

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

Fazli H.<sup>1\*</sup>; Daryanabard G.R.<sup>1</sup>; Janbaz A.<sup>1</sup>; Naderi M.<sup>1</sup>; Mirzaei R.<sup>2</sup>; Hosseinpour H.<sup>2</sup>; Vahedi N.<sup>2</sup>

Received: June 2017

Accepted: September 2017

### 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 ( $\pm$ SD) 114.0 ( $\pm$ 15.97), 127.5 ( $\pm$ 25.29) mm and 18.2 ( $\pm$ 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  $L_\infty=170.3$  mm,  $K=0.46$  yr<sup>-1</sup>,  $t_0=-0.59$  yr. The instantaneous coefficient of natural mortality was estimated as 0.85 yr<sup>-1</sup>. The average of condition factor (KF) was 1.27( $\pm$ 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( $\pm$ 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

1-Caspian Sea Ecology Research Center (CSERC), Iranian Fisheries Science Research Institute (IFSRI), Agricultural Research, Education and Extension Organization (AREEO), Sari, Mazandaran, Iran

2-Department of Fisheries, Jihad-Agriculture of Kordestan Organization, Sanadaj, Kordestan, Iran

\*Corresponding author's Email: fazlihasan@gmail.com

## 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<sup>3</sup>.

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.

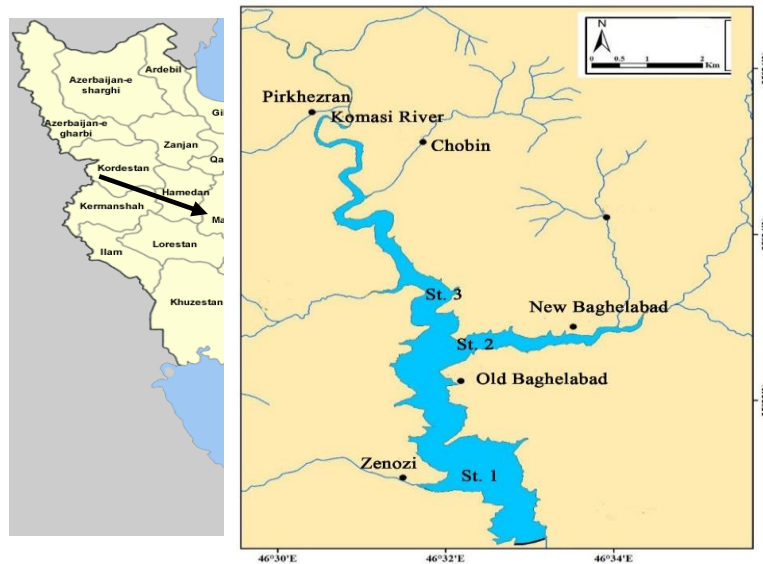


Figure 1: Map of Azad Dam located at west of Sanandaj.

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:  $\ln(W) = \ln(a) + b \times \ln(FL)$ .

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):

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

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  $t$ ,  $L_\infty$  is the theoretical maximum length,  $K$  is a growth coefficient and  $t_0$  is the hypothetical age for  $L_t=0$ .

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

$$\emptyset' = \log K + 2 \log L_\infty$$

Where  $K$  is the growth coefficient and  $L_\infty$  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.

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

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 ( $\pm$ SD) 114.0 ( $\pm$ 15.97), 127.5 ( $\pm$ 25.29) mm and 18.2 ( $\pm$ 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  $88.2 \pm 13.41$  mm,  $9.16 \pm 4.58$  g in the river and  $117.1 \pm 13.23$  mm and  $19.3 \pm 4.6$  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:  $W = 0.0003 \times FL^{2.7434}$  ( $r^2 = 0.89$ ,  $n = 522$ ).

