt Al- Arab River (Iraq). Ghorbani (2011) studied the reproductive biology and population dynamics of the fish in Bibi-Sayyedan River of Tigris basin in Iran. Mousavi-Sabet *et al.* (2013, 2014) studied the length-weight relationships and condition factor of the fish in the Persian Gulf basins. Dorafshan *et al.* (2014) studied the genetic differentiation in *Alburnus mossulensis* using simple sequence repeats**.** Esmaeili *et al.* (2014) studied the LWR in this species in Iran. Abdul-Razak *et al.* (2015) studied some biological aspects of this species in the southern reaches of Euphrates River, Iraq. Alkan Uçkun and Gökçe (2015) assessed the age, growth, and reproduction of *A. mossulensis* in Karakaya Dam Lake (Turkey). Keivany *et al.* (2017) studied the reproductive biology and morphological diversity of *Alburnus mossulensis* populations in Iran. Keivany *et al.* (2015, 2016a,), Radkhah (2016) and Keivany and Zamani-Faradonbeh (2017) studied the length-weight relationship and condition factor of *A. mossulensis* in Beheshtabad River, Bibi-Sayyedan River, Hamzeh-Ali Spring and Jarrahi River. However, there is little information on its growth parameters in inland waters of Iran. The aim of this study was to investigate the population characteristics of *A. mossulensis* in Bibi-Sayyedan River of Semirom, a tributary of Karun River system in the Tigris basin. The results of this study could be used for conservation and management purposes of this species in the region.

Materials and methods

Sampling

Bibi-Sayyedan River flows south-westward from the heights of the central part of Zagros Mountain, joining Marbor River and terminating in Khersan River a tributary of Karun River (Tigris basin). For this study, 446 specimens were caught by monthly sampling from December 2010 to December 2011 from Bibi-Sayyedan River. Specimens were caught using a seine net (5 mm mesh size) anesthetized in 1% clove oil solution and transported to the laboratory on ice for biometric measurements. Water temperature was measured by a digital thermometer. The recorded water temperature during the 13-month study period varied from 10.5ºC to 21.4ºC.

Measurments and age determination

Total length (TL) was measured to the nearest 0.01 cm and the total weight (W) to the nearest 0.01 g. The individuals were sexed by macroscopic examination of the gonads. The age was determined by reading growth rings on the sclaes and opercula under a compound microscope using reflected light. Also, the age reading was performed by three investigators and only coincident readings were accepted to assure the accuracy of the readings (Biswas, 1993).

Condition factor and growth parameters

The condition factor was measured using the equation $Cf = (W/L^3)\times 100$, where, W=weight of fish (g), L=total length of fish (cm). Parameters of the length-weight relationship were calculated for both sexes and for the whole sample, by fitting the power function to length and weight data using equation $W=aL^b$ (Froese, 2006) where, W = weight of fish (g), L= total length of fish (cm), a = intercept, and b is the slope. Pauly (1984) t-test was used to determine if the slope of relationships was significantly different from 3. Sex was determined by dissection and examination of the fish gonads. The relationships between age and length, age and weight were also calculated by regression.

Statistical analyses

Statistical differences between the means were determined by Independent-sample *t*-test. In order to test for possible significant differences between the sex ratio from the 1:1 ratio, chi-square test was used. The degree of association between the variables was computed by the determination coefficient, r^2. All the statistical analyses were performed at 95% confidence limits using Excel 2013 and SPSS.20 computer software.

Results

The total length of females ranged from 4.50-16.80 cm (mean=10.80±2.38 cm) and that of the males from 4.60-14.10 cm (mean=10.19±1.98 cm) and their weight ranged between 0.72 and 55.67 g (mean=13.79±9.03 g) and between 0.91 and 30.91 g (mean=10.81±5.94 g),

respectively (Table 1). The length frequency is presented in Fig. 1. The length class interval 10-12 cm was the most aboundant for both males and females. The females were larger in length and weight.

