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Feeding ecology and prey selection of European perch, *Perca fluviatilis* inhabiting a eutrophic lake in northern Turkey

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ABSTRACT

Feeding habits and prey selection of European perch (*Perca fluviatilis*) were examined in Lake Ladik between November 2009 and October 2010. Stomach contents of 308 individuals ranging in size from 73 to 275 mm total length were analyzed and 55.2% were empty. The fullness index indicated that feeding intensity of this species was the highest in summer and the lowest in winter. European perch feeds on prey fish and macroinvertebrates. The most important food items were *Scardinius erythrophthalmus* and *Perca fluviatilis*, followed by chironomidae larvae. Diet composition and feeding habits varied seasonally and ontogenetically. Macroinvertebrates were only consumed by small individuals, while prey fishes were only eaten by large individuals. *S. erythrophthalmus*, *P. fluviatilis*, and *Blicca bjoerkna* were positively selected but their selection indexes were not statistically significant ($p > 0.05$). This prey selection is important for combating eutrophication. *Abramis brama* constitute 24.03% of all fish species in this lake; however, it was a negatively selected prey item ($V_a = -0.198$, $\chi^2 = 7.86$, $p < 0.05$). *Esox lucius*, *Squalius cephalus*, *Chondrostoma regium*, and *Carassius gibelio* inhabiting this lake were not preferred by European perch. Cannibalism rate was 12.3%.

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Prey item; feeding ecology; prey selection; European perch; Lake Ladik

Introduction

Having knowledge of predator–prey relationships, prey abundance, and feeding and food habits of piscivorous fish is essential for effective lake fisheries management and conservation biology in an aquatic environment (Alp et al. 2008). Prey selection is also an important aspect of fish feeding ecology (Sánchez-Hernández et al. 2013).

European perch, *Perca fluviatilis* L., 1758, is a carnivorous percid species feeding on zooplankton, macroinvertebrates, and fish species (Jamet 1994; Lorenzoni et al. 2007), and is an ecologically significant predator for both commercial and recreational fisheries in temperate waters (Popova & Sytina 1977; Langangen et al. 2011). *Perca fluviatilis* is commonly used to combat eutrophication (Lammens 2001). Specifically, their predation pressure on cyprinids causes an increase in biomass of zooplankton. In turn, phytoplankton biomass decreases in eutrophic lakes. As a result, perch can contribute to the recovery of lakes from eutrophic conditions (Beklioglu et al. 2011). Interactions between piscivorous fish and their prey play an important role in biomanipulation (Mehner et al.

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2002). A well-functioning perch population can be important for the success of a lake's restoration and, thus, understanding the biological characteristics of perch populations is critical (Dörner et al. 2003). In this respect, our study may help managers understand the role of perch in the mechanism of eutrophication and help them deal with its harmful effects.

The purposes of this paper are to describe the feeding habits and diet composition of *P. fluviatilis*, evaluate temporal variations and ontogenetic shifts in feeding habits, determine feeding intensity in relation to seasons and size classes, investigate prey choice by European perch in Lake Ladik, report information about its potential effect on eutrophication, and compare our results with the findings of previous studies.

Methods

Study area

Lake Ladik (35°40′–36°05′ E and 40°50′–41°00′ N) is situated near the borders of the Ladik district of Samsun Province in northern Turkey. It is 10 km from the Ladik district and situated on the northern side of Akdağ Mountain (Apaydin Yagci et al. 2015; Yilmaz et al. 2015). The lake has tectonic character in terms of formation (Bulut 2012). Its length, width, depth, and altitude are 5 km, 2 km, 2.5–6 m, and 867 m, respectively. The water temperature ranges from 3.8 to 25.2 °C throughout the year. The lake has been classified as eutrophic and shallow (Apaydin Yagci et al. 2015) and harbors nine fish species: common bream (*Abramis brama*), Anatolian khramulya (*Capoeta tinca*), white bream (*Blicca bjoerkna*), king nase fish (*Chondrostoma regium*), European chub (*Squalius cephalus*), rudd (*Scardinius erythrophthalmus*), pike (*Esox lucius*), perch (*Perca fluviatilis*), *Barbatula kosswigi*, and Prussian carp (*Carassius gibelio*; Uğurlu et al. 2009; Yılmaz et al. 2012).

