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Food and feeding habits of the Mossul bleak, *Alburnus mossulensis* Heckel, 1843 (Cyprinidae) in the Azad dam of Sanandaj, Iran

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ABSTRACT: The feeding habits of Mossul bleak, *Alburnus mossulensis* Heckel 1843 in Azad dam of Sanandaj province were investigated by stomach content analysis of 75 fish collected seasonally in 2015-2016. The diet consisted mainly of fish prey dominated by Bosminidae of zooplankton (50.2%), with *Bosmina longirostris* being the dominant prey item based on numerical percentage. The next major food group was Daphniidae (36.3%), followed by Sididae (11.3%), Cyclopidae (1.5%), Acartidae (0.7%), Nematoda (0.1%) and Testudinelidae (0.1%). Based on frequency of occurrence, *B. longirostris* was the main prey in the stomach of Mossul bleak (F_i =75.4%), with an important species index (ISI) of 39.5%. The fish fed on a wider variety of food items during spring than during other seasons. The lowest feeding activity (GaSI) was recorded in summer. The gastrosomatic index (GaSI) ranged from 2.67 to 4.27 with season variations increase in spring coincides closely with spawning season and energy preservation for gonadal development.

***Keywords*:** Bleak Mossul, Cyprinidae, Alburnus mossulensis, Azad dam, Sanandaj, Iran, Feeding habits.

INTRODUCTION

The cyprinid fishes of genus *Alburnus* in Iran, comprise eight confirmed species including *Alburnus mossulensis* (Mousavi-Sabet et al., 2013, 2015). *Alburnus mossulensis* is found in the Tigris-Euphrates basin and adjacent basins. In Iran, it is recorded from the Tigris River, Kor River, Persis, Maharlu Lake, and upper reaches of the Hormuz basins (Berg 1949; Abdoli 2000; Mousavi-Sabet et al. 2015; Coad 2017; Esmaeili et al., 2010, 2017; Esmaeili & Teimori 2016) also from the whole middle to upper Karkheh basin including Simareh, Qarasu and Gamasiab rivers (Abdoli 2000). This species is found in streams, rivers, lakes, reservoirs and marshes. *Alburnus mossulensis* feeds on the phytoplankton, organic detritus and insects (Coad, 2017). In Iran, this species has a good distribution and there is no threat, but in Turkey it is on the list of endangered species (Fricke et al., 2007).
Found in the Tigris-Euphrates basin and adjacent basins. In Iran it is recorded from the Tigris River, Gulf, Lake Maharlu, Kor River and upper reaches of the Hormuz basins (Berg, 1949; Bianco and Banarescu, 1982; Abdoli, 2000) and questionably from the Esfahan basin (Abdoli, 2000). Records also include the Shapur and Dalaki rivers in the Gulf basin and the upper Mand including Qara Agaj reach and Shur tributary, Shur tributary to Dasht-e Palang; upper Zohreh, Marun and Jarrahi, upper Karun and Khersan, Dez, whole middle to upper Karkheh basin (Simarreh, Qarasu, Gav Masiab) (Abdoli, 2000). This species is found in streams, rivers, lakes, reservoirs and

marshes. Al-Habbib (1981) has demonstrated experimentally for specimens taken from the Aloka River, north of Mosul, Iraq that this species can survive temperatures in the range of about 1.25-36.2°C when acclimated. Abbasi et al., (2009) in their study of wetlands in Hamadan Province found this species was dominant out of 23 species at 28%. Information on the biology and nutrition of *Alburnus mossulensis* is very small. The production season of *A. mossulensis* was reported from June to August (Berg, 1949). The main objectives of the study were to describe the diet, frequency of occurrence of different food items in the stomach, monthly changes in diet composition, feeding intensity, and feeding habits in relation to fish size.

MATERIALS AND METHODS

Study area

This present study was carried out in the Azad dam of Sanandaj from spring to winter 2015 (Figure1). Fresh samples of *A. mossulensis* were collected by gill nets catch.