Table 1: Total length and weight in males and females of *Alburnus mossulensis* during December 2010 to December 2011in different months.

Months	Sex	Counts	Total length (cm)		Weight (g)	
			Min-Max	Mean±SD	Min-Max	Mean±SD
December 2010	Male	2	9.50-9.70	9.60±1.32	7.78-7.85	7.81±0.55
	Female	20	5.80-14.20	8.53±2.40	1.57-29.59	7.49±7.17
January 2011	Male	7	7.44-11.00	9.51±1.45	3.36-13.03	8.50±3.85
	Female	36	4.50-14.60	8.62±2.42	0.72-30.90	7.44±7.07
February	Male	14	4.60-11.80	7.27±1.85	0.91-16.65	4.46±4.19
	Female	15	5.70-14.00	9.86±2.42	1.55-27.82	11.54±8.28
March	Male	26	7.50-13.80	10.79±1.39	4.61-30.91	13.98±6.12
	Female	24	8.00-13.20	10.50±1.41	5.25-23.89	12.98±5.42
April	Male	22	6.30-12.70	8.79±2.19	1.90-22.6	8.66±6.56
	Female	27	5.50-13.60	8.98±2.34	1.36-27.92	9.08±7.96
May	Male	13	10.30-14.10	12.13±1.13	8.79-28.19	17.27±5.37
	Female	37	10.40-16.00	12.98±1.73	10.12-41.49	21.99±8.68
June	Male	13	7.90-12.40	10.10±1.55	3.94-16.93	9.13±4.16
	Female	37	7.80-16.30	10.67±1.88	0.75-38.95	11.91±7.53
July	Male	5	9.50-13.50	11.74±1.70	7.69-20.83	14.15±5.16
	Female	39	7.40-14.00	10.64±1.54	3.24-26.90	12.06±5.5
August	Male	13	9.90-12.30	10.72±1.76	8.19-17.58	11.16±2.69
	Female	37	9.10-15.20	11.95±1.35	8.07-28.76	16.36±5.23
September	Male	10	10.00-12.40	11.03±0.91	8.87-17.58	12.78±3.88
	Female	40	9.30-16.80	11.96±1.89	7.04-49.12	17.49±9.99
October	Male	18	9.80-13.50	11.24±1.01	4.43-18.98	10.78±4.00
	Female	19	9.20-16.40	12.26±1.78	5.17-37.38	15.37±7.65
November	Male	11	7.00-14.10	14.10±2.27	2.56-26.51	9.52±6.73
	Female	12	6.70-16.70	10.91±2.63	1.63-55.67	16.24±15.91
December 2011	Male	6	7.00-11.50	12.96±2.01	0.91-30.91	10.81±5.94
	Female	10	7.20-14.50	11.48±2.35	2.35-40.27	20.45±10.76

Amongst the 512 mature specimens of *A. mossulensis* used for the length-weight relationship, 159 were males (30%), while 353 were females (70%), indicating a sex ratio of 1M: 2.2F. The results of length weight relationship indicated a positive allometric growth pattern for females ($W= 0.0061L^{3.1751}$, $r^2=0.97$) and all fish (male, female and immature) ($W= 0.0066\ L^{3.1392}$, $r^2=0.98$) ($p<0.05$), and an isometric for males ($W=0.0084\ L^{3.0355}$, $r^2=0.95$) and (Fig. 2).

The mean monthly condition factor ranged from 0.49 to 0.98 and the mean in males was 0.61 and in females was 0.84.