Fish sampling and laboratory analysis

Sampling of perch was carried out in different regions of the lake on a monthly basis from November 2009 to October 2010. Fish sampling was conducted by means of benthic gill nets of five different mesh sizes (20, 25, 30, 35, and 40 mm, knot to knot). The total length (TL) of each specimen was measured to the nearest 1 mm and weight was determined using a digital scale (0.01 g). Fish were dissected, the guts were removed, and then preserved in a 4% formalin solution to stop digestion. The stomach of each individual was cut open and the contents were flushed into a Petri dish. Prey fish found in the stomachs were identified to species level. Also, other prey items were identified to the lowest taxonomic levels possible. The wet weights of prey fish and other food items were determined to the nearest 0.01 g. Also, full and empty stomach weights were measured with a precision of 0.01 g.

Data analysis

Ontogenetic shifts in diet of European perch were examined by grouping the fish into three size classes: small (<140 mm TL, $n = 79$); medium (140–209 mm TL, $n = 157$); and large (>210 mm TL, $n = 72$). Analysis of changes in the feeding intensity in different seasons was performed using the fullness index (FI = weight of stomach content/weight of fish) × 100 (Hyslop 1980). The variation of the feeding intensity between seasons and the length classes (mean FI) was tested with the Kruskal–Wallis test (K-W test; Zar 1999). Also, vacuity index (VI% = the number of empty stomachs/total number of the examined stomachs) × 100 was calculated. The chi-square test was used to test the significance of the VI values between seasons and the length classes (Zar 1999).

Diet composition was analyzed by employing the following traditional indexes (Hyslop 1980): percentage frequency of occurrence (FO% = number of stomachs containing prey i/number of stomachs with any food item × 100); numerical percentage (N% = number of prey i/total number of all prey items × 100), and percentage by weight (W% = weight of prey i/total weight of all prey items × 100). To determine the importance of food items in stomach content, index of relative importance (IRI) of Pinkas et al. (1971), as modified by Hacunda (1981), was estimated as follows:

$$\mathrm{IRI} = (N\% + W\%) \times \mathrm{FO}\%$$

This index has been expressed as the percentage of each prey item:

$$\mathrm{IRI}\% = (\mathrm{IRI}/\sum \mathrm{IRI}) \times 100$$

Schoener's overlap index was calculated for seasons and the length classes (Schoener 1970) to determine the diet similarity:

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

where C_{xy} is the overlap between diet of individuals in the length classes or seasons x and y; p_{xi} is the proportion of prey i used by size classes or seasons x; p_{yi} is the proportion of prey i used by size classes or seasons y. This index ranges from 0 (no prey overlap) to 1 (all prey items in equal rate), values greater than 0.6 are usually considered biologically significant (Wallace Jr. 1981).

In order to determine prey preference of perch, the prey selection index (V_a) suggested by Pearre (1982) was calculated. Its values range between 1 (strong positive selection) and −1 (strong negative selection). Also, a value of zero shows neutral selection. The index was calculated as follows:

$$V_a = \frac{(a_d \times b_e) - (a_e \times b_d)}{\sqrt{a \times b \times d \times e}}$$

where V_a is Pearre's index for perch selection of prey type i; a_d is the relative abundance of prey type i in the diet; b_e is the relative abundance of all other prey in the lake; a_e is the relative abundance of prey type i in the lake; and b_d is the relative abundance of all other prey in the diet.

Values without subscripts are expressed as follows:

$$a = a_d + a_e;\ b = b_d + b_e;\ d = a_d + b_d;\ e = a_e + b_e$$

The statistical significance of the selection index value (V_a) was tested using the chi-squared test:

$$\chi^2 = n \times {V_a}^2,$$

where $n = a_d + a_e + b_d + b_e$.

The value of relative abundance used in the prey selection index for each fish in Lake Ladik was obtained from Yazıcıoğlu (2014).

Results

A total of 308 European perch were captured. The total length of the individuals ranged from 73 to 275 mm with a mean value of 172 mm and weight ranged from 3.45 to 365.2 g with a mean value of 87.34 g. Of the stomachs analyzed, 170 were empty (VI% = 55.2) and prey items were found in 138 of them (Table 1). The VI value was higher in the summer (61.4%) than in other seasons where the index value varied between 50% and 55%, but no significant difference was detected ($\chi^2 = 1.681$,

Table 1. Diet composition of European perch in Lake Ladik.