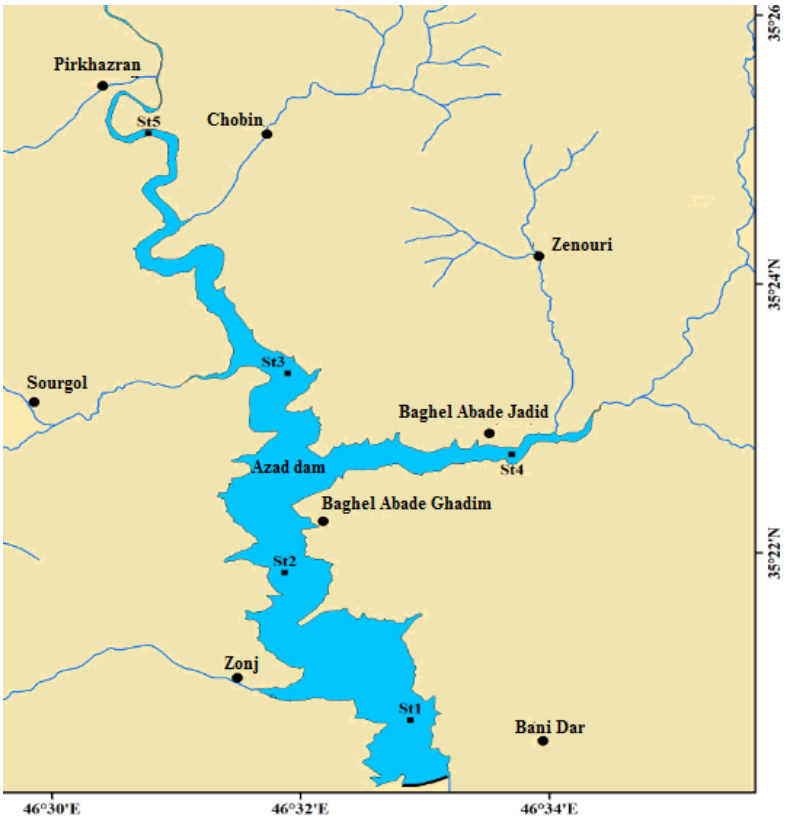

Figure 1. situation of Sanandai Azad dam in Iran

The gill nets which was established in different depth; it has a 18m length and a 1.5-2m height, with a 30mm stretched bag mesh size. The fork length (FL) and somatic wet weight (TW) were measured within 1cm and 1g, respectively. The minimum water temperature in the winter was 6.3°^{C} with an average annual temperature of 11.96±6.6°^{C} and a maximum water temperature of 28.6°^{C} with an average annual temperature of 16.3±10.13°^{C} (Nasrollahzadeh et al., 2017).

Data analysis

A total of 73 fish measuring 5-25.3 cm (FL) with mean 13.5±2.5cm and weight 7.9-155.9 g with mean 23.4±17.1g were collected and examined. Each fish was opened and the gut was excised, weighted (g) together with its content, and preserved in 5% formalin for 72 hour and then transferred in 70% ethanol. Afterwards, stomach contents were suspended in water in Petri dishes, and all prey were identified to the lowest possible taxonomical level using standard taxonomic keys (Birstein et al., 1968). Diet composition was considered in terms

of numbers of prey organisms in the gut. For these purposes the following indices were applied (Hyslop, 1980; Biswass, 1993):

Numerical percentage of prey *i*:

$$[\%]N = \frac{N_i}{N_\Sigma} \times 100$$

Frequency of occurrence:

$$[\%]F_i = \frac{M_i}{M_\Sigma} \times 100$$

where N_i is the number of prey specimen of prey group *i*; N_Σ is total number of prey detected; M_i is the number of stomachs containing prey component *i*; *M* the number of stomachs containing food. When *Fi* > 50%, the prey group is considered the main prey, while 50 > *Fi* > 10 means that the prey is secondary, and *Fi* < 10 indicates rare prey (Euzen, 1987).

The extent of the diet was calculated using the diversity index of Shannon-Wiener (Ludwig and Rynolds, 1988): $H' = -\Sigma P_i \times \log_2 P_i$,

where H′ is the Shannon-Wiener and p_i is the proportion by the number of prey type *i*.

The gastrosomatic index (GaSI) was calculated to investigate monthly variations in feeding intensity, using the equation (Biswas, 1993):

GaSI= (Fresh weight of stomach/Total fresh weight of fish) ×100

To determine important species index (ISI) in food items, we used the equation (Rushforth and Brock, 1991): ISI= $(f_i) \times (D_i)$

where f_i is the frequency percentage of prey *i*, and D_i the mean relative abundance of prey.