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  $1.23 \pm 0.147$  and  $1.28 \pm 0.211$  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  $0.97 \pm 0.130$  and  $1.07 \pm 0.125$ , 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 ( $\Phi'$ ) 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 ( $\chi^2=15.8$ ,  $p < 0.001$ ). 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.**

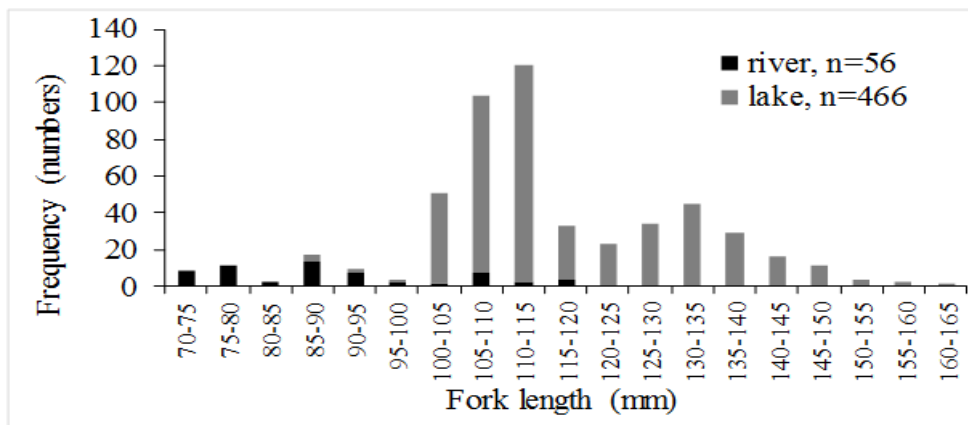
Parameter	Place	N	Mean	SD	Min	Max	t-test
Weight, g	River	56	9.2	4.58	4.3	20.3	t=15.3
	Dam	466	19.3	4.68	7.9	48.1	$p < 0.001$
	Total	522	18.2	5.61	4.3	48.1	
Fork length, mm	River	56	88.2	13.41	70	116	t=15.4
	Dam	466	117.1	13.23	85	164	$p < 0.001$
	Total	522	114.0	15.98	70	164	
KF	River	56	1.24	0.147	0.99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

**Table 1 continued:**

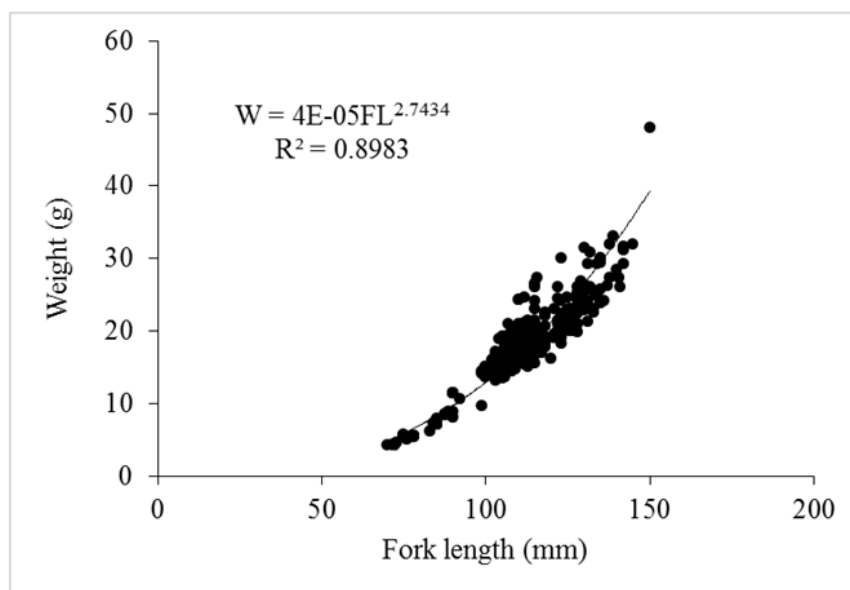
K <sub>n</sub>	Total	522	1.27	0.161	0.93	1.82	
	River	56	0.97	0.130	0.81	1.33	t=5.5
	Dam	466	1.07	0.125	0.80	1.52	p<0.001
	Total	522	1.06	0.130	0.80	1.52	