Food items	*n*	*N*%	*W*	*W*%	*O*	FO%	IRI	IRI%
Fish								
Abramis brama	5	3.47	25.97	7.12	5	3.62	38.34	1.62
Blicca bjoerkna	7	4.86	8.12	2.22	7	5.07	35.90	1.51
Perca fluviatilis	17	11.81	127.66	35.00	16	11.59	542.53	22.88
Scardinius erythrophthalmus	25	17.36	158.86	43.55	23	16.67	1015.4	42.82
Unidentified fish	16	11.11	27.50	7.54	15	10.87	202.7	8.55
Fish remains	–	–	11.91	3.26	32	23.19	75.60	3.19
Macroinvertebrates								
Chironomid larvae	37	25.70	1.01	0.28	17	12.32	320.1	13.5
Odonata (Anizoptera) larvae	6	4.17	1.05	0.29	6	4.35	19.40	0.82
Dipter pupae	14	9.72	0.81	0.22	9	6.52	64.81	2.73
Coleoptera	3	2.08	0.49	0.13	3	2.17	4.80	0.20
Trichoptera larvae	7	4.86	0.51	0.14	7	5.07	25.35	1.07
Unidentified insect	7	4.86	0.44	0.12	7	5.07	25.25	1.06
Insect remains	–	–	0.46	0.13	12	8.70	1.13	0.05
Total	144	100	364.8	100			2371.3	100
Number of stomach analyzed	308							
Full stomach	138	44.8%						
Empty stomach	170	55.2%						

n, prey number; *N*%, numerical percentage; *W*, prey weight; *W*%, percentage by weight; *O*, frequency of occurrence; FO%, percentage frequency of occurrence; IRI, index of relative importance.

$p > 0.05$). The proportion of empty stomachs also decreased with increasing the size class (Figure 1), but VI values were not significantly different among size classes ($\chi^2 = 4.919$, $p > 0.05$).

The mean FI expressing the feeding intensity showed variation among seasons (K-W test, $p < 0.05$). The highest mean FI was recorded in the summer (1.74, standard deviation, SD = 3.62), followed by the autumn (1.50, SD = 2.41), the spring (1.20, SD = 1.94), and the lowest mean FI in the winter (0.53, SD = 1.10). The mean value of FI was highest in the medium size class (1.65, SD = 2.92) and lowest in the small size class (0.09, SD = 0.18). There were significant differences in the mean FI values among the size classes (K-W test, $p < 0.05$, Figure 1).

The diet of European perch in Lake Ladik consisted of 11 different prey species belonging to two major classes (fish and macroinvertebrates). A total of 144 prey items were identified from those 138 stomachs. The number of food items per full stomach ranged between 1 and 7 with a mean of 1.04.

The main food items of European perch were prey fishes. Among them, *S. erythrophthalmus* was the dominant prey in diet by weight (43.55%), number (17.36%), and occurrence (16.67%), followed by European perch (Table 1). Among the macroinvertebrates, the most consumed food type was chironomidae larvae ($N\% = 25.7$, $W\% = 1.01$, and $FO\% = 12.32$). According to the IRI%,

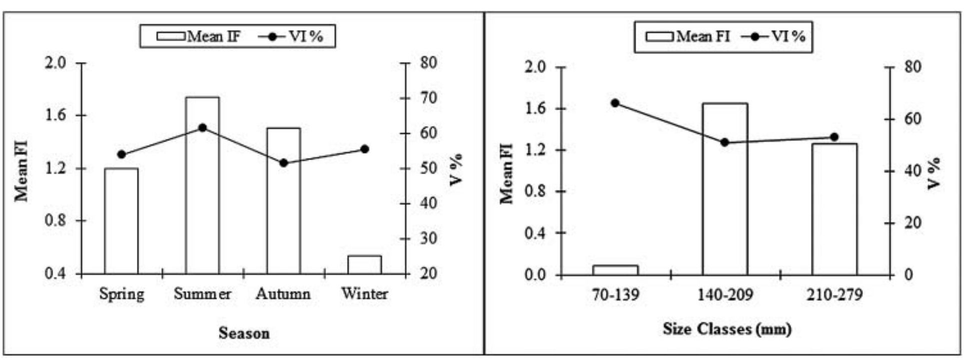

Figure 1. The mean fullness index (FI) and vacuity index (VI%) for seasons (A) and size classes (B) in European perch inhabiting Lake Ladik.