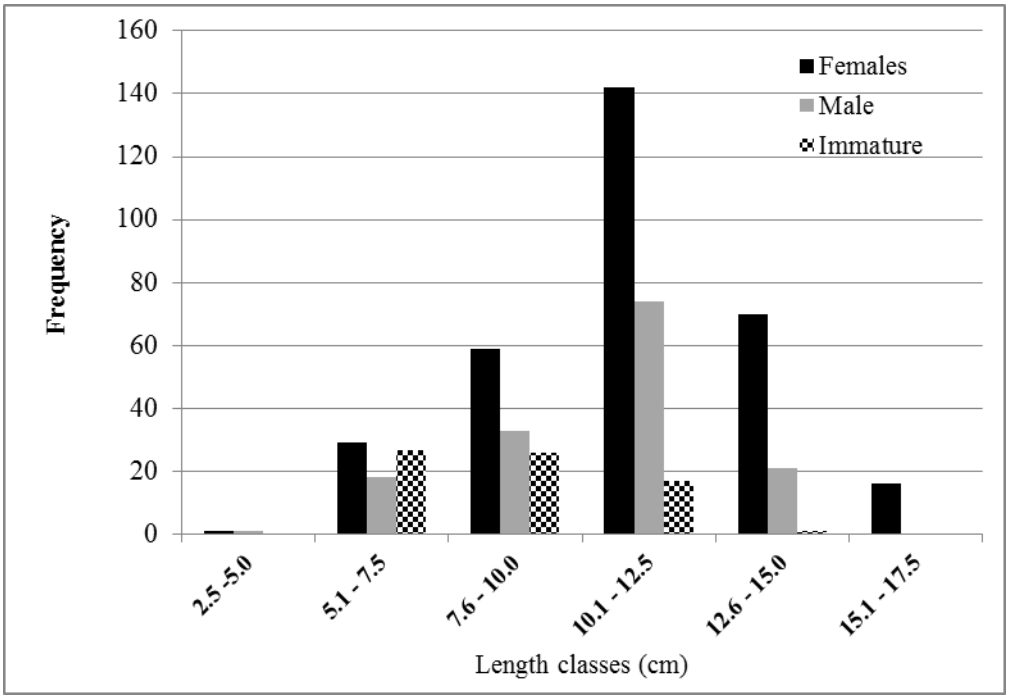


Figure 1: Length frequencies of *Alburnus mossulensis* in Bibi-Sayyedan River during December 2010 to December 2011.

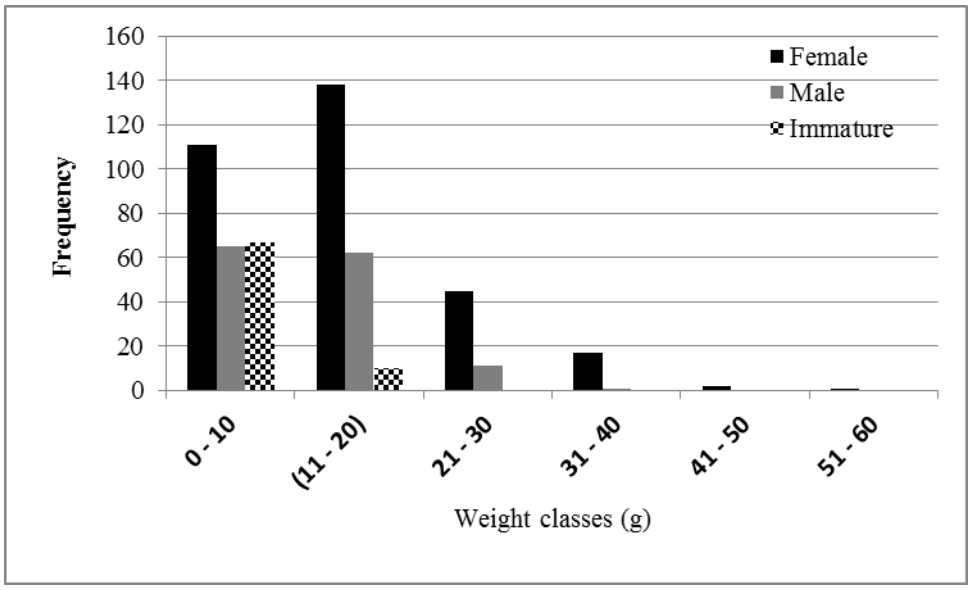


Figure 2: Weight frequencies of *Alburnus mossulensis* in Bibi-Sayyedan River during December 2010 to December 2011.

