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RESEARCH PAPER

Food Items and Feeding Habits of White Bream, *Blicca bjoerkna* (Linnaeus, 1758) Inhabiting Lake Ladik (Samsun, Turkey)

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Abstract

Food and feeding habits of white bream, *Blicca bjoerkna* specimens captured from Lake Ladik between November 2009 and October 2010 were investigated with respect to length groups and seasons. Stomach contents of 207 individuals ranging in size from 115 to 243 mm fork length were analyzed and 23.67% were empty. There was a seasonal variation in the feeding intensity of this species. The spring and summer feeding intensity were quite lower than other seasons. The food items in stomach showed a wide spectrum, ranging from phytoplankton, macrophytes, zooplankton to aquatic insects. Therefore, white bream displayed an omnivorous feeding. The relative importance index (RII%) indicated that *Bosmina*, Macrophytes, Chironomid larvae, *Melosira*, *Navicula*, *Cymbella* and Cyclopoid copepod were the most importance food items of white bream. The feeding strategy indicated that white bream plays an accelerator role in eutrophication. According to the Schoener's overlap index values, there was a high degree of consumed food overlap between spring-autumn (C_{xy} = 0.78095) and summer-winter (C_{xy} = 0.92035).

Keywords: Prey, feeding intensity, cyprinid fish, eutrophic lake, Turkey.

Introduction

The food and diet knowledge is very important for fish biology (Ramana and Manjulatha, 2014). Dietary ecology and feeding habits can be explored by quantifying variation in resource use, feeding intensity and trophic niche breadth (Hammerschlag *et al*., 2010). Also, the information on the food and feeding habits of a fish can be useful in finding out the distribution of a fish population for successful management of fishery (Ramana and Manjulatha, 2014).

The white bream, *Blicca bjoerkna* (L., 1758), is a cyprinid fish species. They live shallow, warm lowland lakes and slow-flowing lower parts of river and canal (Kottelat and Freyhoff, 2007). White bream constitutes main component of the ichthyofauna in eutrophic lakes and dam reservoirs. This species spawn in May-July at temperatures above 15 °C and spawn along shore on submerged vegetation, roots. They are predominantly nocturnal species (Kottelat and Freyhoff, 2007) and feed mostly on benthic invertebrates (Wielgosz and Tadajewska, 1988). This species graze upon aquatic invertebrate (zooplankton, mollusks and chironomids) and penetrate sediment (Wielgosz and Tadajewska, 1988). It applies predation on zooplankton and plays role at eutrophication process (Beklioglu *et al*., 2011). In addition, it is one of the target species selected for biomanipulation practices in eutrophic lakes (Prejs *et al*., 1994). Eutrophication is one of most important dangers in shallow lakes and decrease water clarity and oxygen. Biomass of species at trophic level has change in connection with eutrophication. The eutrophication leads to a negative acceleration in economy by reducing the number of commercial species. Fish manipulation which is one of the biomanipulation techniques is conduct as a based on food chain (Beklioglu *et al*., 2011). Fish play a central role in biomanipulaiton. Because they are easily affect to phytoplankton and zooplankton (Lammens, 1999). Therefore, it is necessary to determine the feeding features of this species.

The white bream does not have any commercial value because of its unpleasant taste (Yılmaz *et al*., 2015) and having a great number of intermuscular bones (Okgerman *et al*., 2012). However, it is an important food supply for predator species inhabiting aquatic habitats. There are very few researches on food types and feeding habits of white bream in the

worldwide (Wielgosz and Tadajewska, 1988; Tadajewska, 1993; Specziár *et al*., 1997; Specziár *et al*., 1998; Didenko and Kruzhylina, 2015) and Turkey (Okgerman *et al*., 2009). The aims of this study were to (i) describe food items of white bream; (ii) examine seasonal and different to size class changes in feeding habits and intensity; (iii) compare our results with findings of the previous studies.

Materials and Methods

Lake Ladik (35°40' - 36°05' E and 40°50' - 41°00' N) is 10 km far from Ladik district of Samsun province, northern Turkey (Figure 1). It has a surface area of 10 km^2 and the depth range from 2.5 to 6 m (Yılmaz *et al*., 2012). This lake which is a wetland has eutrophic character (Apaydin Yagci *et al*., 2015).

