Feeding habits of introduced European perch (Perca fluviatilis) in an impounded large river system in Turkey

Article *in* African Journal of Agricultural Research · September 2011

DOI: 10.5897/AJAR11.397

African Journal of Agricultural Research Vol. 6(18), pp. 4293-4307, 12 September 2011
Available online at http://www.academicjournals.org/AJAR
ISSN 1991-637X ©2011 Academic Journals

Full Length Research Paper

Feeding habits of introduced European perch (*Perca fluviatilis*) in an impounded large river system in Turkey

Şenol Akin[1]*, Cemalettin Şahin[2], Bülent Verep[2], Davut Turan[2], Ahmet Mutlu Gözler[2], Ahmet Bozkurt[3], Kemal Çelik[4], Evren Çetin[1], Ayşe Aracı[1] and İrfan Sargın[1]

[1]Faculty of Agriculture, Department of Fisheries and Aquatic Sciences, Gaziosmanpasa University 60240 Tokat, Turkey.
[2]Faculty of Fisheries, Rize University, 53100, Rize, Turkey.
[3]Faculty of Fisheries, Mustafa Kemal University, 31200, İskenderun, Hatay, Turkey.
[4]Faculty of Art and Literature, Biology Department, Çağış Campus, 10145 Balıkesir, Turkey.

Accepted 30 May, 2011

The feeding habits of perch (*Perca fluviatilis*) were documented by analyzing gut contents of more than 3300 specimens collected seasonally at nine stations located along the impounded large river in Turkey. Perch largely preferred fish (36%), insects (54%), other crustaceans (16%) and daphnia (13%). Spatial analysis showed that perch substantially preferred fish in the river section above the dam lakes and insects, crustacean and fish in the river section below the dam lake and in dam lakes. The perch at every size seemed to prefer fish with the highest and lowest percentage obtained for 0 to 80 and 141 to 200 mm. Insects and crustaceans were important for 81 to 140 mm and 0 to 120 mm length, respectively. Crustaceans were important in June, November and July. Insects and fish except for June 2009 constituted an important portion of the diets during every sampling month. The perch showed a piscivory feeding habit, a result obtained by trophic level calculated by stomach contents (3.87) and stable isotope (3.91) methods. Trophic level change little during the ontogeny with relatively higher value obtained for the larger length. The perch inhabiting in the river section above the dam lakes had the highest trophic level compared to the other sites. Diet breadth of perch was lower and higher for larger and middle length (101 to 140 mm), respectively. The diet breadth was higher in dam lakes, indicating opportunistic feeding habits in lakes. Being the most abundant fish species in the study system and showing predatory feeding habits suggested that perch may have an effect on local fish assemblage and itself through predation.

Key words: European perch, impounded river, stable isotope, gut contents analysis, Turkey, feeding habits, Yeşilırmak River, *Perca fluviatilis*.

INTRODUCTION

Resolving feeding habits of fish provides understanding of the trophic interactions among organisms. The feeding habits of fish species also present information on species assemblages and the role of fish in food webs (Cohen et al., 1993). Trophic position that a species occupy in the community resolves food web interactions. Trophic position reflects the information on energy transferred along the food web before being used, thereby quantifying species role in food webs (Vander Zanden et al., 1997; Post, 2002; Akin and Winemiller, 2008).

Determining the trophic position of species especially introduced ones in an ecosystem and determining the role of this species in the systems are crucial to understand the effects on the species inhabiting in the same systems. Trophic position of species can be determined by performing stomach contents analysis and use of stable isotopes. Stomach contents provide information on what are consumed by the species, whereas, stable isotope gives information on what is actually assimilated by the species. It has been indicated that using both methods to quantify trophic positions of species are important by providing full knowledge on the species feeding habits (Winemiller et al., 2007).

Identifying the patterns of changes in diets can also be a key to understanding mechanisms that regulate growth,

*Corresponding author. E-mail: senol.akin@gop.edu.tr. Tel: +90(356) 252 1616 (ext:2104-2136). Fax: +90 (356) 2521488.

survival, and recruitment processes (Nunn et al., 2007). The changes in dietary composition of most fish species occur throughout ontogenetic development and availability of food resources. Juvenile fish during the ontogenetic development are particularly susceptible to fluctuations in food availability.

