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Age and growth of *Alburnus mossulensis* Heckel, 1843 in Azad Dam Reservoir and Komasi River in Kordestan Province, Iran

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Abstract

The aim of the present study was to estimate the population parameters including length-weight relationship (LWR), condition factor (KF), relation condition factor (K_n), age, growth and mortality of *Alburnus mossulensis* in Azad dam and Komasi River in Kordestan Province, Iran. Of 522 specimens, the fork length, total length and weight of *A. mossulensis* ranged from 70 to 164, 75-175 mm, and 4.3 to 48.1 g and averaged (±SD) 114.0 (±15.97), 127.5 (±25.29) mm and 18.2 (±5.61) g, respectively. The length-weight regression was $W=0.0003\times FL^{2.7434}$ indicating a negative allometric growth. The sex ratio (M:F) was 1:0.49, for adult *A. mossulensis* (n=134) which differed significantly from the expected 1:1 ratio ($p<0.001$). The von Bertalanffy growth parameters were estimated as L_∞=170.3 mm, K=0.46 yr^{-1}, t_0=-0.59 yr. The instantaneous coefficient of natural mortality was estimated as 0.85 yr^{-1}. The average of condition factor (KF) was 1.27(±0.161). Statistically significant differences were found in KF during different seasons ($p<0.001$). There was a significantly negative correlation between FL and KF ($r^2=0.60$). The average of relative condition factor (K_n) was 1.06±(0.130). In the present study, the K_n of *A. mossulensis* were close to 1 and greater than 1 in Komasi River and reservoir, respectively. These results suggested the well-being of the fish was good in Azad Dam region.

Keywords: Age, Growth, Condition factor, *Alburnus mossulensis*, Azad Dam, Kordestan

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Introduction

The freshwater fish mossul bleak, *Alburnus mossulensis* (Heckel, 1843) is a cyprinid fish found in the Euphrates and Tigris Rivers in Turkey and Iraq, and their adjacent basins in Iran (Kuru, 1978; Coad, 2010; Esmaeili *et al*., 2010). Also, *A. mossulensis* have been find (or spread out) in Asia from the Tigris–Euphrates basin to the very upper parts of the delta of the Kor, Mond, and Kol Rivers in Iran (Bogutskaya, 1997). This species is found both in lentic and lotic environments (FAO, 2014). It feeds on insects, algae, plants, diatoms and crustaceans (Coad, 2017).

Knowledge of length-weight relationship, length-length relationship, condition factor, growth and recruitment are important tools for the adequate management of any fish species (King, 2007). The length-weight relationship (LWR) parameters are important in fish biology and can provide information on stock condition, condition indices and several aspects of fish population dynamics (Bagenal and Tesch, 1978; Martin-Smith, 1996; Gonçalves, *et al*., 1997). Also, these relationships have been used in the conversion fish length and body weight to provide some measure of biomass (Froese, 1998) and helps to estimate the condition, reproduction, life cycle and general health of the fish species (Pauly, 1983). The condition factor (KF) is used to compare the condition, fatness or well-being of the fish (Bagenal and Tesch 1978). The relative condition factor (K_n) is influenced by many environmental and biological factors (Le Cren, 1951). KF measures the deviation from a hypothetical ideal fish but K_n measures the deviation from the average weight or length of fish. A comprehensive review of body condition indices is described by Anderson and Neumann (1996). Growth of an organism means a change in length or weight or both with the increase in age (Le Cren, 1951). The determination of fish growth is fundamental for population modeling, stock assessments, and managing exploited species (Gulland, 1988).

Previous studies on the population ecologic characteristics of *A. mossulensis* in Iranian inland waters is limited to the length-weight and condition factor (Mosavi-Sabet *et al*., 2013; Hedayati *et al*., 2016; Radkhah, 2016; Keivany and Zamani-Faradonbe, 2017) and still there is a great need for biology study, ecology and conservation status of this fish species in Iranian freshwaters. Therefore, the aim of the present study was to estimate the population parameters including LWR, condition factor, relation condition factor, age, growth and mortality of *A. mossulensis* in Azad dam in Kordstan Province, Iran.