A total of 207 specimens of white bream were collected from different regions of the lake on a monthly basis from November 2009 to October 2010. The fish were caught using gill nets of various mesh sizes (17, 20, 25, 30, 35 and 40 mm knot to knot), trammel nets of various mesh sizes (30, 35, 45, 50, 55, 60, 70 and 80 mm knot to knot) and fyke nets. The nets were set at nightfall and hauled in the morning (approximately twelve hours). Fork length (FL) of each specimen was measured to the nearest mm, body weight (BW) and stomach weight were weighed with an precision of 0.01 g. For dietary analysis, fish were dissected and the stomach content analyzed under a binocular and inverted microscope in a sedgewick rafter counting chamber at different magnification. Prey items were identified to the lowest possible taxon. The variations in feeding habits were evaluated according to the seasonal and length groups. The specimens were divided into three size classes, small specimens (115-154 mm FL, n = 78), medium specimens (155-194 mm FL, n = 106) and larger sized specimens (195-245 mm FL, n = 23) in order to determine the variation in feeding habits between length groups.

The vacuity index (VI%) and fullness index (FI) were calculated to investigate the variations in feeding intensity. Vacuity index (VI%) was estimated as number of empty stomachs divided by total number of stomachs multiplied by 100 (Berg, 1979). Fullness index (FI) was calculated as stomach contents weight divided fish weight multiplied by 100 (Hyslop, 1980). Stomach contents of the white bream were analyzed using numerical percentage (N%) and frequency of occurrence percentage (FO%) (Hyslop, 1980). The main food items were identified using absolute importance index (AII) and relative importance index (RII%) of George and Hadley (1979), as modified by Meye *et al*. (2008):

$$AII = N\% + FO\%$$

where *AII* is the absolute importance index, N% is the percentage number of food types, FO% is the percentage frequency of occurrence of food types.

$$RII\% = AII \times 100 / n\sum AII$$

where RII% is relative importance index, n is the number of the different food types.

Schoener's overlap index was calculated for seasons and size groups to determine the diet similarity (Schoener, 1970):

$$C_{xy} = 1 - 0.5\left(\sum_{i=1}^{n} \left| p_{xi} - p_{yi} \right|\right),$$

where C_{xy} = overlap between diet of individuals in length groups or seasons x and y

p_{xi} = proportion of prey i used by size classes or seasons x

p_{yi} = proportion of prey i used by size classes or seasons y

n = number of prey

This index ranges from 0 (no prey overlap) to 1

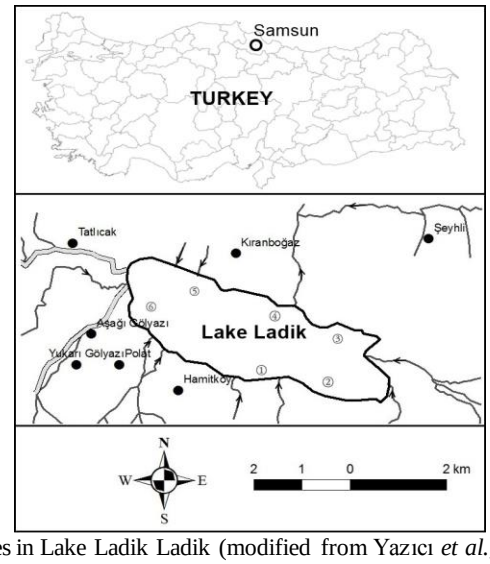

Figure 1. Location of sampling sites in Lake Ladik Ladik (modified from Yazıcı *et al*., 2014).

(all prey items in equal rate). Its values greater than 0.6 are usually considered as biologically significant (Wallace, 1981).

Statistical difference in vacuity index among seasons was tested by a chi-square test. The variation of the vacuity index (VI%) was tested by a chi-square test (Zar, 1999). Kruskal-Wallis test (K-W test) was used to test significance of the difference of mean fullness index values (FI) between seasons and size groups (Zar, 1999). Statistical analyses were performed using SPSS 20 software package.

Results

The fork lengths of samples examined ranged from 115 mm to 243 mm, with the mean value of 163 ± 0.16 mm. Their weights varied between 22.8 and 259.0 g, with the average value of 75.22 ± 2.571 g. Of the 207 stomachs examined, 49 (23.7%) were empty. The percentage number (N%), frequency of occurrence (FO%), absolute importance index (AII), and relative importance index (RII%) of different food items are given in Table 1. The stomach contents

Table 1. Diet composition of *Blicca bjoerkna* from Lake Ladik (N% = percentage of numerical, FO% = percentage frequency of occurrence, AII = absolute importance index and RII = relative importance index)