The perch, *Perca fluviatilis*, is a freshwater species inhabiting different ecosystems varying from artificial ponds to brackish water. The perch is an introduced fish species in Turkey. The perch especially adults are known to prefer slow-slowing rivers, deep lakes and ponds; avoids cold, fast-flowing waters but may penetrate into but not breed in such waters. Normally they are found lying close to or amongst obstacles in the water. Larval perch chose habitats to increase survival. For this purpose, the larval perch move from littoral zone to the open water and then return to littoral zone after a few weeks (Urho, 1996). The perch may also stay in pelagic zone for several months (Čech and Kubečka, 2006). Stomach contents analysis of perch indicates that they go through two major ontogenetic shifts during their life span. The larval perch feed on protozoan, phytoplankton, rotifers and copepod nauplii and switch to macro invertebrates at intermediate sizes and then to piscivory at larger sizes (Persson and Greenberg, 1990; Hjelm et al., 2000), although piscivory may occur at early stages under certain conditions (Beeck et al., 2002). Studies showed that the perch show trophic polymorphisms influenced by habitat and resource use. The overall food composition of different perch populations is usually dissimilar, and is dependent on the specific lake, the species composition, and the availability of the feed base. It has been observed that the diet structure of individuals inhabiting littoral and pelagic habitats change within the same lake.

The effects of impoundment on feeding habits and trophic organizations of fish community are well described by several studies. Forming the river into lakes leads to variations in both abundance and distribution of fishes, available food resources and feeding habits of species. The impacts of the introduced species on local fish assemblage structure and ecosystem are well resolved in many studies. Perch is an introduced fish species in the system where this study was performed. We therefore in this study aimed to document spatial, temporal and ontogenetic variations in feeding habits of perch inhabiting in an impounded river and dam lake in order to determine the effects of damming on feeding habits and evaluate the degree of impacts on local fish community through predation.

MATERIALS AND METHODS

Study area

This study was carried out in the lower basin of Yeşilırmak River in Turkey. The river originates within the Kose Mountain located on the northeastern parts of Turkey and flowing into the Black Sea near Çarşamba, a district of Samsun. The river, which is the second longest river (529 km) of Turkey, contains three main branches Kelkit, Çekerek and Tozanlı. The natural flow of the river is interrupted by five main power plants which were built on Kelkit River (Kılıçkaya Power Plant), on the Tozanlı River (Almus and Ataköy) and on the main channel (Hasan Ugurlu and Suat Ugurlu). This study was performed on the lower portion of the river basin at consecutive nine stations. Three sites (1,2,3) were located on the downstream just below Suat Ugurlu Dam Lake, which was constructed in 1981 for production of electricity; four of them were placed within the Suat Ugurlu (4,5) and Hasan Ugurlu Dam Lakes (6,7), two for each lake; and finally two of them (8K and 8T) were located on the Tozanlı and Kelkit branches flowing into Hasan Ugurlu Dam Lake after joining to each other near Erbaa, district of Tokat (Figure 1).

Sampling protocols

Fish samples were collected seasonally between April 2008 and July 2009 at 9 sites located along the river and dam lakes built on the river. Fish specimens in dam lakes and deep river sites (Sites 1 and 8K) were collected by a four 100 m long gillnets with mesh size of 20, 25, 30, 40 and trammel nets with inner nets consisting of five 100 long panels of 50,60, and 70 mm. The nets were deployed at 15:00 pm and remained approximately until 10:00 am of the following days. The shallow river sites were sampled with a LR-24 Smith-Root Backpack Electrofisher. Captured fish specimens were anesthetized in MS-222 then fixed in 10% formalin in the field. For each sample, fish were sorted, measured (standard length to nearest 0.1 mm), weighed (to nearest 0.1 g), and counted in a laboratory at the Department of Fisheries and Aquaculture, Gaziosmanpasa University.

Stomach contents analysis

Stomach contents analysis was performed to document feeding habits of *P. fluviatilis* using methods described in Winemiller (1990). All specimens collected were dissected for stomach contents analysis. All food items were removed from the anterior half of the gut and examined under a dissecting microscope or compound microscope depending on the size of the prey. Prey items were identified to the smallest feasible taxonomic unit. Prey taxa were later combined into more general taxonomic categories to examine functional feeding relationships. Prey items were sorted, blotted dry and measured in a graduated cylinder by water displacement. Items with volumes larger than 0.1 ml were quantified in graduated cylinders by water displacement. For volumes less than 0.1 ml, items were placed on a glass slide and visually compared with a water drop of known volume extracted from a pipette. In addition to the volume of the stomach contents, length of the measurable prey items were measured, counted and weighed. But, the most of the stomach contents included non measurable prey items. So the information on the feeding habits was obtained from the volumetric quantification of stomach contents.