The differences between females and males in the same age groups were not significant (p>0.05) and followed the same trend in both sexes (Fig. 4.).

The age of the specimens ranged between 0^+ and 5^+. The age class 2^+ was the most frequent for both males and females (Fig. 5).

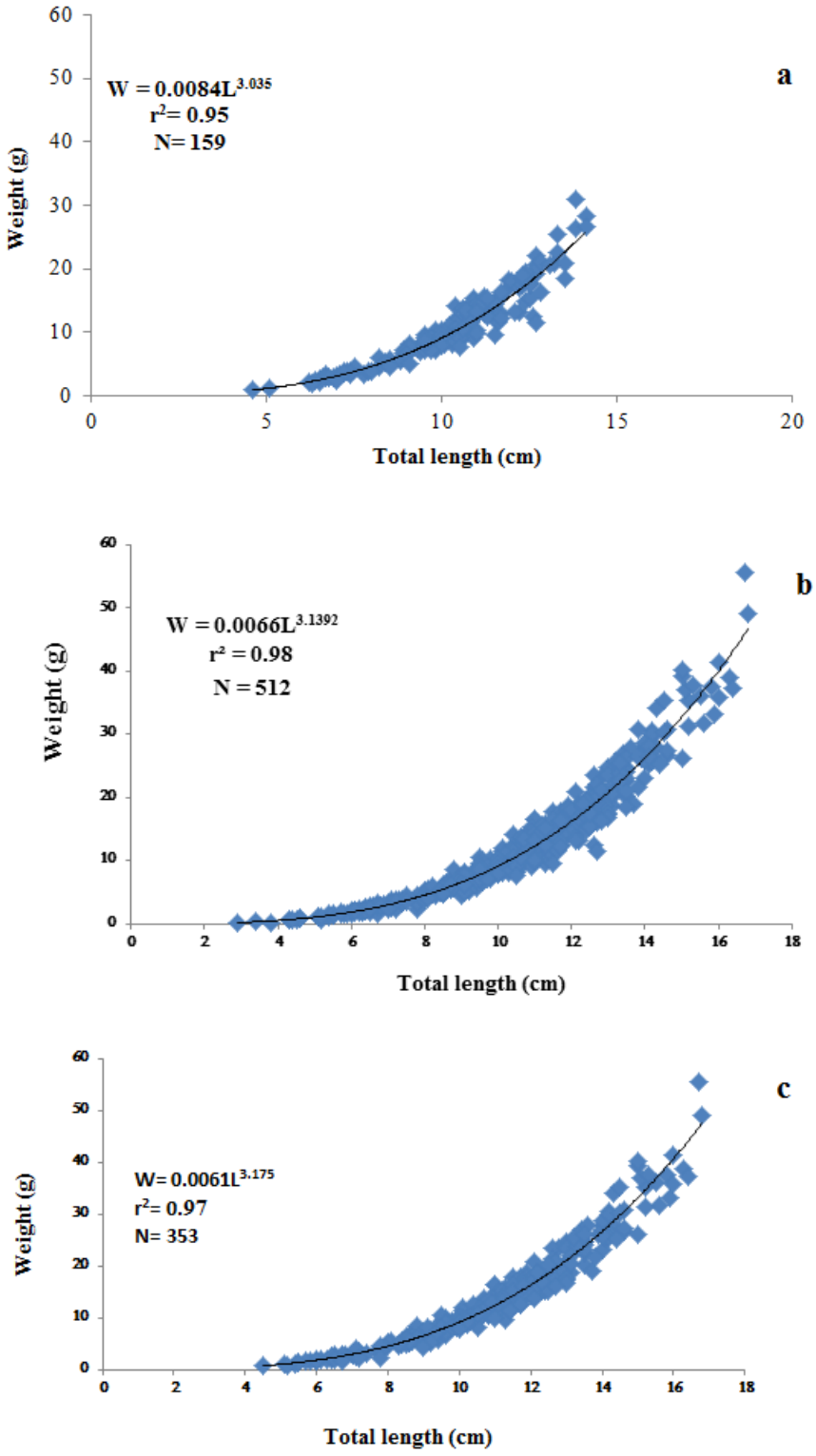


Figure 3: Length-weight relationships in males (a), females (b) and all fish (c) of *Alburnus mossulensis* during December 2010 to December 2011.

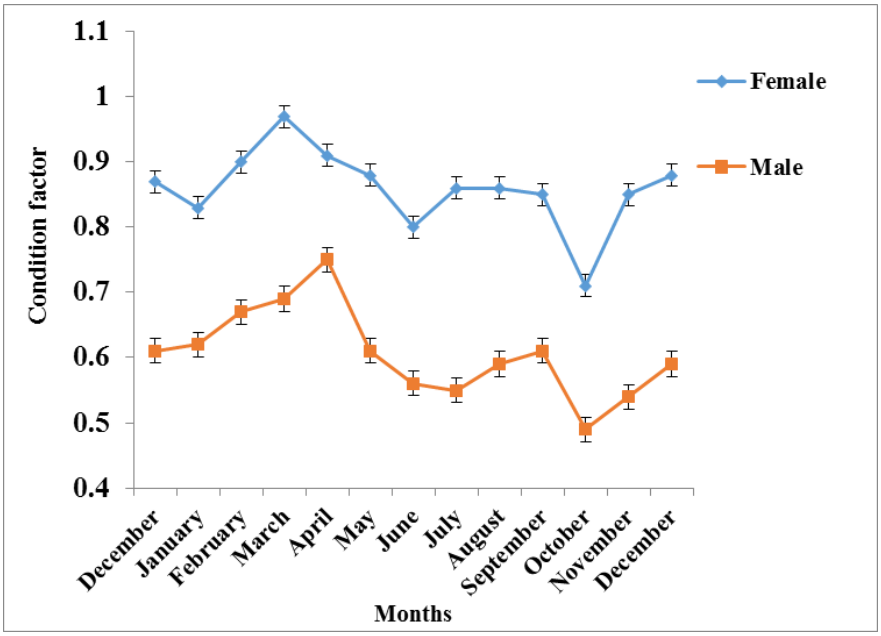


Figure 4: Mean condition factor and standard error in different months for males and females of *Alburnus mossulensis* during December 2010 to December 2011.