Materials and methods

The study was performed in Azad Dam Reservoir. The dam is located on the Komasi River, 75 km west of Sananadaj (Fig. 1). It is an earthen dam with a clay core. The crest length and maximum height of the dam are 595 and 117 m, respectively. The total capacity of dam is 300 million m^3.

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This investigation was carried out on August, November, 2015 and February, May, 2016. Three sampling sites were selected along the dam using multi-mesh gill net (20 m length and 4 m height, with 14, 18, 22, 26, 30, 33 and 40 mm mesh sizes) and electrofisher in the Komasi River. A total of 522 specimens of *A. mossulensis* were collected. The fork (FL), standard length (SL) and total length (TL) was measured to the nearest 1 mm and total weight to the nearest 1 g (for overall individuals). Sex was determined by visual observation.

Scales were collected from the middle part of the body behind the pectoral fins just above the hypothetical lateral line and preserved in the envelopes for future treatment in the laboratory. The scales were washed, placed in small covered petri dishes containing tap water. Then, the organic layers were removed by rubbing and washing the scales between the fingers in tap water.

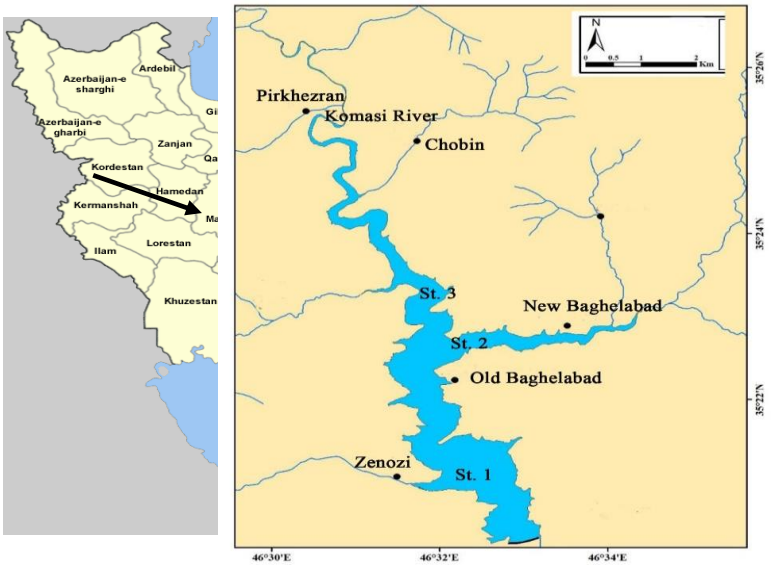


Figure 1: Map of Azad Dam located at west of Sanandaj.

The length-weight relationship was derived by applying an exponential regression as the following equation:

$$W = aFL^b$$

Where *W* is the total weight (g). *FL*, the fork length (mm), and *a* and *b* are parameters to be estimated (Ricker, 1975). Parameters estimation was conducted by least squares linear regression on log-log transformed data:

ln(W) = ln(a) + b×ln(FL).

T-test for departure from isometry (b=3) was carried out using Pauly, 1984):

$$t = \frac{s.d.\ln(FL)}{s.d.\ln(W)} \times \frac{|b-3|}{\sqrt{1-r^2}} \times \sqrt{n-2}$$

Where s.d.ln (FL) and s.d.ln (W) are standard deviations natural logarithm of the fork length (cm) and weight, respectively, and *a* and *b* are parameters and r^2 is regression coefficient between length and weight and n is sample size.

The condition factor (*KF*) was calculated as the following equation (Bagenal and Tesch 1978, 1978):

$$KF = \frac{W}{FL^3} \times 100$$

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Where W (g) is weight and FL (cm) is fork length.

The relative condition factor (K_n) compensates for changes in form or condition with increase in length and was calculated using following equation (Froese, 2006):

$$K_n = \frac{W}{aFL^b}$$

Where W is weight (g), FL is fork length (mm), a and b are the exponential form of the intercept and slope, respectively, of the logarithmic length–weight equation.

The Pearson correlation coefficient was calculated to investigate the relationship of K_n and K length.