For stable isotope analysis, approximately 5 g of tissue samples from beneath the dorsal fin was removed from each specimen. Fish tissues were examined to remove skin, scales or small bones. The tissue then was rinsed with distilled water. The rinsed tissue samples then were dried at 60°C for at least 48 h. Dried fish tissues were ground to a fine powder using a mortar and pestle. The powdered samples of fish tissue were weighed approximately 2 mg into ultrathin capsule and sent to the Analytical Chemistry Laboratory of the Institute of Ecology, University of Georgia, for analysis of carbon and nitrogen isotope ratios. Results are

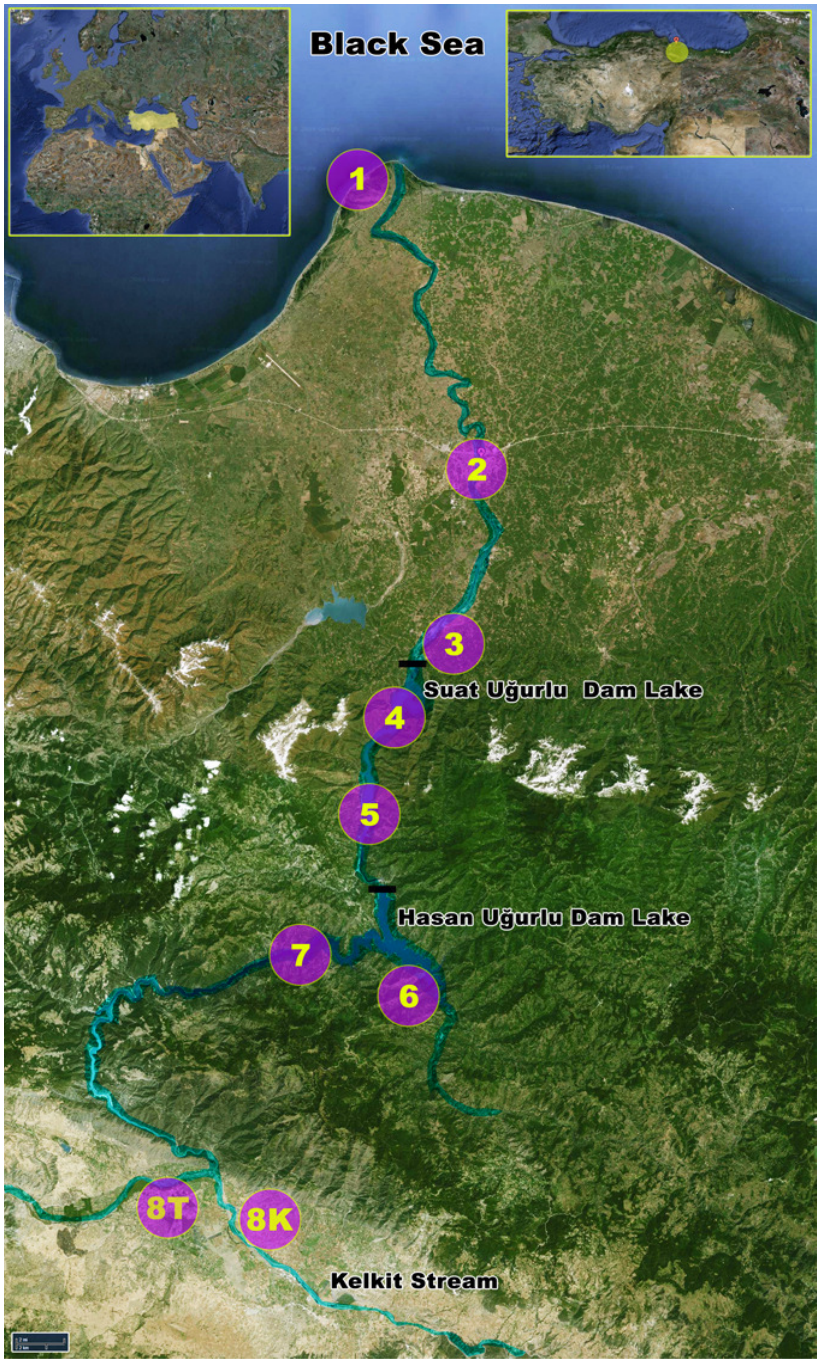


Figure 1. Study area and position of the sampling sites.

expressed in delta notation (parts per thousand deviations from a standard material):

$\delta^{13}C$ or $D^{15}N = [(R_{sample}/R_{standard}) -1] \times 1000$

Where $R = {}^{15}N/{}^{14}N$ or ${}^{13}C/{}^{12}C$.