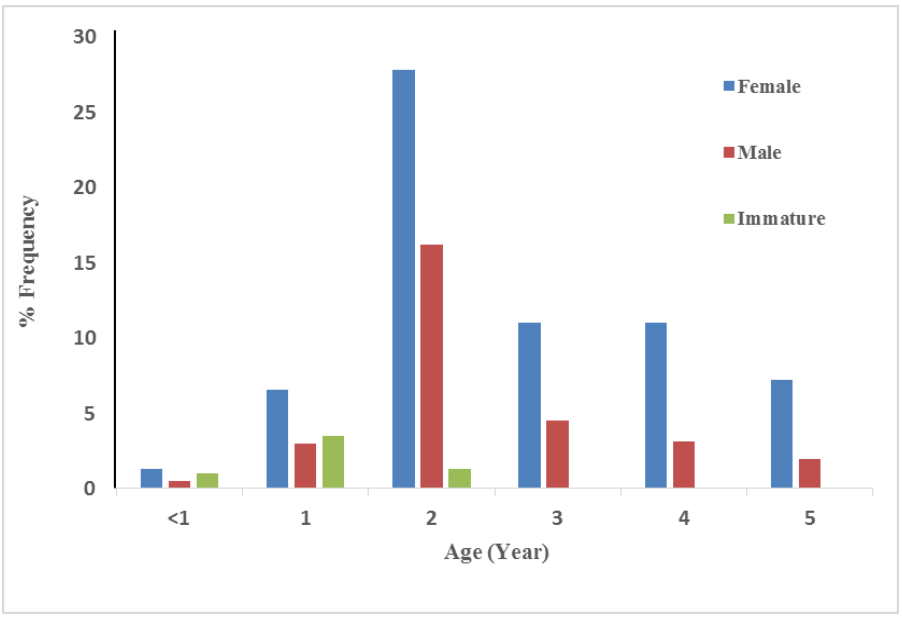


Figure 5: Age class frequency in females, males and immature *Alburnus mossulensis* during December 2010 to December 2011.

The age-length and age-weight relationship is provided in Figs. 6 and 7. Both are moderately correlated (r^2=0.60). The females reached maturity at age 2 and total length of 