Food Items	N	%N	F	%FO	AII	RII%
Aquatic Insects						
Chironomidae larvae	265	0.34	68	43.04	43.38	7.06
Diptera pupae	9	0.01	3	1.90	1.91	0.31
Odonata larvae	57	0.07	16	10.13	10.20	1.66
Trichoptera larvae	17	0.02	8	5.06	5.09	0.83
Copepoda						
Calanoida	1170	1.52	30	18.99	20.51	3.34
Cyclopoida	2595	3.37	50	31.65	35.02	5.70
Harpacticoida	390	0.51	16	10.13	10.63	1.73
Cladocera						
Bosmina	10010	13.00	80	50.63	63.63	10.35
Chydorus	2680	3.48	43	27.22	30.70	4.99
Coronatella	305	0.40	13	8.23	8.62	1.40
Daphnia	755	0.98	17	10.76	11.74	1.91
Rotifera						
Brachionus	545	0.71	9	5.70	6.40	1.04
Keratella	280	0.36	9	5.70	6.06	0.99
Bacillariophyta						
Amphora	730	0.95	13	8.23	9.18	1.49
Caloneis	925	1.20	11	6.96	8.16	1.33
Cocconeis	540	0.70	7	4.43	5.13	0.84
Cyclotella	4330	5.62	35	22.15	27.77	4.52
Cymatopleura	35	0.05	2	1.27	1.31	0.21
Cymbella	8715	11.32	39	24.68	36.00	5.86
Epithemia	50	0.06	2	1.27	1.33	0.22
Fragilaria	1785	2.32	9	5.70	8.01	1.30
Gomphonema	3050	3.96	25	15.82	19.78	3.22
Gyrosigma	195	0.25	7	4.43	4.68	0.76
Licmophora	1375	1.79	16	10.13	11.91	1.94
Melosira	12605	16.37	36	22.78	39.15	6.37
Navicula	9440	12.26	38	24.05	36.31	5.91
Nitzchia	630	0.82	15	9.49	10.31	1.68
Pinnularia	20	0.03	1	0.63	0.66	0.11
Rhoicosphenia	400	0.52	3	1.90	2.42	0.39
Stauroneis	290	0.38	5	3.16	3.54	0.58
Surirella	235	0.31	8	5.06	5.37	0.87
Syndera	6375	8.28	27	17.09	25.37	4.13
Chlorophyta						
Ankistrodesmus	2575	3.34	40	25.32	28.66	4.66
Closterium	20	0.03	1	0.63	0.66	0.11
Cosmarium	230	0.30	8	5.06	5.36	0.87
Pediastrum	100	0.13	3	1.90	2.03	0.33
Scenedesmus	835	1.08	17	10.76	11.84	1.93
Oedogonium	2415	3.14	8	5.06	8.20	1.33
Euglenophyta						
Euglena	30	0.04	3	1.90	1.94	0.32
Macrophyte	-	-	72	45.57	45.57	7.41

of white bream consisted of 40 different prey items belonging to eight major groups: Aquatic insects, Copepoda, Cladocera, Rotifera, Bacillariophyta, Chlorophyta, Euglenophyta and Macrophyte. The most important prey types were *Bosmina* (RII% = 10.35) belonging to Cladocera, Macrophyte (RII% = 7.41), Chironomidae larvae (RII% = 7.06) belonging to aquatic insects, *Melosira* (RII% = 6.37), *Navicula* (RII% = 5.91), *Cymbella* (RII%=5.86) belonging to Bacillariophyta and Cyclopoida (RII% = 5.70) belonging to Copepoda. Other food types were less important as prey with their RII% ranging between 0.11-4.99. Food items of animal origin constituting 42.12 of the total *RII*% were consisted approximately half of diet (Table 1).