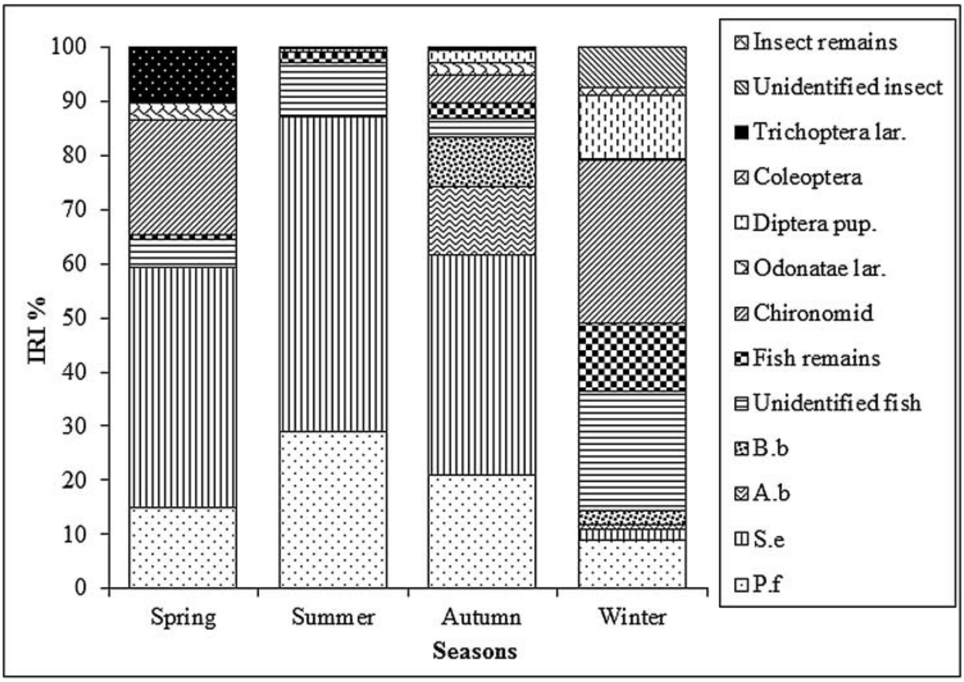

Figure 2. Seasonal variation in the diet composition by IRI% in European perch from Lake Ladik (P.f = *Perca fluviatilis*, S.e = *Scardinius erythrophthalmus*, A.b = *Abramis brama*, B.b = *Blicca bjoerkna*).

S. erythrophthalmus and European perch were the most important prey items (IRI% = 42.82 and IRI% = 22.88, respectively), followed by chironomidae larvae (IRI% = 13.5). Other prey taxa were less important in the diet, constituting 20.8% of the total IRI (Table 1). The cannibalism rate was determined as 12.3% in Lake Ladik and it was only observed in the medium- and large-size classes.

Diet composition of perch showed seasonal variation with prey fish as the most consumed food group from spring to autumn. The importance of macroinvertebrates in the diet was higher in the spring and winter (in spring IRI% = .34.68 and winter IRI% = 50.97). Among the prey fish, rudd and European perch were observed in the diet during all seasons. Common bream and white bream were absent in the diet of the species in the spring and the summer. Rudd was the most important prey item in the spring, summer and autumn, with a peak value recorded in the summer (IRI% = 58.14), followed by chironomid larvae in the spring and European perch in the summer and autumn. The winter diet was different from the other seasons. Chironomidae larvae (IRI% = 29.97) and identified prey fish (IRI% = 22.25) were the most important prey items in the winter. Chironomidae larvae and Diptera pupae were found in the stomachs throughout the year. In terms of variety of food items, macroinvertebrates were the least consumed ones in the summer (Figure 2).

According to the Schoener's overlap index values, there was a low degree of consumed food overlap between spring–summer, spring–autumn, and summer–autumn ($C > 0.650$). The greatest dietary overlap was formed between the spring and the autumn. However, there was no similarity between the other paired seasons ($C < 0.40$; Table 2).