5.3-9.9 cm and males at age 1 (year) and total length of 4.60-9.10 cm.

The general sex ratio was 1M: 2.2F which showed a significant difference from the expected ratio (p>0.05). The sex ratio in different months and age classes are provided in Tables 2 and 3.

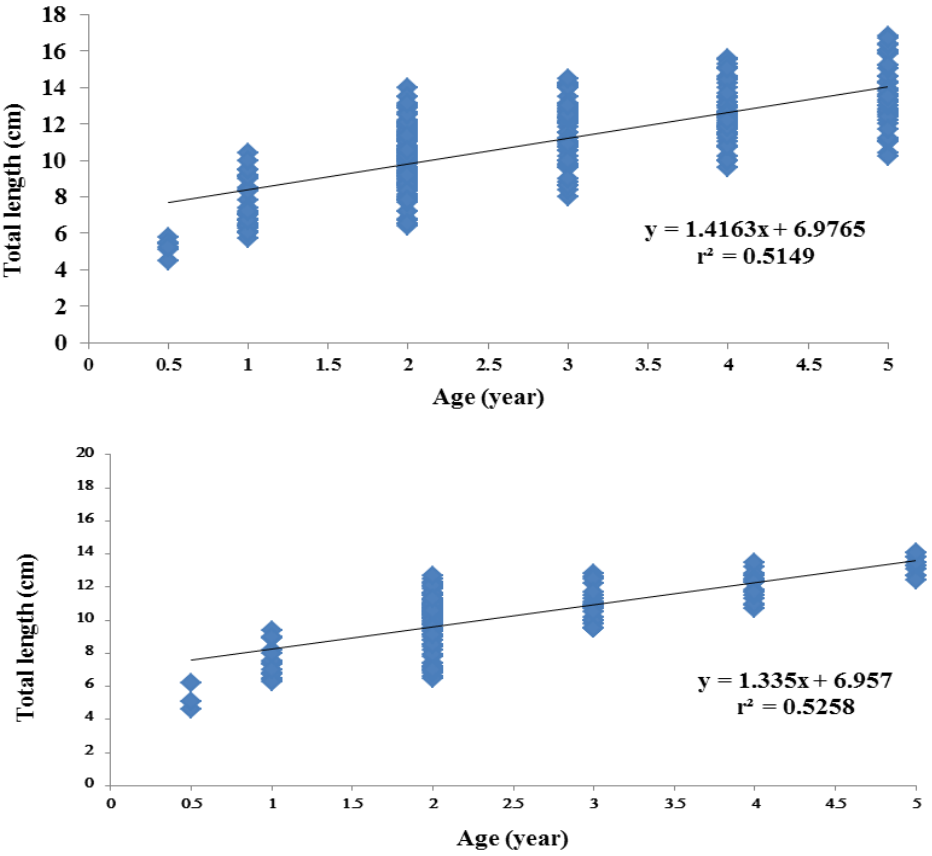
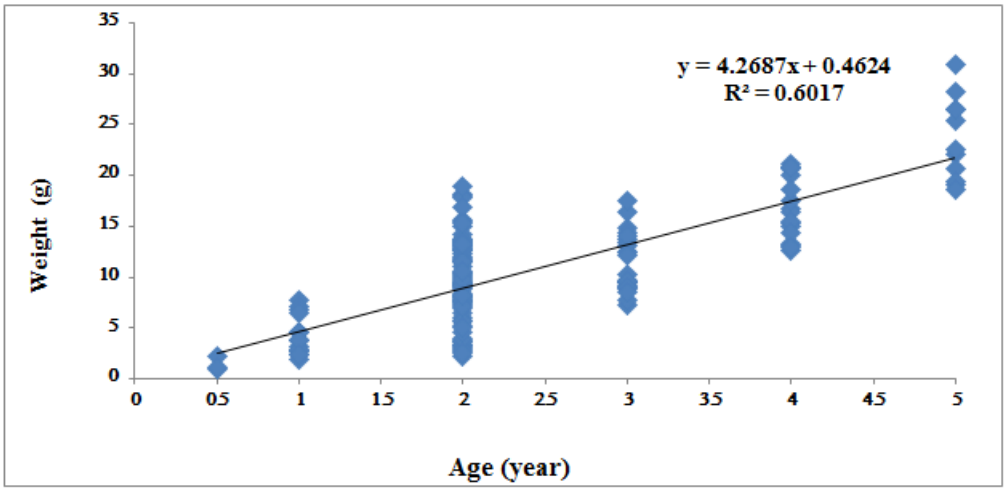