The pearson's correlation coefficient and Jaccard's correlation coefficient were used to determine the association between all food items in stomach contents. The unweighted pair group method with arithmetic mean (UPGMA) (Van Tongeren, 1995) and multivariate statistics package (MVSP) version 3.11(Kerbs, 1989) were used to calculate and construct the dendogram.

RESULTS

Food items

Four genera of Daphniidae, two genera of Cyclopidae, one genus of Acartidae, Bosminidae, Sididae, Testudinelidae and Nematode were identified in *A. mossulensis* stomach contents in the present study (Table. I). *B. logirostris* was the most frequent prey, constituting 39.5% of the total ISI, followed by *D. pulex* (21.6%), *D. brachyrum* (9.31%), *Daphnia sp.* (6.09%), *D. longispina* (1.97%) and *C. scutifer* (0. 7%). The proportion of each prey types is represented in Figure 2 and shows that major contribution of Bosminidae (50.2%).

Table 1. Monthly percentage frequency of occurrence of different prey types in *A. mossulensis* stomachs from the Sanandaj Azad dam

	Frequency of occurrence (%)			
Food items	May	August	November	February
Mesocyclops sp**.**	4.3	-	-	75
Cyclops scutifer	8.4	-	-	-
Daphnia sp**.**	56.5	-	-	-
Daphnia pulex	52.2	-	-	100
Daphnia cucullata	17.4	-	-	-
Daphnia longispina	30.4	-	-	-
Nematod	-	-	-	25
Diaphonosoma brachurum	-	55.6	100	25
Bosmina longirostris	82.6	77.8	81.3	50
Pompholyx sulcata	4.3	-	-	-
Acartia tonsa	-	-	25	25
Number	23	9	16	5

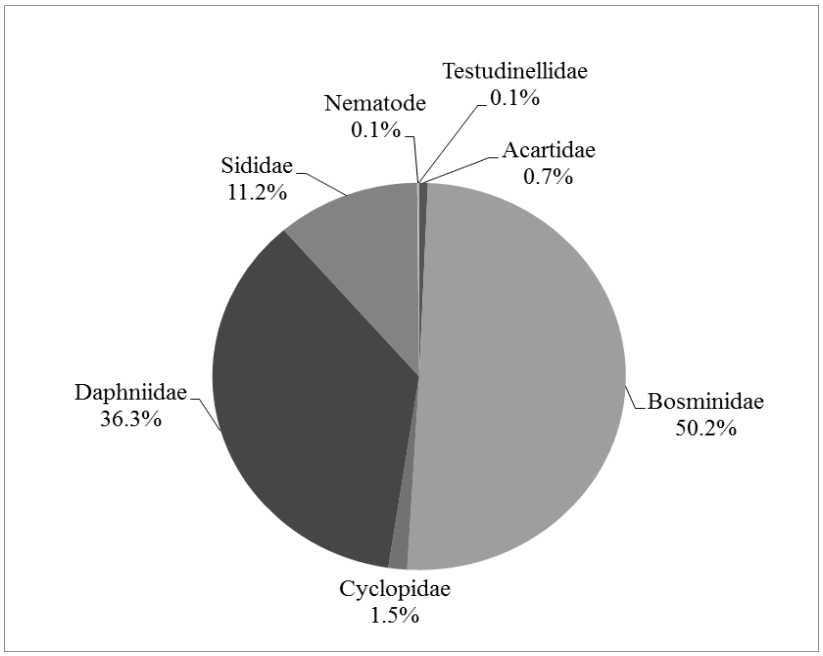

Figure 2. Numerical percentage of prey in the stomachs of *A. mossulensis* from the Azad dam of Sanandaj

The F_i value of the different food items is represented in Figure 3. *B. longirostris* has the highest F*i* values (75.4%) as a main (Fi>50%), followed by *D*. *brachyrum* (43.9%), *D. pulex* (31.6%), *D*. sp. (24.4%) and *C. scutifer* (10.5%) as rarely (10<Fi<50). The others food items was randomly consumed (F*i* <10%).