The von Bertalanffy growth curve (von Bertalanffy, 1938) was fitted to the observed lengths at age for the resulting age-length key using a non-linear estimation method as the following:

$$L_t = L_\infty(1-e^{-K(t-t_0)})$$

Where L_t is the fork length at age t, L_∞ is the theoretical maximum length, K is a growth coefficient and t_0 is the hypothetical age for L_t=0.

The parameter (Ø'), the growth performance index, was calculated as (Pauly, 1983):

$$Ø' = logK + 2logL_\infty$$

Where K is the growth coefficient and L_∞ is the theoretical maximum length (cm).

The instantaneous coefficient of natural mortality was estimated using the methods in Pauly model (Pauly, 1980) with von Bertalanffy growth parameters.

$$\ln(M) = -0.0152 - 0.279\ln(L_\infty) + 0.6543\ln(K) + 0.463\ln(T)$$

Where M is the instantaneous coefficient of natural mortality, K is the growth coefficient and T is the mean annual habitat temperature, T=12.0 °C.

The comparison between the average values for sexes was carried out by t-test and for seasons by analysis of variance (ANOVA). Differences in sex ratios from the expected 1:1 were analyzed by chi-square tests (Zar, 2010).

Results

A total of 522 specimens were caught in this study, with 466 specimens caught by gillnet in Azad Reservoir and 56 specimens caught by electrofishing in Komasi River. The fork length, total length and weight of *A. mossulensis* ranged from 70 to 164, 75-175 mm, and 4.3 to 48.1 g and averaged (±SD) 114.0 (±15.97), 127.5 (±25.29) mm and 18.2 (±5.61) g, respectively. The fork length distribution was ranged 70-120 and 85-165 mm in the river and reservoir, respectively. The length group of 110-115 mm was prevailing and formed 25.3%, followed by the length group of 105-110, comprising 20.8% of the total catch (Fig. 2). The mean fork length and weight were 88.2±13.41 mm, 9.16±4.58 g in the river and 117.1±13.23 mm and 19.3±4.6 g in the reservoir, respectively. Statistically significant differences were found in the parameters between the river and reservoir (t-test; p<0.001; Table 1).

The fork length and weight regression from all of the whole samples was: $W=0.0003\times FL^{2.7434}$ (r^2=0.89, n=522).

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The estimation of "b" was 2.7434, significantly different from 3.0 (t-test, p<0.001), indicating an negative allometric growth (Fig. 3).

The average of KF values were 1.23±0.147 and 1.28±0.211 in the river and reservoir, respectively. These averages were not significantly different (t-test, p>0.076; Table 1). But statistically significant differences were found in the parameters between seasons (ANOVA, p<0.001; Table 2). In spring KF was the highest (1.31). The correlation between FL and KF was statistically significant with a negative correlation (r^2 = 0.60; Fig. 4).

The relative condition factor K_n was calculated in the river and reservoir by making use of the length-weight relationship. The average of K_n values were 0.97±0.130 and 1.07±0.125, respectively, with significant difference (t-test, p> 0.001; Table 1). Statistically significant differences were found also in the parameters between seasons (ANOVA, p<0.001; Table 2) with the highest value (1.09) in spring. There was not correlation between FL and K_n (Fig. 4). A perusal of the data on the K_n values showed that the parameter were lower than 1 in all size classes except 90-100, 100-110 and 110-120 mm. In the size 90-100 mm K_n was the highest (1.13).

The age of *A. mossulensis* ranged 1–4 years. In the age compositions, age 2 was the most dominant age group, representing 56.2% of samples (Fig. 3). The von Bertalanffy growth equation was estimated as shown in Fig. 5:

$$L_t = 170.3(1 - e^{-0.46(t-(-0.59))})$$

The growth performance index (Ø') of *A. mossulensis* was computed as 2.12. Estimates of the instantaneous coefficient of natural mortality for *A. mossulensis* obtained from the Pauly method was 0.85/yr.

In the reservoir, sex ratio (M:F) was 1:0.49, for adult *A. mossulensis* (n=134) which differed significantly from the expected 1:1 (χ^2=15.8, p<0.001). In the seasons of summer and autumn the sex ratios were not significantly different (p>0.05), but in winter and spring, males were predominated (p<0.05; Fig. 6).