The analysis of stomach content showed that the vacuity index (VI%) was affected by seasonal changes and VI% value was highest in the summer (39.02%) followed by spring (32.81%). The lowest VI% value was observed in winter (11.48%). The mean value of fullness index (FI) was higher in winter (1.21%) than other seasons. The VI% showed an inverse trend to mean FI (Figure 2). There was significant difference both VI% values (x^2 = 16.319, P<0.05) and FI values (K-W test, P< 0.05) between seasons. RII% values of major food group consumed varied between seasons. Also, there were significant differences among seasonal values of RII% major prey group (df = 7, F = 7.516, ANOVA, P<0.001) in the diet of white bream. In spring and autumn, white bream fed on mostly animal food constituting 70.06% and 83.92% of the total RII respectively. Cladocera were dominant prey group in diet of white bream (RII% = 42.11 in spring and RII% = 41.32 in autumn) in this seasons. Among Cladocera, *Bosmina* was the most consumed to prey in spring, whereas *Bosmina* and *Chydorus* were eaten commonly in autumn. The secondary prey type was aquatic insect in spring (*RII*% = 13.66) and Copepoda in autumn (RII% = 13.79). In summer and winter, Bacillariophyta was the most important major prey group with RII% 27.88 in summer and RII% 29.58 in winter. The secondary food item was Cladocera in both seasons (RII% = 19.93 in summer, RII% = 14.86 in winter). Among Bacillariophyta, *Melosira*, *Cymbella* and *Navicula* were ingested mostly in winter, while *Cymbella* and *Navicul*a were consumed frequently in summer. Among aquatic insects, the most consumed prey item was Chironomidae larvae throughout the year especially in winter. Euglenopyhta were consumed only in summer by white bream individuals. Among animal food groups, the least ingested food was Rotifera along the year, especially in spring (RII% = 0.84) (Figure 3). Schoener's overlap index values between spring-autumn and summer-winter were relatively high with C_{xy} = 0.78095 and C_{xy} =0.92035 respectively (Table 2).

The food composition, VI%, and mean FI values of the three size groups are presented in Table 3. The maximum value of VI% was observed in large sized group, while the minimum *VI*% value was determined in small sized samples. The VI% values presented a similar trend as the FI values. The highest mean FI value was detected the large sized group, while the lowest mean FI value was determined in the small sized samples (Table 3). The mean fullness index (FI) was significantly different between the sized groups (K-W test, P<0.001), while the vacuity index (VI%) was not statistically different (x^2 = 3.498, P>0.05). The main prey group was Cladocera in small sized samples. Among them, the most eaten prey was *Bosmina* (RII% = 31.26) in the 115-154 mm size group. Aquatic insects and Copepod were formed the secondary food groups. Animal prey items comprised

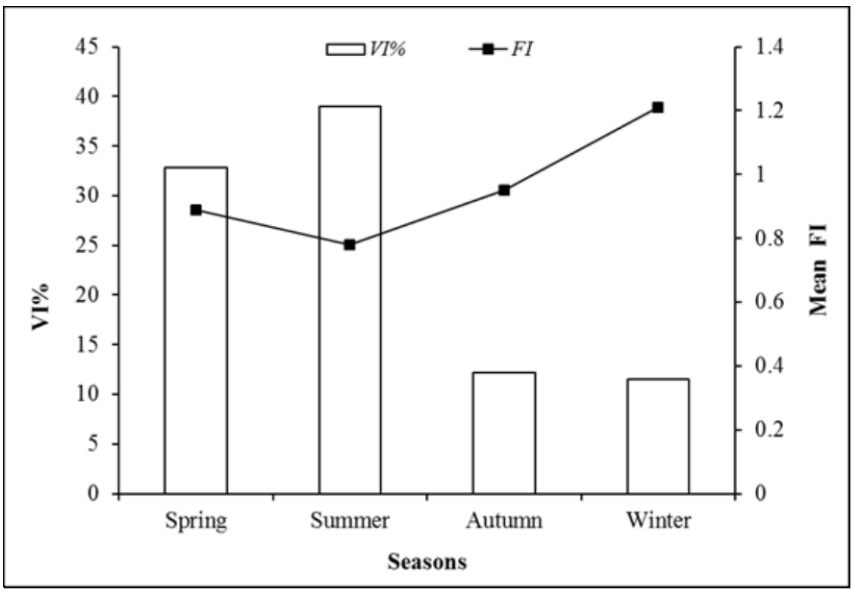

Figure 2. Seasonal variation in vacuity index (VI%) and mean fullness index (FI) of white bream.

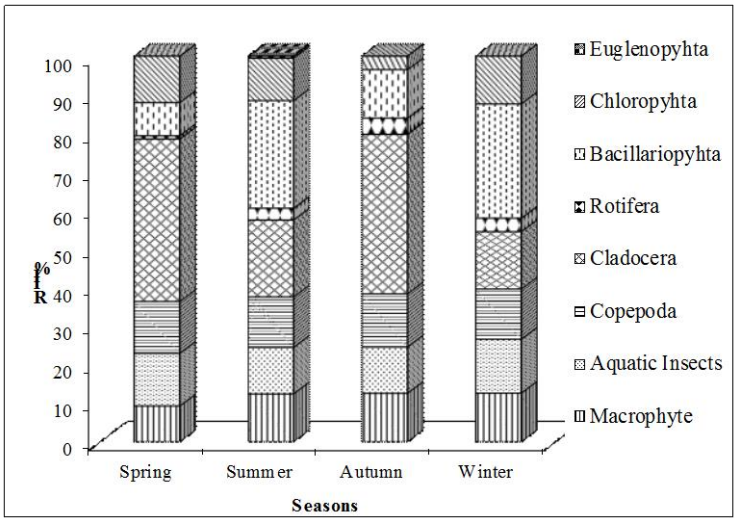

Figure 3. Seasonal variation in diet composition of white bream by RII%.