There were ontogenetic shifts in the feeding habits among the length classes of European perch. The shift from macroinvertebrates to fish was determined in the diet when perch reached a total length above 182 mm. The small-sized fish fed only on macroinvertebrates. Chironomidae larvae were the most important food item of this size class, followed by insect remains. The importance of macroinvertebrates decreased with the increase in fish size and they were not consumed by the large-sized individuals (Table 3).

Table 2. The values of Schoener's overlap index of perch in Lake Ladik according to seasons.

C_{xy} (IRI%)	Spring	Summer	Autumn	Winter
Spring	–			
Summer	0.659	–		
Autumn	0.683	0.680	–	
Winter	0.392	0.237	0.288	–

Table 3. The variation in the diet composition in European perch depending on size classes.

	70–139 mm TL				140–209 mm TL				210–279 mm TL			
Food items	*N*%	*W*%	FO%	IRI%	*N*%	*W*%	FO%	IRI%	*N*%	*W*%	FO%	IRI%
Fish												
Abramis brama	–	–	–	–	5.95	13.81	6.49	5.53	–	–	–	–
Blicca bjoerkna	–	–	–	–	7.14	3.08	7.79	3.43	3.85	1.33	2.94	0.32
Perca fluviatilis	–	–	–	–	11.9	41.41	12.99	29.85	26.92	28.41	17.65	20.51
S. erythrophthalmus	–	–	–	–	15.48	25.92	16.88	30.12	46.15	62.84	29.41	67.34
Unidentified fish	–	–	–	–	11.91	11.01	12.99	12.83	23.08	3.88	14.71	8.33
Fish remains	–	–	–	–		3.04	20.78	2.72	–	3.54	47.06	3.50
Macroinvertebrates												
Chironomidae larvae	67.65	37.58	40.74	79.87	16.67	0.24	0.24	5.68	–	–	–	–
Odonatae larvae	5.88	15.44	7.41	2.94	4.76	0.43	0.43	1.16	–	–	–	–
Diptera pupae	5.88	10.74	7.41	2.29	14.29	0.34	0.34	5.73	–	–	–	–
Coleoptera	5.88	14.77	7.41	2.85	1.19	0.14	0.14	0.07	–	–	–	–
Trichoptera larvae	5.88	2.01	7.41	1.1	5.95	0.25	0.25	1.74	–	–	–	–
Unidentified insect	8.83	4.69	11.11	2.8	4.76	0.2	0.2	1.11	–	–	–	–
Insect remains	–	14.77	29.63	8.15	–	0.13	0.13	0.03	–	–	–	–

*A reference to the text of Table 1 for an explanation of the abbreviations.

The diet of medium-sized perch comprised fish and macroinvertebrates. Rudd and European perch were the main food of this size group, followed by unidentified fish (IRI% = 12.83). Common bream was found only in the diet of the medium-sized specimens (Table 3).

The largest sized individuals consumed only prey fishes. The most important food item of this size group was rudd with IRI% = 67.34, followed by European perch. The importance of European perch in diet decreased with increasing fish size while the importance of rudd increased (Table 3). According to the Schoener's overlap index values, a similarity was observed in the diet of the medium- and large-sized specimens ($C = 0.62$). The diets of other paired sized classes were not the same in terms of consumed food (Table 4).

According to the finding of Yazıcıoğlu (2014) between November 2009 and October 2010, values for relative abundance of fishes in Lake Ladik were reported as follows: rudd is the most abundant fish species with 34.10%, followed by European perch with 26.21%, common bream with 24.03%, white bream with 12.26%, Prussian carp with 1.94%, pike with 1.10%, king nase fish with 0.24%, and European chub with 0.12%, respectively.

Rudd, European perch, and white bream comprised 70% of all prey fish consumed by this species, while common bream constituted 7.15% of all prey fish, neither pike, king nase fish, nor European chub were consumed by perch (Figure 3). According to the prey selection index (V_a), rudd ($V_a =$ 0.124), European perch ($V_a = 0.058$,) and white bream ($V_a = 0.011$) were positively selected by European perch; however, their selection indexes were not statistically significant ($\chi^2 = 3.09$, 0.67,

Table 4. The values of Schoener's overlap index in European perch according to size classes.

C_{xy} (IRI%)	70–139 mm TL	140–209 mm TL	210–279 mm TL
70–139 mm TL	–		
140–209 mm TL	0.114	–	
210–279 mm TL	0	0.620*	–

*Significant result.