Table 1: Descriptive statistics of weight, fork length, condition factor (KF) and relative condition factor (K_n) of *Alburnus mossulensis* in Azad Dam.

Parameter	Place	N	Mean	SD	Min	Max	t-test
Weight, g	River	56	9.2	4.58	4.3	20.3	t=15.3
	Dam	466	19.3	4.68	7.9	48.1	p<0.001
	Total	522	18.2	5.61	4.3	48.1	
Fork length, mm	River	56	88.2	13.41	70	116	t=15.4
	Dam	466	117.1	13.23	85	164	p<0.001
	Total	522	114.0	15.98	70	164	
KF	River	56	1.24	0.147	0.99	1.61	t=1.7
	Dam	466	1.28	0.162	0.93	1.82	p>0.076

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Table 1 continued:

K_n	Total	522	1.27	0.161	0.93	1.82	
	River	56	0.97	0.130	0.81	1.33	t=5.5
	Dam	466	1.07	0.125	0.80	1.52	p<0.001
	Total	522	1.06	0.130	0.80	1.52	

Table 2: Seasonal condition factor (KF) and relative condition factor (K_n) of *Alburnus mossulensis* in Azad Dam.

Seasons		Summer 2015	Autumn 2015	Winter 2016	Spring 2016	ANOVA
Parameters	N	36	106	27	353	
KF	Mean	1.19^b	1.20^b	1.07^a	1.30^c	F = 27.7
	SD	0.136	0.154	0.109	0.151	p<0.001
K_n	Mean	1.00^a	0.97^a	0.92^a	1.09^b	F = 31.1
	SD	0.105	0.124	0.081	0.119	p<0.001

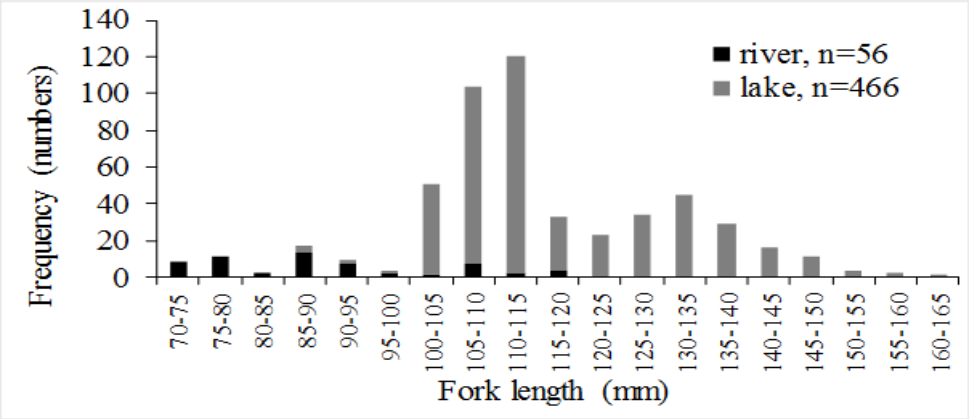


Figure 2: Size distribution of *Alburnus mossulensis* in Azad Dam, n=sample size.