Table 2. Schoener index values between seasons of white bream in Lake Ladik

C_{xy}	Spring	Summer	Autumn	Winter
Spring	-			
Summer	0.3463	-		
Autumn	0.7809*	0.5232	-	
Winter	0.2670	0.9203*	0.4440	-

* Statistically significant

Table 3. VI% values, FI values of main food categories importance in different size groups

Food Groups	Small sized (115-154 mm FL) VI%= 16.67 FI= 0.75			Medium sized (155-194 mm FL) VI%= 27.36 FI= 1.15			Large sized (195-245 mm FL) VI%= 30.43 FI= 1.29		
	N%	FO%	RII%	N%	FO%	RII%	N%	FO%	RII%
Aquatic Insects	0.19	20.19	6.46	0.38	54.55	13.60	3.11	87.5	22.30
Copepoda	15.00	66.15	25.98	2.31	29.87	7.97	3.42	6.25	2.38
Cladocera	61.51	92.31	49.25	4.37	35.06	9.76	0.31	6.25	1.61
Rotifera	0.92	10.77	3.74	1.04	9.09	2.51	2.49	12.50	3.69
Bacillariophyta	17.41	6.15	7.54	83.42	54.55	34.16	72.63	56.25	31.72
Chlorophyta	4.91	4.62	3.05	8.47	50.65	14.64	18.04	56.25	18.29
Euglenophyta	0.05	1.51	0.51	0.04	2.60	0.65	-	-	-
Macrophyte	-	10.77	3.45	-	67.53	16.72	-	81.25	20.00

85.43 % of total RII in small length samples. The medium size samples fed on mostly Bacillariophyta group (RII% = 34.16). Among Bacillariophyta, the most eaten prey item was *Cymbella* with 7.99 of RII%. The secondary prey group was macrophytes constituting 16.72% of the total RII. Animal prey items composed of 33.84 % of total RII in 155-194 mm length individuals. In large size group, the most important prey group was Bacillariophyta with 31.72 of RII%. Within Bacillariophyta, *Navicula* was eaten commonly by white bream. Aquatic insect was the secondary food items (RII% = 22.30). Euglenophyta food group was absent from the diet in large sized individuals. Among aquatic insects, the importance of Chironomid larvae increased with length group in diet of white bream (RII% = 4.51 in small specimens, RII% = 8.19 in medium and RII%= 11.88 in large size). The overlap index values between medium-large size classes were found higher than 0.80. Diet of small samples was not similar other size groups (C_{xy} < 0.60).

Discussion

This study is the first reference on the food types and feeding habits of the white bream inhabiting Lake Ladik. In the present work, the proportion of empty stomach was found as 23.7%. This ratio was

determined as 55.2% by Tadajewska (1993) in Zegrzynski Dam Reservoir. This difference could be explained by sampling time and duration, consumed food type (Yılmaz and Polat, 2003), fish collection equipment types, environmental conditions such as prey encounter rate and temperature (Vinson and Angradi, 2011).