**Table 2: Seasonal condition factor (KF) and relative condition factor (K<sub>n</sub>) of *Alburnus mossulensis* in Azad Dam.**

Seasons		Summer	Autumn	Winter	Spring	ANOVA
Parameters		2015	2015	2016	2016	
KF	N	36	106	27	353	
	Mean	1.19 <sup>b</sup>	1.20 <sup>b</sup>	1.07 <sup>a</sup>	1.30 <sup>c</sup>	F = 27.7
	SD	0.136	0.154	0.109	0.151	p<0.001
K <sub>n</sub>	Mean	1.00 <sup>a</sup>	0.97 <sup>a</sup>	0.92 <sup>a</sup>	1.09 <sup>b</sup>	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.**

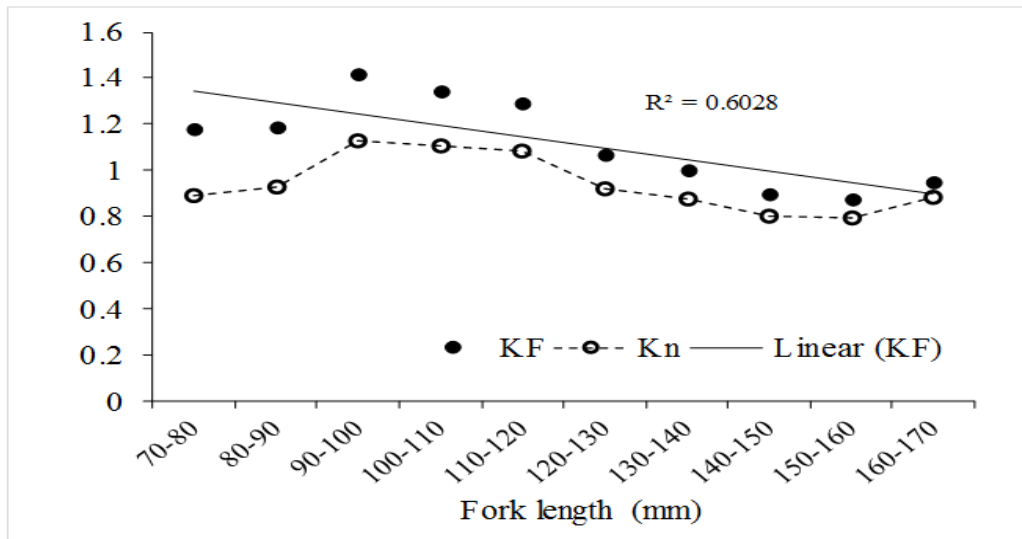


Figure 4: Variation of mean condition factor (KF) and relative condition factor ( $K_n$ ) of *Alburnus mossulensis* in different size classes in Azad Dam.

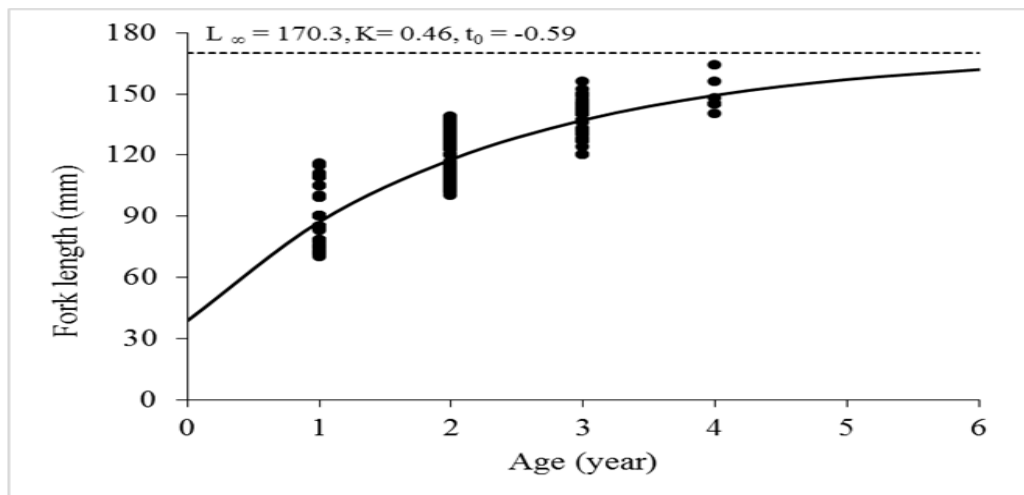


Figure 5: Theoretical growth curve calculated for fork length of *Alburnus mossulensis* in Azad Dam.