Figure 6: Age-length relationships in females (top) and males (bottom) of *Alburnus mossulensis* during December 2010 to December 2011.

Table 2: Sex ratio in different months of *Alburnus mossulensis* during December 2010 to December 2011. Stars indicate significant differences.

Month	M/F	X^2
December 2010	0.10	14.72*
January 2011	0.19	19.56*
February	0.93	0.03
March	1.08	0.08
April	0.81	0.51
May	0.35	11.52*
June	0.32	12.75*
July	0.13	26.27*
August	0.35	11.52*
September	0.25	18.00*
October	0.95	0.03
November	0.95	0.04
December 2011	0.60	1.00
Total	0.45	73.50*



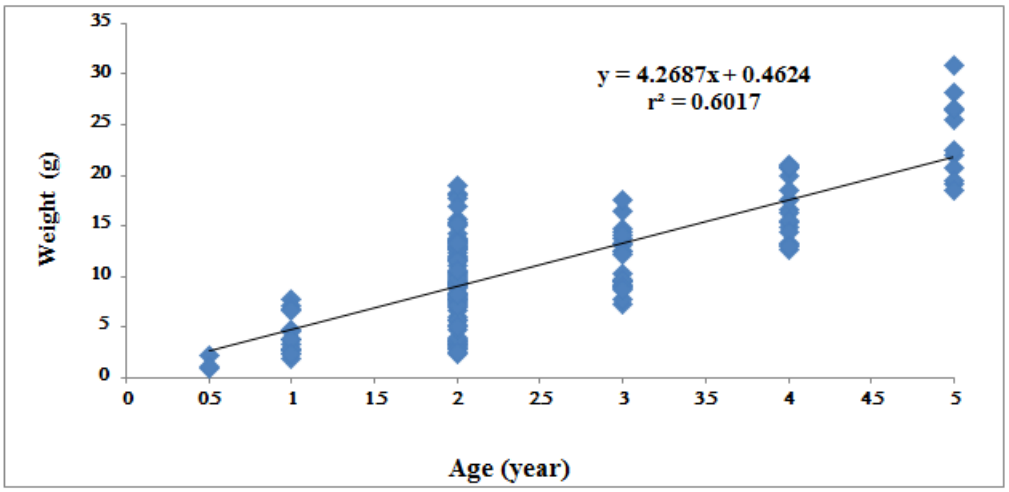


Figure 7: Age-weight relationships in females and males of *Alburnus mossulensis* during December 2010 to December 2011.