Bowman and Bowman (1980) stated that feeding intensity is negatively related to the percentage of empty stomachs. This situation was coincident with our findings. The feeding intensity of white bream in Lake Ladik varied between seasons. The white bream individuals fed more intensively during winter (especially January), while the feeding intensity of them displayed a downward trend in spring (especially May) and summer (especially June). Two reasons may be suggested to explain this case. Firstly, the vacuity index (VI%) was higher in summer than other seasons (Figure 2). This situation can be explained by the change of water temperature among seasons. Turker (2006) stated that the seasonal decline in the feeding activity of cyprinid fish is related to water. Wielgosz and Tadajewska (1988) reported that water temperature accelerated rate of feeding and food digestion of fish. Similarly, Yalcin-Ozdilek *et al*. (2013) stated that the high vacuity index values of *Pseudorasbora parva* inhabiting Gelingüllü Reservoir was found in summer of 2003 and 2005, and this could be explained by a high digestion ratio as a result of the high temperatures. Okgerman *et al*. (2013) indicated that water temperature is the main environmental factor affecting the stomach fullness of fish. Secondly, low feeding intensity in summer and spring could be attributed to reproduction season of the white bream. Yılmaz *et al*. (2015) stated that spawning season of the white bream population in Lake Ladik is between May and June. Sourinejad *et al*. (2015) indicated that most aquatic animals generally do not feed during the reproductive period, or their feeding habits are greatly decreased and there is a relationship between the reproductive season and feeding activity. Afraei Bandpei *et al*. (2009) reported that the lowest value of feeding intensity was observed in April, which coincided with the peak of spawning period in *Rutilus frisii kutum* inhabiting Caspian Sea. The similar observations were obtained for the white bream in this study. The lowest FI values were found in May-June which was known as the spawning period. Contrary to our results, Okgerman *et al*. (2009) found that feeding activity of the white bream inhabiting Lake Sapanca was highest in October and was lowest in January.

In our study, white bream individuals have the broad diet spectrum including animal origin prey items and plant origin food items. The stomach content of the white bream was composed by 40 different prey items in this study. Our results indicated that white bream is euryphagous, feeding on a wide variety of food items. The number of food items was similar as indicated by other authors. Wielgosz and Tadajewska (1988) found 39 prey taxa in *B. bjoerkna* from Włocławek Dam Reservoir. Okgerman *et al*. (2009) reported 39 food items in diet of specimens inhabiting Lake Sapanca.

According to the RII% values, *Bosmina*, Macrophyte, Chironomidae larvae, *Melosira*, *Navicula*, *Cymbella* and Cyclopoid copepod were the most important prey items of white bream in Lake Ladik. Other food types were of minor importance (Table 1). Similarly, the most important food components of white bream were Chironomidae, Copepoda, Mollusca in Włocławek Dam Reservoir (Wielgosz and Tadajewska, 1988). In Zegrzyński Dam Reservoir, Chironomidae larvae and mollusks were the principal food taxa at Wierzbica station, while only Chironomidae larvae was the main prey item at Bug station (Tadajewska, 1993). In contrast to our findings, *Dreissena polymorpha*, *Corophium curvispinum* and bait were the most important food type in Lake Balaton (Specziár *et al*., 1997; Specziár *et al*., 1998). The variation in the main food consumed are chiefly due to different abundance, density, distribution and availability of the prey between habitats.

In this study, the white bream consumed a wide variety of prey types and its diet varied between seasons (Figure 3). Same result was reported for this species in different researches (Wielgosz and Tadajewska, 1988; Okgerman *et al*. 2009). Wielgosz and Tadajewska (1988) reported that *B. bjoerkna* individuals eaten commonly Copepoda in spring, mollusks in summer and *Chironomus* sp. pupae in autumn. Okgerman *et al*. (2009) indicated that the main food item of species was Macrophyte followed by Bacillariophyta and *Dreissena polymorpha* in all seasons. Also the composition of diet was similar between spring-autumn and summer-winter.

The RII% values of major food groups were observed differences between size classes. Didenko and Kruzhylina (2015) reported that zooplankton played an important role in juvenile samples (25-31 mm) and also these prey items were *Bosmina spp*. and *Chydorus sphaerucus*. On the contrary, Okgerman *et al*. (2009) stated that the main food item of this species was Macrophyte followed by Bacillariophyta and *Dreissena polymorpha* in all size groups. In addition, the importance of aquatic insects in white bream diet increased with increasing fish length. Among them, Chironomid larvae were eaten most by white bream individuals.

Apaydin Yagci *et al*. (2015) investigated the zooplankton composition of Lake Ladik between November 2009 and October 2010. According to their finding Rotifera was the most dominant zooplankton group in this lake (59%). But among animal origin food groups, Rotifera were eaten the least by white bream. This situation can be attributed to prey selection. Besides, Apaydin Yagci *et al*. (2015) reported that this lake was defined as eutrophic. In this study, animal prey items such as *Bosmina*,

Chironomid larvae, Cyclopoid copepods and *Chydorus* were found as the most important food types in diet. This feeding habit could play an important role in increase of the eutrophication.

In conclusion, the white bream has a broad food spectrum. The feeding habits and intensity of *B. bjoerkna* vary between seasons and size groups. It is considered that the feeding character of this fish species with a high predation on zooplankton has a negative effect on the level of the eutrophication of Lake Ladik.

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