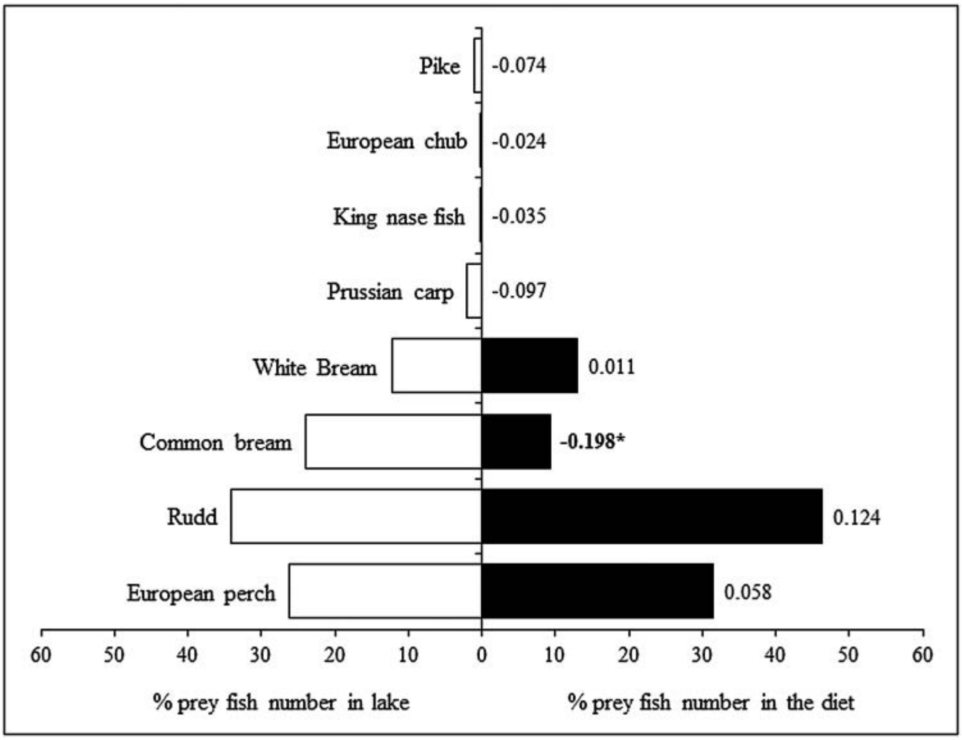

Figure 3. Pearre's selectivity index of the prey fishes in Lake Ladik. *Significant at $p < 0.05$ in the χ^2-test.

and 0.02, respectively, $p > 0.05$). Common bream was negatively selected by European perch ($V_a = -0.198$) and selectivity index value was statistically significant ($\chi^2 = 7.86, p < 0.05$).

Discussion

In this study, out of all the stomachs examined, 55.2% were found empty. Previous studies reported that the percentage of empty stomachs of European perch varied between 4% and 58% (Gargan & Grady 1992; Yılmaz et al. 2003a; Dörner et al. 2003; Wziatek et al. 2004; Akin et al. 2011; Ceccuzzi et al. 2011; Pavlović et al. 2013). Generally, the presence of a high percentage of empty stomach is a common occurrence in piscivorous fish (Arrington et al. 2002). Similarly, the value of VI expressed as the percentage of empty stomachs was high in Lake Ladik and it was generally consistent with the previous studies (Dörner et al. 2003; Yılmaz et al. 2003a).

Our study indicated that the feeding intensity of European perch inhabiting Lake Ladik differed among seasons. The fluctuation in the feeding intensity is thought to be related to the water temperature in winter and reproduction activity in spring. Water temperature is known to be one of the main factors influencing the rate of feeding in fishes (Weatherley & Gill 1987). Yılmaz et al. (2013) reported that the spawning season of European perch was spring (March and April) in this lake. Thus, the spawning period of this species in Lake Ladik coincided with the period of lower feeding intensity. In the literature, this reduction in the feeding activity of European perch was associated with spawning activity in the spring (Jamet 1994; Jacobsen et al. 2002; Dörner et al. 2003).