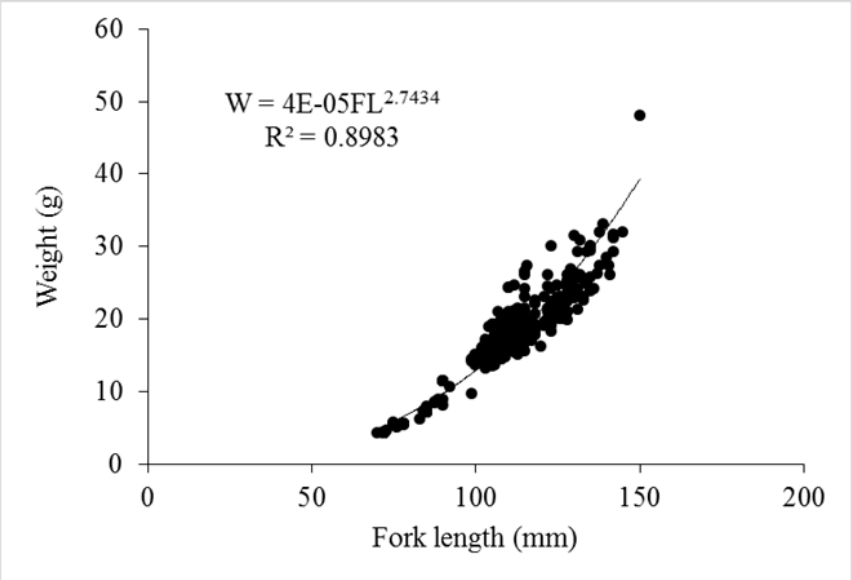


Figure 3: Length-weight relationship of *Alburnus mossulensis* in Azad Dam.

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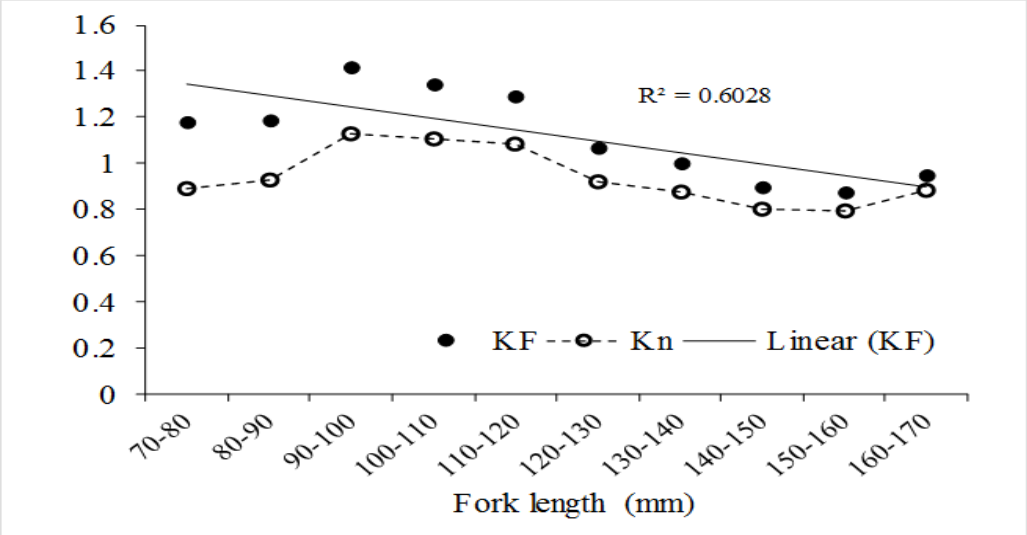


Figure 4: Variation of mean condition factor (KF) and relative condition factor (K_n) of *Alburnus mossulensis* in different size classes in Azad Dam.

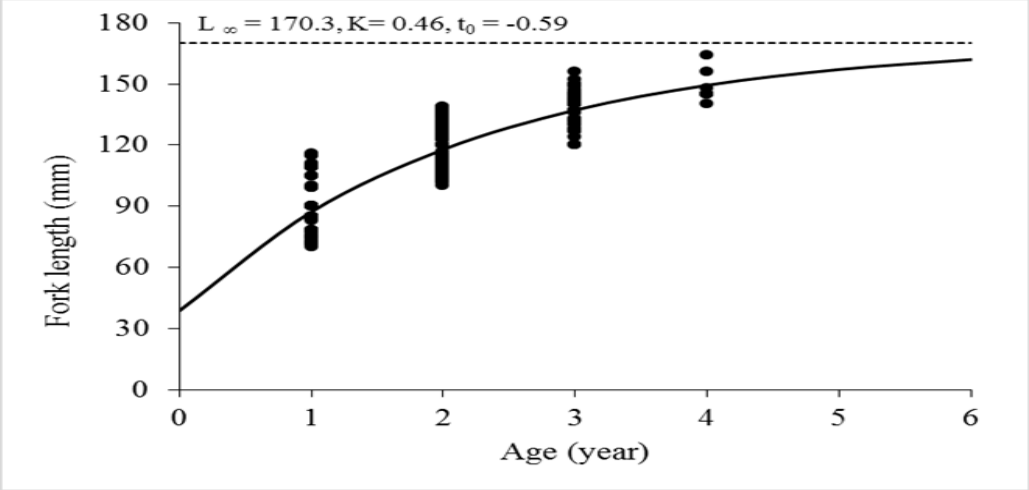


Figure 5: Theoretical growth curve calculated for fork length of *Alburnus mossulensis* in Azad Dam.