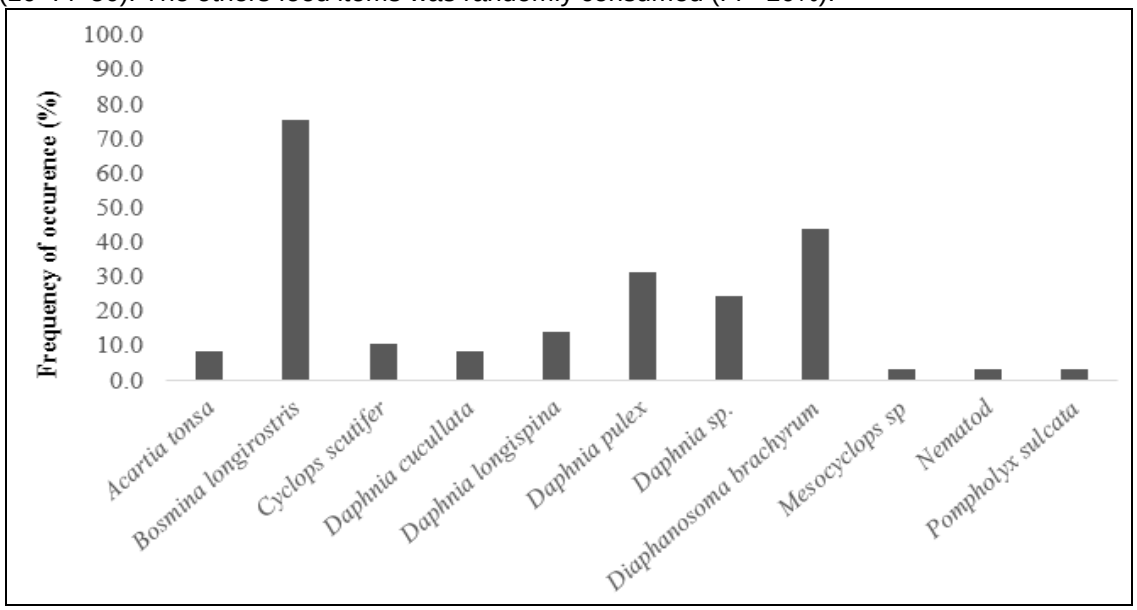

Figure 3. Frequency of occurrence of different food items in the diet of *A. mossulensis*

Monthly variations in diet composition and feeding activity

Significant seasonally differences in the diet composition were found during the study's span time ($p<0.05$) while *B. longirostris* was the most frequent prey throughout the study period (Tab. I). Variation in food items was the lowest in February and the highest in May. *C. scutifer, Daphnia sp., D. cuculata and D. longispina* were found in May, and *Mesocyclops* sp*. and D. pulex* were found in May and February. *D. brachyrum* was found in August, November and February, and *A. tonsa* was found in November and February, and Nematod and *P. sulcate* were found in February and May, respectively. *B. longirostris* has the highest ISI value (39.5%), followed by *D. pulex*

(21.6%), *D. brachyrum* (9.3%), *Daphnia* sp. (6.1%), *D. longispina* (2%), *C. scutifer* (0.7%), *A. tonsa* (0.4%), *Mesocycops* sp. (0.3%), *D. culculata* (0.1%), Nematode (0.1%) and *P. sulcata* (0.02%).

GaSI value of *A. mossulensis* ranged from 0.6% to 11.2% and fluctuated over season (Figure 4). The GaSI value increased in May (4.27) and decrease in August (2.76). A noticeable increase gradually was observed in November (3.21) and February (3.85).

Of the 73 stomachs examined, 16 (21.9%) were empty. The proportion of empty stomachs varied significantly among the season (χ^2 = 8.86, P< 0.05). The minimum and maximum proportion of empty stomachs occurred in August (1.4%) and February (12.3%), respectively.