Table 3: Number and sex ratios of *Alburnus mossulensis* specimens in different age groups during December 2010 to December 2011

Age group	Sex	Number	M:F ratio
0^+	M	3	1:2.1
	F	7	
1^+	M	16	1:2.3
	F	36	
2^+	M	88	1:1.7
	F	151	
3^+	M	24	1:2.5
	F	60	
4^+	M	17	1:3.5
	F	60	
5^+	M	11	1:3
	F	29	

In October-December when there is no sexual activity (Keivany *et al.* 2017), the ratio is equal (p>0.05), but in other months the ratio was significantly different, indicating that in the reproduction season the number of females is twice that of males. The sex ratio among different age groups was significant in all age groups.

Discussion

As observed in many other fishes, the females reach higher length and weight (Ghorbani, 2011; Keivany *et al*., 2012; Asadollah, *et al*., 2016; Dopeikar *et al*., 2016; Ghanbarzadeh *et al.* 2017). The maximum length for females was 16.80 cm and that for males was 14.10 cm. Ergene (1993) reported the mean fork length as 16.30 cm, Turkmen and Akyurt (2000) reported the maximum fork length for females as 18.50 and for males as 18.10 cm in Qarasu River of Turkey. Parsa and Bahramian (2010) reported the mean total length for this species as 14.10 cm in Vahdat reservoir, a value higher than ours. Yildrim *et al.* (2003) reported the maximum fork length for this fish in Qarasu River as 18.50 for females and 17.80 for males. The maximum total length reported for this fish from Ataturk reservoir was 38.20 cm (Başusta and Çiçek**,** 2006) which might be due to a mistake in species identification. The most frequent length group was the 10-12 cm in both sexes in this study, Yildrim *et al.* (2003) reported the 12-13 cm length group and Turkmen and Akiyurt (2000) the 12-15 cm length group as the most frequent one in their studies. As in other studies (Turkment and Akiyurt, 2000; Başusta and Çiçek, 2006; Turkmen and Erdogan, 2003; Yildrim *et al*., 2003) the growth pattern showed positive allometric in females and isometric in males. Esmaeili and Ebrahimi (2006) reported the b value as 2.90. The difference between males and females might be related to their sexual condition. The b value may vary by sex, age, feeding condition, season and population (Alavi Yeganeh *et al.*, 2011; Daneshvar *et al.* 2013).

The maximum age reported in this study was 5 years. Ergene (1993) reported it as 5 and Yildrim *et al.* (2003, 2007) as 7 years in Qarasu River and Turkmen and Akiyurt (2000) as 6 years. Yildrim *et al.* (2003, 2007) reported the most frequent age group as 3 years.

The condition factor indicates the physiological condition of the fish and is mostly affected by feeding condition and sexual energy expenditure (Craik and Harvey, 1986). The condition factor differences between females and males were not significant (p>0.05), but it was significant in different months (p<0.05). The highest condition factor for males and females was in March which concided with the fish reproduction season indicating active feeding during reproduction and it was not coincident with GSI cycle (Keivany *et al*., 2017). Ergene (1993) reported the mean condition factor as 0.86 in different age groups. Turkmen and

Akiyurt (2000) reported it as 1.023 in males and as 1.047 in females. The condition factor may vary by sex, age, feeding condition, season, reproduction cycle, parasites and population (Parsa and Bahramian, 2010; Alavi Yeganeh *et al.*, 2011; Daneshvar *et al.* 2013; Mousavi-Sabet *et al*., 2013; Dopeikar and Keivany, 2015; Kiani *et al.*, 2016). The results of this study could be used in evaluating the relative condition of this fish for conservation purposes and fisheries management in the region.

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