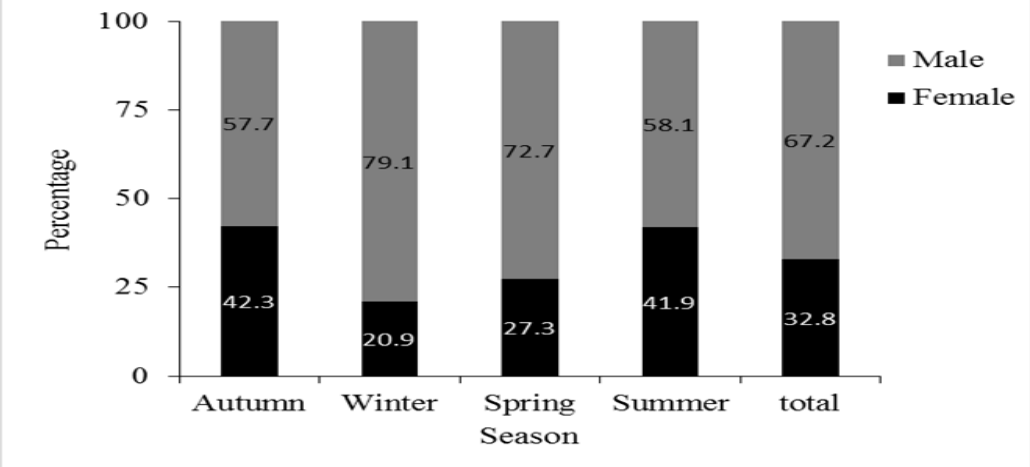


Figure 6: Seasonal sex composition of of *Alburnus mossulensis* in Azad Dam.

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Discussion

The study on life history of *A. mossulensis* in Iranian inland waters for the previous years are scarce, were limited to the length-weight and condition factor (Mosavi-Sabet *et al*., 2013; Hedayati *et al*., 2016; Radkhah, 2016; Keivany and Zamani-Faradonbe, 2017). The *b* value usually varies between 2 and 4 (Tesch, 1971) or ranges from 2.50 to 3.50 (Froese, 2006). According to the present study, the exponent *b* of length–weight relationship was 2.7434 remained within the expected range for all species. There was great variation in the literature on the minimum and maximum recorded b for *A. mossulensis*. In contrast, Alkan Uckun and Gokce (2015) reported a lower *b* value (2.12) in Karakaya Dam, Turkey and Mosavi-Sabet *et al*. (2013), Hedayati *et al*. (2016), Radkhah (2016) and Keivany and Zamani-Faradonbe (2017) reported a higher, different b (3.172, 3.135, 3.09 and 3.15, respectively, Table 3) in Iranian inland waters. The sampling gear might influence the size range covered and cause deviations from existing values LWR parameters. In addition, geographical location and associated environmental conditions such as water temperature, which is the determining factor of feeding capacity, seasonality, stomach fullness, disease and parasite loads can affect the value of *b* (Bagenal and Tesh, 1978; Froese, 2006).

According to Kumolu and Ndimele (2010) the condition factor reflects information on physiological states of fish with relation to welfare. Also, high condition factor values indicate favorable environmental conditions (Blackwell *et al*., 2000). In the present study, *A. mossulensis* was observed to be in suitable condition, as the value of "KF" was >1, in both river and reservoir and all seasons (Tables 1, 3). As shown in Fig. 4 there was a significantly negative correlation between size classes and KF, and KF was <1 for fish bigger than 140 mm.