Our results related to diet composition (macroinvertebrates and fish) are similar to the findings of previous studies (Jacobsen et al. 2002; Dörner et al. 2003). On the other hand, Pavlović et al. (2013) stated that the food of this species consists of only five prey fish in three reservoirs in Serbia. The richest diet of this species was observed in the lower basin of the Yeşilırmak River (Akin et al. 2011). European perch in Lake Ladik had a normal diet composition when compared with other

Table 5. Comparison of food items in European perch populations inhabiting different habitats.

Allen (1935) (England)	Gargan and O'Grady (1992) (Ireland)	Lappalainen et al. (2001) (Finland)	Wziqtek et al. (2004) (Poland)	Lorenzoni et al. (2007) (Italy)	Akin et al. (2011) (Turkey)	Ceccuzzi et al. (2011) (Italy)	This study (Turkey)
Bosmina	Perch fry	Poychaeta	Cladocera	Hirudinea	Detritus	Daphnia sp.	Chiron. larvae
Cyclops	*A. aquaticus*	Mysidacea	Copepoda	Gasteropoda	Aquatic veg.	*L. kindtii*	Dipter pupae
Diaptomus	*Gammarus* sp.	Isopoda	Heteroptera	Bivalvia	Bacillariophyta (9 items)	Chiron. larvae	Odonata larvae
Daphnia	Chiron. larvae	Amphipoda	Rototoria	Crustacea (5 items)	*Ulothrix* sp.	Chiron. pupae	Coleoptera
Bythotrephes	Chiron. pupae	Decapoda	*Chaoborus* sp.	Chiron. larvae	Crustacea (9 items)	*Chaoborus larvae*	Trichoptera larvae
Leptodora	Trichop. larvae	Chironomidae	Chironomidae	Chiron. pupae	Nematodes	*Chaoborus pupae*	Unidentified Insect
Chiron. larvae	Trichop. adults	Odonata	Zygoptera	Tanypodinae	Oligochaetes	Copepoda	Insect remains
Chiron. pupae	Gastropoda	Trichoptera	*Sialis* sp.	Simuliidae	Insecta (21 items)	*O. limosus*	*A. brama*
Gammarus	Plankton	Mollusca	Trichoptera	Ephemeroptera	*P. fluviatilis*	*R. rutilis*	*B. bjoerkna*
Sialis	Terres. diptera	Fish	Other Inverteb.	Eteroptera	*R. amarus*	*S. erythrophth.*	*P. fluviatilis*
Ephemera	Ceratopogonidae	Other	*R. rutilis*	Sialidae	*P. marmoratus*		*S. erythrophth.*
Gasterosteus	Corixidae		*P. fluviatilis*	Odonata	*Gambusia* sp.		Unidentified fish
Phoxinus			*A. bjoerkna*	Trichoptera	Gobidae		Fish remains
Unidentified			*G. gobio*	*G. cernus*	Unidentified fish		
			A. brama	*R. rutilis*			
			A. alburnus	*P. fluviatilis*			
				S. erythrophth.			

*Chironomidae larvea and pupae, Trichopteran larvae and adults, *Asellus aquaticus*, Terrestrial diptera, *Rutilus rutilus, Perca fluviatilis, Abramis bjoerkna, Gobio gobio, Abramis brama, Alburnus alburnus, Gymnocephalus cernus, Scardinius erythrophthalmus, Rhodeus amarus, Proterorhinus marmoratus,* Aquatic vegetation, *Orconectes limosus, Blicca bjoerkna.*

studies (Table 5). However, the diet compositions of European perch populations inhabiting varied habitats may display differences (Table 5). These differences in diet composition are mainly due to different distribution, density, abundance, and availability of prey items (Šantić et al. 2003), as well as environmental factors (Rask 1983). Dörner et al. (2003) reported that the important factor affecting the feeding behavior of large perch was prey fish availability.

According to the IRI% values, the most important prey items were rudd and European perch throughout the year. Griffiths (1976) reported that common bully, *Gobiomorphus cotidianus*, was the most important food type of this species in the Selwyn River, New Zealand. On the contrary, Ceccuzzi et al. (2011) stated that the main food category was Chironomidae (larvae or pupae) and Chaboridae (larvae or pupae) in Lake Varese, northwestern Italy. Akin et al. (2011) found that the most important food item was insects in the diet in Yeşilırmak River. These results can be related to fish and benthic fauna of lakes, sample sizes, and geographical and climatic differences of habitats. Intraspecific predation (cannibalism) was recorded in this lake and was detected in the individuals larger than 157 mm TL. Cannibalism has been reported in several previous studies (Lorenzoni et al. 2007; Akin et al. 2011; Pavlovic et al. 2013), and the intensity of cannibalism is shown to vary with the size structure of the population (Persson et al. 2004).