Data analysis

The spatial and temporal dynamics of feeding regime of perch were examined. The temporal variation was documented by aggregating the all diet data obtained from each site in a given month. Likewise, the spatial dynamics of feeding habits were analyzed by aggregating the data obtained from 1, 2, and 3 sites in all months into a broader site called "BLDAM" standing for below the dam. The data obtained from Sites 4 and 5, located on the Suat Ugurlu Dam Lake, and 6 and 7, located on Hasan Ugurlu Dam Lake, were aggregated and named as "RESSU" and "RESHU", respectively. The diet data obtained from sites 8T and 8K, located on the river above the dam flowing into Hasan Ugurlu Dam Lake, were aggregated and called as ABDAM. In addition, possible ontogenetic variations in diets of the fish were analyzed. For this purposes, the fish were grouped into eight size classes (0 to 80, 81 to 100, 101 to 120, 121 to 140, 141 to 160, 161 to 180, 181 to 200 and 201 to 300 mm).

The seasonal, spatial and size aggregated diet data were analyzed using different indices and statistics. Percentage relative importance value (PRIV) (Marian et al., 2002) was used to determine the dietary importance of prey item. The index (PRIV) is an extended version of relative importance (RIV=V%F%), that accounts for both frequency of occurrence and volumes and varies from 0 to 100. The PRIV of the ith prey item is given by:

$$PRIV_i = 100V_i(\%)F_i(\%)\left[\sum_i^n V(\%)F(\%)\right]^{-1}$$

Where $V_i(\%)$ is the percentage contribution to the volume of all dietary items present in each of nonempty stomachs. $F_i(\%)$ is the number of stomachs in which a particular food item was present and expressed as a percentage of the total number of non-empty stomachs.

Diet breadth (B), an indication of prey diversity, was calculated using Levins (1968) measure:

$$B = \left[\sum_{i=1}^n p_i{}^2\right]^{-1}$$

Where p_i is the volumetric proportion of food category i in the diet and n is the number of food categories in the diet. B values vary from 1.0 (when the species uses for one resource category exclusively) to the number of all resource categories (when the species uses all categories in equal proportions). A standardized Levins's measure was also used, which gives a measure of breadth if all diet items were in equal proportion, or a measure of the evenness of prey utilization (Hulbert, 1978), using the equation:

$$BA = \frac{B-1}{n-1}$$

Where: BA = Levin's standardized index for predator i; p_{ij}= proportion of diet of predator i that is made up of prey j; n = total number of food resources.

Breadth niche values were arbitrarily set at the following levels: high (> 0.6), intermediate (0.4 to 0.6) or low (< 0.4) (Novakowski et al., 2008).

Using volumetric proportional dietary data from stomach contents analysis, trophic position were calculated from the formula given by Adams et al. (1983):

$$T_i = 1 + \sum_{i=1}^n T_j(p_{ij})$$

Where T_j is the trophic position of prey species j, and p_{ij} is the fraction of the consumed food (volume) of species *i* consisting of prey species j.

In addition to trophic level calculation based on stomach contents data, trophic level of the species was calculated using stable isotope ratios. Stable isotope ratios were used to calculate continuous estimates of species trophic positions which integrate energy assimilated and material flow along all pathways leading to the consumer. Trophic positions (TP) of species were calculated using:

$$TP = \lambda + (\delta^{15}N_{predator} - \delta^{15}N_{baseline}) / F$$

Where TP is the trophic level of consumers estimating the food web base (in this case λ = 2 because primary consumers were used, $\delta^{15}N$ predator is the nitrogen isotopic signature of the species, $\delta^{15}N_{baseline}$ is the average nitrogen isotope signature of the consumers used to estimate the base of the food web, and F is the per trophic level fractionation of nitrogen. We used a fractionation of $\delta^{15}N$ as 2.54 (Hoeinghaus et al., 2008).

As a baseline $\delta^{15}N$, we used primer producers (algae, phytoplankton and aquatic vegetation) signature of $\delta^{15}N$.

Feeding overlap was used to examine dietary similarity between the individuals of different size, season and sites using Pianka (1973) formula:

$$\theta_{jk} = \frac{\sum_{i=1}^n p_{ij} p_{ik}}{\sqrt{\sum_{i=1}^n p_{ij}{}^2 \sum_{i=1}^n p_{ik}{}^2}}$$

Where: O_{jk} = Pianka's measure of niche overlap index between j and k species; pij = proportion resource i of the total resources used by species j; p_{ik} = proportion resource i of the total resources used by species k; n = total number of resource states. Overlap values were arbitrarily set at the following levels: high (> 0.6), intermediate (0.4 - 0.6) or low (<0.4) (Grossman et al., 1986). This index assumes prey to be equally available to all predators (Reinthal, 1990).