K_n has been used as it indicates suitability of the environment for fish growth. According to George *et al*. (1985) K_n indicates the general well-being of the fish. If the values of K_n>1 indicates that the well-being of the fish is good whereas, its value <1 reflects that the well-being of the fish is not in a good condition and poor feeding activity. In the present study, the K_n of *A. mossulensis* were close to 1 and greater than 1 in the river and reservoir, respectively. These results suggested that the well-being of the fish was good in Azad Dam region. According to Le Cren (19), Bagenal and Tesch (1978), Papageorgiou (1979) and Simon *et al*. (2012) seasonal variation of K_n can be influenced by the maturity, gonad development, feeding activity and several other factors. The lower K_n value in winter might be the result of winter feeding.

Knowledge of fish age and growth is necessary for stock assessment, develop management or conservation plans (Helfman *et al*., 1997). There are no previous estimates on growth rates of *A. mossulensis* in the Iranian inland waters. The results showed that the rapid growth of *A. mossulensis* was

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found during the first year of life, followed by a period of slow growth rate in the rest of life (Fig. 5). The age of *A. mossulensis* varied from 1 to 4 yr. Similar results reported by Alkan Uckun and Gokce (2015) and Mohamed *et al*. (2015). In contrast, Yıldırım *et al*. (2003) found that the age ranged between 1 to 7 (Table 4). According to Holmgren and Appelberg (2001) and Bautista *et al*. (2012) the range of age distribution in a population is closely related to the nutritional status of the environment.

The asymptotic length (L_∞) of *A. mossulensis* was 17.0 cm. In contrast, Yıldırım *et al*. (2003), Alkan Uckun and Gokce (2015) and Mohamed *et al*. (2015) reported a higher, different L_∞ (ranged between 19.6-21.9 cm). The growth performance index (*Ø'*) of *A. mossulensis* (2.12) is similar to that found Mohamed *et al*. (2015). The index was estimated difference in Turkish inland waters (Table 4). Holmgren and Appelberg (2001) and Bautista *et al*. (2012) reported that the growth characteristics of the local populations in the same species change due to habitat variations, water quality and nutrients.

The result showed that the overall female:male ratio was 1:2.04, significantly different from 1:1 (p<0.001). Similar results (1:1.29) were reported by Mosavi-Sabet *et al*. (2013) in Gamasiab River (Iran). In contrast, the overall sex ratio was 3.12:1 in Karakaya Dam Reservoir (Turkey, Alkan Uckun and Gokce, 2015). Also in winter and spring, males were predominated (p<0.05; Fig. 6). Nikolsky (1963) reported that the sex ratio of fish population changes based on spawning season, life stage of the fish, spawning ground, and migration. Moreover, sex ratio depends on the fishing area, since it is possible to determine females and males as being more abundant in heterogenic habitats (Mouine *et al*., 2011).

Table 3: The length-weight relationships of *Alburnus mossulensis* from different locations.

Study area	N	Total length (cm) Min-Max	b	r^2	Author (s)
Gamasiab River, Iran	325	7.0-15.5	3.172	0.94	Mosavi-Sabet *et al*., 2013
Gamasiab River, Iran	120	3.1-11.6	3.135	0.98	Hedayati *et al*., 2016
Hamzeh-Ali Region, Chaharmahal and Bakhtiari Province, Iran	40	2.0-7.4	3.090	0.98	Radkhah, 2016
Zohreh River, Iran	26	3.0-10.1	3.150	0.98	Keivany and Zamani-Faradonbe, 2017
Karakaya Dam, Turkey	626	12.3-20.4	2.120	0.94	Alkan Uckun and Gokce, 2015
Azad Dam, Iran	522	7.5-17.5	2.7434	0.89	Present study

Table 4: The von Bertalanffy growth parameters of *Alburnus mossulensis* from different locations.

Study area	Sex	Age	L_∞	K	t_0	Ø'	Author (s)
Karasu River, Turkey	M	1-6	19.9	0.187	-2.30	1.87	Yıldırım *et al*., 2003
	F	1-7	21.9	0.168	-2.10	1.91	
Karakaya Dam, Turkey	M	0-4	20.1	1.40	-1.04	2.75	Alkan Uckun and Gokce, 2015
	F	0-4	19.6	0.14	-1.39	1.73	
Euphrates River, Iraq	M+F	1-4	20.4	0.35	-0.28	2.16	Mohamed *et al*., 2015
Azad Dam, Iran	M+F	1-4	17.0	0.46	-0.59	2.12	Present study

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