Our findings indicated that the diet composition of European perch was different between seasons. Seasonal variations in the diet of European perch are generally reported (Craig 1978). Previous studies stated that European perch showed seasonal changes in their diet components (Jamet 1994; Dörner et al. 2003). Akin et al. (2011) reported that the relative importance of dominant food items revealed strong temporal variations. On the other hand, Griffiths (1976) demonstrated that food composition did not vary significantly between seasons. Likewise, Yılmaz et al. (2003b) observed that the food preferences of this species did not vary between seasons. The variations in seasonal diet are attributed to the density, abundance, and availability of prey items, as well as metabolism rate (Šantić et al. 2003), energy requirements of fish (Ronneberger & Anwand 2000; Akin et al. 2011), and environmental factors (Rask 1983; Pavlovic et al. 2013).

The life cycle of European perch includes potentially ontogenetic shifts in their diet (Swynnerton & Worthington 1940; Hjelm et al. 2000; Ceccuzzi et al. 2011) and our results correspond to this. The food composition of the smallest individuals was completely different from the largest ones. The small-sized group fed only on macroinvertebrates, while large-sized individuals (>210 mm TL) only consumed prey fish. The diet of medium-sized perch was composed of more prey fish and less macroinvertebrates. Similarly, Wziqtek et al. (2004) indicated that the diet of the specimens larger than 200 mm comprised solely of prey fish. Juveniles of European perch start to feed on pelagic zooplankton, and then they switch to feeding on benthic resources at middle sizes, and finally, when large enough, their diet consists of prey fish (Allen 1935; Rask 1983; Hjelm et al. 2000).

In our study, the shift from macroinvertebrates to fish was observed in perch exciding 182 mm of length, and the importance of macroinvertebrates in the diet decreased with the increasing fish length. The large individuals above 182 mm TL showed completely piscivorous feeding behavior, corresponding to the previous studies (Lappalainen et al. 2001; Wziqtek et al. 2004; Ceccuzzi et al. 2011). Rezsu and Specziár (2006) reported that the individuals larger than 160 mm showed piscivorous feeding behavior in Lake Balaton. Akin et al. (2011) stated that 141−160 mm and 181−200 mm length classes mainly preferred prey fish in Yeşilırmak River. Lappalainen et al. (2001) indicated that European perch larger than 200 mm consumed mostly fish at Tvärminne in the western Gulf of Finland. As values of Schoener overlap index is greater than 0.6, European perch had a similar feeding strategy in the medium-sized and large-sized specimens ($C = 0.62$).

We found through selectivity index of perch that rudd, smaller sized conspecifics, and white bream were positively preferred by perch, though the selection indexes were non-significant ($p > 0.05$). This is a positive finding to coping with eutrophication because these species, which is preferred by European perch, apply predation pressure on zooplankton. Mehner et al. (2002) indicated that the stocking of fish, such as the strongly day-active perch, might cause a behaviorally mediated biomanipulation effect by preventing the feeding of planktivores on daphnids in the open water. Common bream was negatively selected in Lake Ladik and its selective index was statistically significant ($p < 0.05$). This condition can be due to both body height of common bream and the mouth size of *P. fluviatilis*. In piscivorous fishes, there are strong relationships between prey's body depth and predator fish's mouth gape size (Hambright et al. 1991). Juanes et al. (2002) claimed that a predator's mouth form and size can also be affected from the types and sizes of prey that will be ingested.

In conclusion, the food composition and the feeding habits of European perch in Lake Ladik showed seasonal variations. Ontogenetic changes in the feeding habits of *P. fluviatilis* were observed. The small individuals performed predation on macroinvertebrates, whereas the large individuals showed predation on prey fish, especially cyprinid specimens. European perch larger than 150 mm in TL started to consume prey fish in this lake. It is suggested that their feeding features play a regulatory role on the eutrophication in lake. European perch stocking can be used to combat against eutrophication.

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Disclosure statement

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