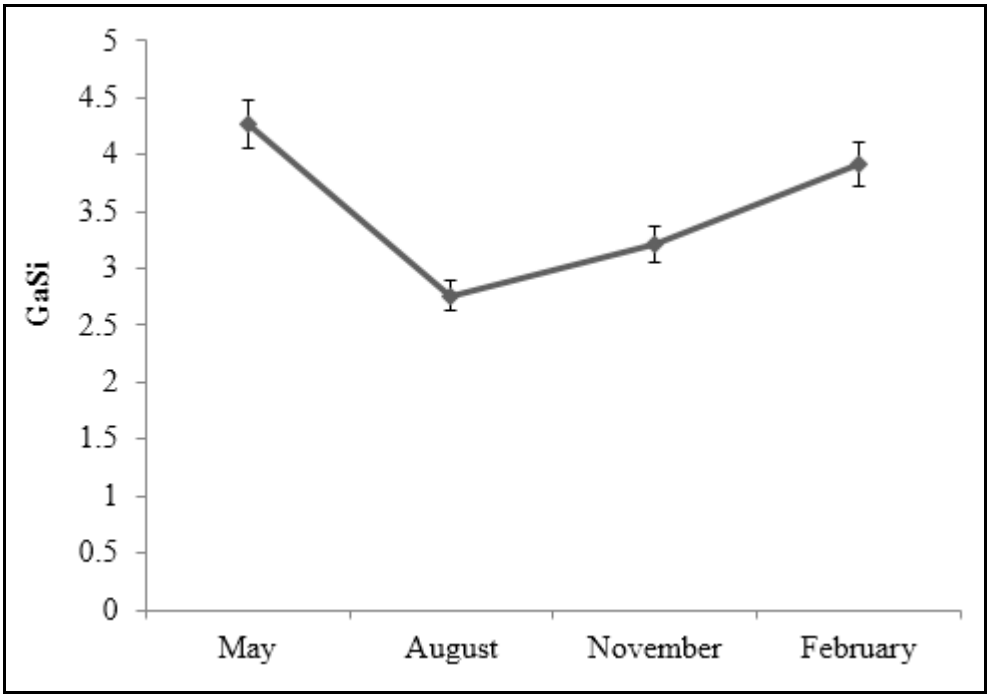

Figure 4. Monthly variations in the gastrosomatic index of *A. mossulensis* index. Vertical bars indicate standard deviations

The relationship between stomach contents and fish size

The diet composition of stomach contents of the different size classes of *A. mosulensis* ranged from 0.34% for the 5-9 cm class, from 0.05% to 45.43% for class 10-15 cm and 0.09% to 5.02% for the size class 15-19 cm of food items in fish stomach (Figure 5). The diet composition of stomachs varied significantly among the size classes (P< 0.05). The diet of Mossul bleak was dominated by Bosminidae (*B. longirostris*) (45.4% by abundance) in length groups 10-14cm. Sididae, mainly *D. brachyrum*, constituted 5.1% by abundance of the food of fishes of 15-19 cm

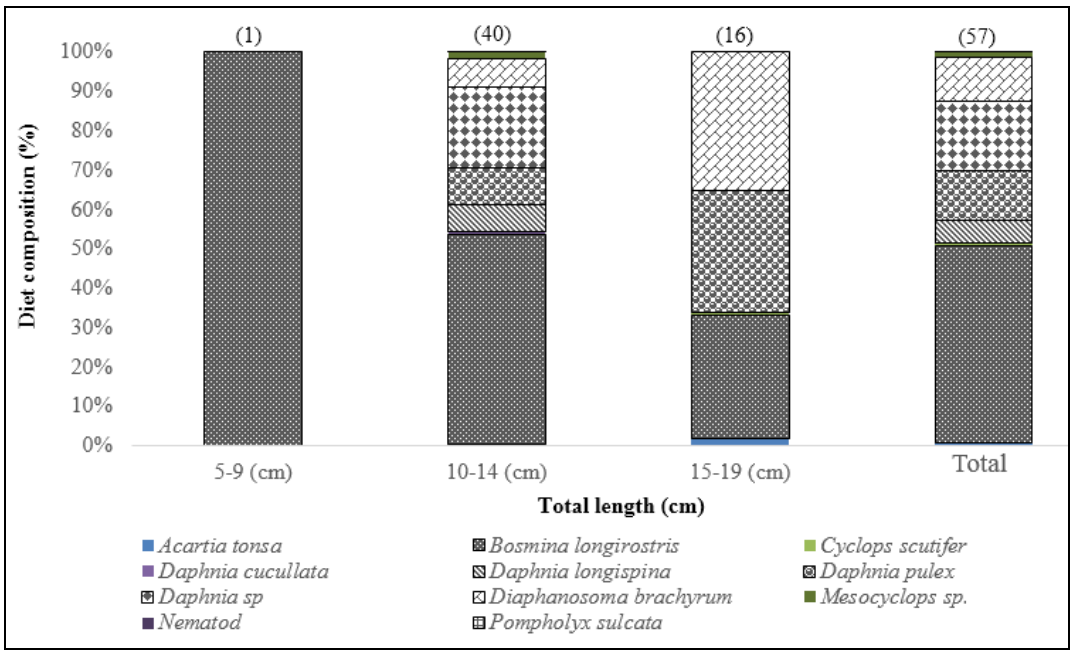

Figure 5. Composition of *A. mossulensis* diet with respect to size classes, based on frequency of prey in different length groups. parentheses indicate number of stomachs examined.