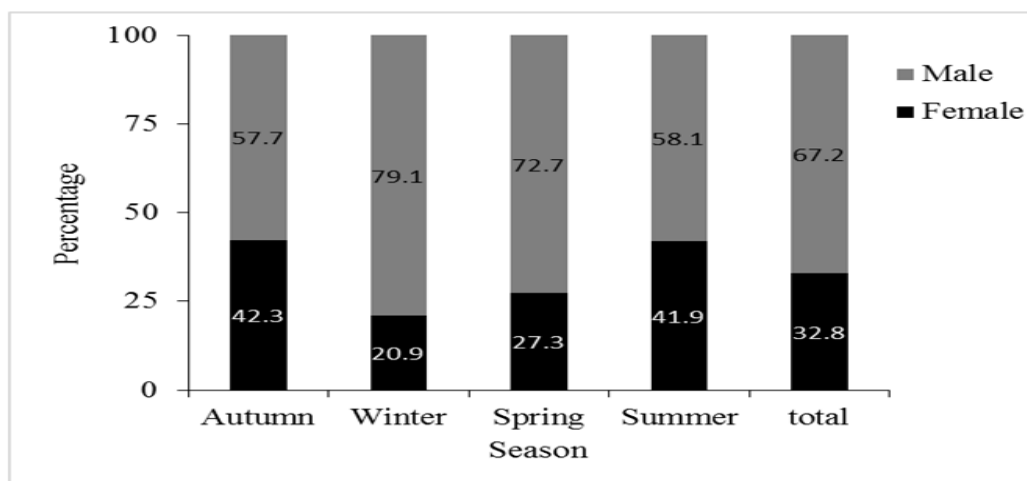


Figure 6: Seasonal sex composition of of *Alburnus mossulensis* in Azad Dam.

## 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



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, Yildirim *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 ( $L_{\infty}$ ) of *A. mossulensis* was 17.0 cm. In contrast, Yildirim *et al.* (2003), Alkan Uckun and Gokce (2015) and Mohamed *et al.* (2015) reported a higher, different  $L_{\infty}$  (ranged between 19.6-21.9 cm). The growth performance index ( $\phi'$ ) 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 <sup>2</sup>	Author (s)
Gamasiab River, Iran	325	7.0-15.5	3.172	0.94	Mosavi-Sabet <i>et al.</i> , 2013
Gamasiab River, Iran	120	3.1-11.6	3.135	0.98	Hedayati <i>et al.</i> , 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	$L_{\infty}$	K	$t_0$	$\phi'$	Author (s)
Karasu River, Turkey	M	1-6	19.9	0.187	-2.30	1.87	Yildirim <i>et al.</i> , 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 <i>et al.</i> , 2015
Azad Dam, Iran	M+F	1-4	17.0	0.46	-0.59	2.12	Present study

## References

- Alkan Uckun A. and Gokce, D., 2015.** Assessing age, growth, and reproduction of *Alburnus mossulensis* and *Acanthobrama marmid* (Cyprinidae) populations in Karakaya Dam Lake (Turkey). *Turkish Journal of Zoology*, 39,1-14.
- Anderson, R.O. and Neumann, R.M., 1996.** Length, weight, and associated structural indices. In: Fisheries techniques, 2nd edn. B. R. Murphy and D. W. Willis (Eds). American Fisheries Society, Bethesda, Maryland, USA, pp. 447-482.
- Bagenal, T.B. and Tesch, F.W., 1978.** Age and growth. In: Methods for assessment of fish production in freshwaters. 3rd edn. T. Bagenal (Ed.). IBP Handbook No. 3. Blackwell Scientific Publications, Oxford, UK, pp. 101–136.
- Bautista, J.J., Romero, S.S., Gonzalez-Pelaez, L., Campos-Davila, D.B. and Lluch-Cota, J., 2012.** Length–weight relationships of wild fish captured at the mouth of Rio Verde, Oaxaca, Mexico and connected lagoons (Miniyua, El Espejo, Chacahua and Pastoria). *Journal of Applied Ichthyology*, 28, 269–271.
- Blackwell, B.G., Brown, M.L. and Willis, D.W., 2000.** Relative weight ( $W_r$ ) status and current use in fisheries assessment and management. *Review Fisheries Science*, 8, 1-44.
- Bogutskaya, N.G., 1997.** Contribution to the knowledge of leuciscine fishes of Asia Minor. Part 2. An annotated check-list of leuciscine fishes (Leuciscinae, Cyprinidae) of Turkey with description of a new species and two subspecies. *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut*, 94, 161-186.
- Coad, B.W., 2010.** Freshwater fishes of Iraq. Sofia, Bulgaria: Pensoft Publishers. 274 P.
- Coad, B.W., 2017.** Freshwater fishes of Iran. www.briancoad.com.
- Esmaeili, H.R., Coad, B.W., Gholamifard, A., Nazari, N. and Teimory, A., 2010.** Annotated checklist of the freshwater fishes of Iran. *Zoosystematica Rossica*, 19(2), 361–386.
- FAO. 2014.** Report of the expert meeting on the review of fisheries and aquaculture activities in the Tigris Euphrates Basin, Erbil, Iraq, 11–12 November 2012. FAO Fisheries and Aquaculture Report No. 1079. Rome. 125 P.
- Froese, R., 1998.** Length-weight relationships for 18 less-studied fish species. *Journal of Applied Ichthyology*, 14, 117-118.
- Froese, R., 2006.** Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22, 241-253.
- George, J.P., Sharma, A.K., Venkateshvaran, K., Sinha, P.S.R.K., Venugopal, G. and Biradar, R.S., 1985.** Length- weight relationship and relative condition factor in *Cirrhinus mrigala* and *Labeo rohita* from a sewage fed tank. *The Annals of Zoology*, 23, 70-90.