The cluster analysis separated six groups of food cohorts (Figure 6). *D. cucullata* and *D. longispina* represented the highest similarity indices of food item composition with the Pearson coefficient (100%), whereas Nematode had the lowest similarity index (~31%). Shannon index values ranged from 1.899 for the summer to 0.491 for winter.

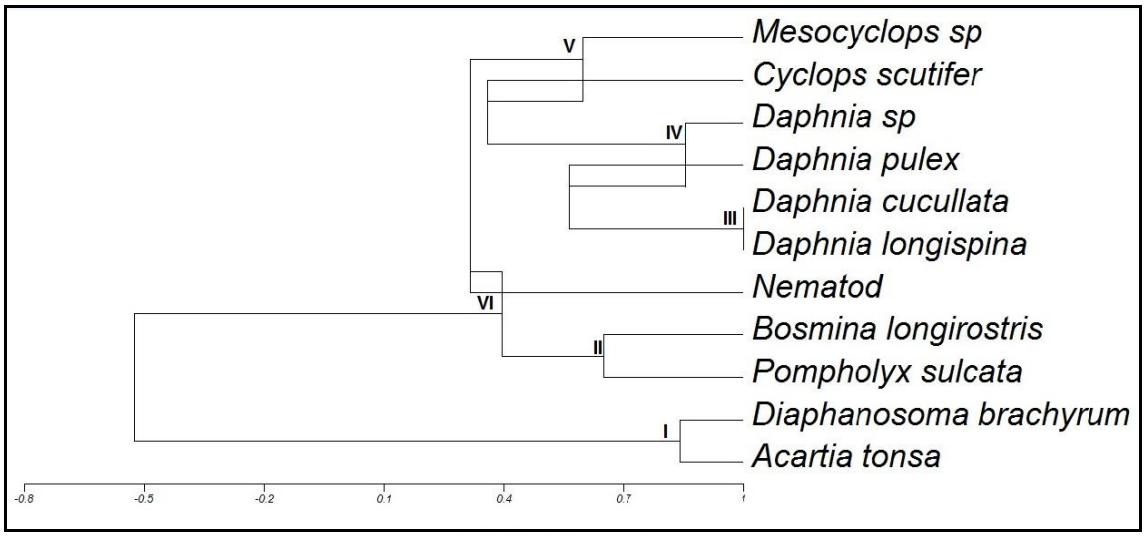

Figure 6. The dendrogram of cluster analysis of food items in the stomach of *A. mossulensis* from the Azad dam of Sanandaj

DISCUSSION

Limited information is available on the feeding habits of the Mossul bleak *A. mossulensis.* Generally, this species is classified as omnivorous and fed mainly on insects (41.2%), algae (28.74%), diatoms (15.94%), aquatic plants (12.36%), fishes (3.74%), and snails (0.3%) according to the index of relative importance (IRI) (Abdul-Razak et al., 2016). In the present study, this fish was based on the relatively low-fat gastric emptying index, which corresponded to 74.7% of the stomach filling index, while the relative length of the intestinal trait index was found in

the carnivorous fish. In the present study, zooplankton *B. logirostris* and *D. pulex* were the most frequent among the food items identified during the spring in the intestinal tract and more than 50% of the abundance were introduced as the main food.

Younis et al., (2001) demonstrated that *A. mossulensis* in Shattol Arab river of Iraq fed on phytoplankton (algae and diatoms) at 44%, followed by organic detritus at 36.7%, and arthropods at 3.1%. Food items in the stomach of *A. mossulensis* in the present study were different from the diets of other *Alburnus* species in the Iranian freshwaters as well as other areas. For example, Hussain et al., (1997) reported that *A. mossulensis* in the Hammar Marshes, Hawar al Hawizah and Al Kaba'ish Marsh of Iraq feed mainly on insect with 68.0%, 62%, and 73.7%, respectively. On the other hand, *Alburnus mossulensis* feeds on the phytoplankton, organic detritus and insects (Coad, 2017).

Table II provides more details on food and feeding habits of different *Alburnus* spp. in different geographic areas.