- Gonçalves, J.M.S., Bentes, L., Lino, P.G., Ribeiro, J., Canario, A.V.M. and Erzini, K., 1997.** Weight-length relationships for selected fish species of the small-scale demersal fisheries of the south and south-west coast of Portugal. *Fisheries Research*, 30, 253-256.
- Gulland, J.A., 1988.** Fish population dynamics: the implications for management, John Wiley and Sons Ltd., New York. 422 P.
- Hedayati, S.A., Ghafari Farsani, H. and Gerami, M.H., 2016.** Length-weight relationships of two fish species from Gamsiab Reservoir, western Iran: *Alburnus mossulensis* Heckel, 1843 and *Luciobarbus esocinus* Heckel, 1843. *Journal of Applied Ichthyology*, 32(1), 139-140.
- Helfman, G.S., Collette, B.B. and Facey, D.E., 1997.** The diversity of fishes. Blackwell Science. 528 P.
- Holmgren, K. and Appelberg, M., 2001.** Effects of environmental factors on size-related growth efficiency of perch, *Perca fluviatilis*. *Ecology of Freshwater Fish*, 10, 247-256.
- Keivany, Y. and Zamani-Faradonbe, M., 2017.** Length-weight and length-length relationships for seven fish species from the Zohreh River, Iran. *Journal of Applied Ichthyology*, 33(3), 625-627.
- King, M., 2007.** Fisheries biology, assessment and management. Wiley-Blackwell, 400 P.
- Kumolu, C.A. and Ndimele, P.E., 2010.** Length weight relationships and condition factors of twenty-one fish species in Ologe Lagoon, Lagos, Nigeria. *Asian Journal of Agricultural Sciences*, 2(4), 174-179.
- Kuru, M., 1978.** The freshwater fish of South-Eastern Turkey-2 (Euphrates-Tigris system). *Hacettepe Bulletin of Natural Sciences and Engineering*, 7-8, 105-114.
- Le Cren, E.D., 1951.** The length-weight relationship and seasonal cycle in the gonad weight and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology*, 20, 201-219.
- Martin-Smith, K.M., 1996.** Length/weight relationships of fishes in a diverse tropical fresh-water community, Sabah, Malaysia. *Journal of Fish Biology*, 49, 731-734.
- Mohamed, A.R.M., Aufy, L.A. and Jasim, B.M., 2015.** Some biological aspects of the Bleak, *Alburnus mossulensis* in the Southern Reaches of Euphrates River, Iraq. *Asian Journal of Applied Sciences*, 3(2), 277-285.
- Mouine, N., Ktari, M.H. and Chakroun-Marzouk, N., 2011.** Reproductive characteristics of *Spondyliosoma cantharus* (Linnaeus, 1758) in the Gulf of Tunis. *Journal of Applied Ichthyology*, 27, 827-831.
- Mousavi-Sabet, H., Abdollahpour, S., Salehi-Farsani, A., Vatandoust, S., Langroudi, H.F., Jamalzade, H.R. and Nasrollahzadeh, A., 2013.** Length-weight and length-length relationships and condition factor of *Alburnus mossulensis* (Heckel, 1843) from the Persian Gulf basin. *AAFL Bioflux*, 6(4), 297-302.

- Nikolsky, G.W., 1963.** The ecology of fishes. Academic Press, London and New York, 352 P.
- Papageorgiou, N.K., 1979.** The length weight relationship, age, growth and reproduction of the roach *Rutilus rutilus* (L.) in Lake Volvi. *Journal of Fish Biology*, 14, 529-538.
- Pauly, D., 1980.** On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. *Journal du Conseil CIEM*, 39(2), 179-192.
- Pauly, D., 1983.** Some simple methods for the assessment of tropical fish stocks. FAO Fish, Tech. Pap., 234 P.
- Pauly, D., 1984.** Fish population dynamics in tropical waters: A manual for use with programmable calculators. ICLARM, Manila. 325 P.
- Radkhah, A., 2016.** A study on length-weight relationship and condition factor of *Alburnus mossulensis* in Hamzeh-Ali Region from Chaharmahal and Bakhtiari Province, Iran. *International Journal of Fisheries and Aquatic Studies*, 4(1), 124-125.
- Ricker, W.E., 1975.** Computation and interpretation of biological statistics of fish populations. *Journal of the Fisheries Research Board of Canada*, 191, 1-382.
- Simon, K.D., Bakar, Y., Mazlan, A.G., Zaidi, C.C., Samat, A., Arshad, A., Temple, S.E. and Brown-Peterson, N.J., 2012.** Aspects of the reproductive biology of two archer fishes *Toxotes chatareus* (Hamilton 1822) and *Toxotes jaculatrix* (Pallas 1767). *Environmental Biology of Fishes*, 93, 491-503.
- Tesch, F.W., 1971.** Age and growth. In: Methods for assessment of fish production in fresh waters, W.E. (Ed.). Blackwell Scientific Publications, Oxford, UK, pp. 98-103.
- von Bertalanffy, L., 1938.** A quantitative theory of organic growth. *Human Biology*, 10, 181-243.
- Yıldırım, A., Haliloğlu, H.I., Türkmen, M. and Erdoğan, O., 2003.** Age and growth characteristics of *Chalcalburnus mossulensis* (Heckel, 1843) living in Karasu River (Erzurum, Turkey). *Turkish Journal of Veterinary and Animal Sciences*, 27, 1091-1096.
- Zar, J. H., 2010.** Biostatistical analysis. 4th edition. Prentice Hall, Upper Saddle River, New Jersey, 946 P.