Table 2. – Food items in the stomachs of different *Alburnus* species (Cyprinidae) in different areas

species	area	Food items	References
A. mossulensis	Hammar Marshes (Iraq)	67.95% insects; 14.34% algae with diatoms; plants, crustaceans and fish at less than 10% each	Hussain et al., 1997
A. mossulensis	Hawr al Hawizah	66.2% insects; 19.2% algae; diatoms and crustaceans less than 10%;	Hussain et al., 1997
A. mossulensis	Al Kaba'ish Marsh	73.7% insects; 13.1% algae with diatoms; plants and crustaceans less than 10%	Hussain et al., 1997
A. mossulensis	Anzali-wetland, Iran	phytoplankton, organic detritus and insects	Coad, 2017
A. filippii	Qareh Su north of Ardebil, Iran	insect remains, a few crustaceans and sand grains	Coad, 2017
A. chalcoides	Anzali-wetland Iran	Diatoms, algae, dragonfly larvae, and copepods	Abdurakhmanov, 1962
A. mossulensis	Azad dam, Sanandaj	Bosminidae, Daphniidae, Sididae, Acartidae, Nematode	Present study

In the present study, the intensity of feeding in different seasons was volatile, with the highest amount in winter and spring, and the lowest in the summer, which may depend on the appropriateness of its reproductive period. Yildirim et al., (2007) reported that the reproductive season of *A. mossulenesis* from July to August, which consistent with the information obtained in the present study. Abdul-Razak et al., (2016) noted that the feeding activity of *A. mossulensis* ranged from 60.5% in March to 87.7% in October and the feeding intensity varied from 6.08 in December to 8.7 in July. The lower feeding intensity of *A. mossulensis* in hot season than cold can be attributed to increased metabolism and faster digestion and absorption of food (Winfield & Nelson, 1991).

B. longirostris occurred at the highest frequency in the stomachs of *A. mossulensis* in 10-14cm length groups. This could be due to the high abundance in the Azad dam. Roohi et al., (2017) noted that *Bosmina longirostris* has high frequency in summer with 6 ind.l. Fish analysed in the present study measured from 9cm to 190cm (FL) because of gill net with mesh size 20mm used catch. The presence of the fish may be due to ecological location of fishing area and temperature changes. Wahbeh & Ajiad (1985) and Abdel Aziz et al., (1993) reported also that food consumption appears to be correlated to temperature, spawning activity, age, and available food items.

The smallest size class of *A. mossulensis* contained the highest food mass while the lowest food content was recorded in larger size class. Feeding activity increases during grow out stages and decreases during spawning seasons. Available information (Geetha et al., 1990; Dadzie, 2007; Afraei Bandpei et al., 2009) suggests that the high occurrence of empty stomachs during the spawning season of fishes is linked to the decrease in feeding activity because mature gonads take more space in the peritoneal cavity, compressing the stomach and making feeding more difficult. Feeding is intensive during the early stages of maturity and decreases as the gonads mature (Dadzie et al., 2000; Afraei Bandpei et al., 2009; Afraei Bandpei et al., 2012). These results are in agreement with present results, where the GaSI value of *A. mossulensis* was highest in May (5.5) which coincides closely with spawning season and energy preservation for development of gonads and lowest in August that depended on the release of eggs while spawning in the river of freshwater waters occurs from early July to August (Yildirim et al., 2007; Coad, 2017) that confirm the results of the present study. Mosavi-Sabe et al., (2017) noted that spawning season occurs within May to August in Gamasiab River which signifies the latitude effect in terms of temperature

on reproductive activity. Temperature (which has major effects on gonad maturation and spawning season) is important in the onset of spawning and has a modifying role, particularly in cueing the precise timing of gamete maturation and spawning, providing the capacity for reproductive cycles to be locally tuned (Wootton 1999; Wright & Trippel 2009; Pankhurst & King 2010). The results showed that empty stomach was high in winter (*CV*=56.4%) in which coincided to decreased temperature and wintering season.

In conclusion, this study showed that *A. mossulensis* in the Azad dam of Sanandaj has an opportunistic feeding behavior. *A. mossulensis* is carnivorous, feeds on a variety of prey items, with changes in diet and feeding behavior according to the season, month, habitat and fish size. Further research is needed to document *A. mossulensis* food and feeding habits throughout the whole year.

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