A one way ANOVA was used to test spatial and temporal differences in standard length of the fish. Data were first tested for normality (Kolmogorov-Smirnov test) and homogeneity of variances (Levene's test). When a significant (P < 0.05) difference for main effects was detected, Student Newman-Keul (SNK) multiple comparison test was used to test for significant mean differences.

RESULTS

General dietary pattern

A total of 3332 specimens were dissected for stomachs contents analysis (Figure 2). The percentage of the empty stomach was 58, with most encountered during February (84%; n = 93), November (68%; n = 133), July 2009 (67%; n = 1035)), June (59%,n = 426). The perch were mostly abundant during warmer months including June, July 2008 and 2009 and November accounted for more than 90% of the total collection of the perch (Figure 3). Most of the individuals were collected and dissected from the dam lakes which accounted for 94% of the all individuals. The percentage of empty stomach was higher (66%) at downstream sites below the RESSU and lower (39%) at RESHU (Figure 2).

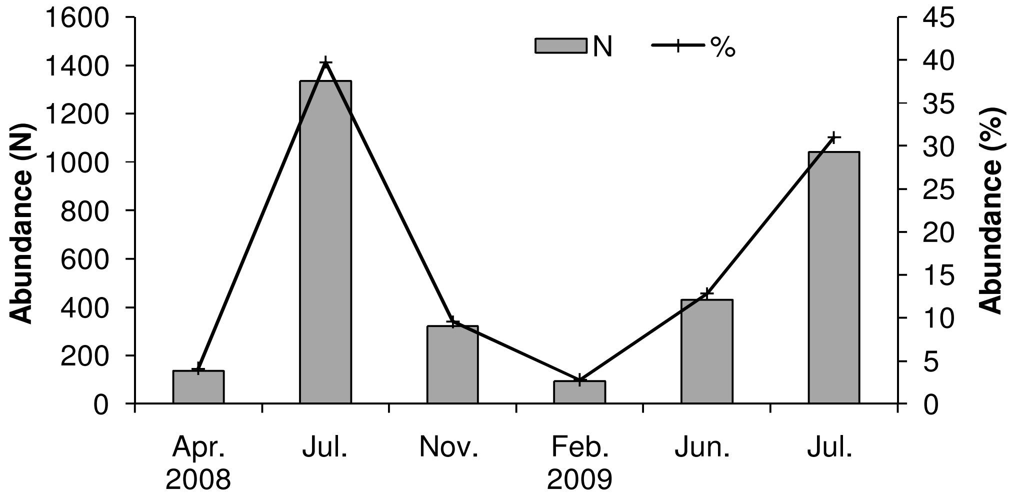
	General	Months						Fish Lenght Classes							
		Apr. 2008	Jul. 2008	Nov. 2008	Feb. 2009	Jun. 2009	Jul. 2009	0-80	81-100	101-120	121-140	141-160	161-180	181-200	201-300
TL (Stomach Contents)	3.87	4.18	3.83	3.95	3.73	3.14	3.80	3.69	3.63	3.66	3.84	4.26	3.44	5.37	3.50
Number of stomach examined	3332	133	1326	319	93	426	1035	5	184	1187	1768	128	41	17	2
Number of stomach full	1394	70	691	103	15	176	339	5	103	498	770	31	13	4	1
Number of stomach empty	1938	63	635	216	78	250	696	0	81	698	998	97	28	13	1
TL (Isotope)	3.91	3.87±0.58	3.67±0.93	3.7±0.53	4.13±0.80	4.50±0.25	4.01±0.57	3.37±0.68	3.37±0.57	4.43±0.67	3.91±0.73	3.77±0.59	3.80±0.68	3.91±0.68	4.20±0.08
Fish lenght for isotope (mm)		135.27±37.20	85.46±36.63	153.33±30.77	134.5±35.75	186.88±86.85	131.39±34.21								
?^{15}N	13.03	12.95±1.47	12.42±2.36	12.49±1.35	13.6±2.00	14.53±0.63	13.31±1.44	11.67±1.73	14.38±1.45	13.04±1.72	12.68±1.86	12.76±1.50	13.02±1.73	13.75±1.74	13.77±0.20
Number of samples for isotopes	96	30	26	6	8	8	18	15	15	19	15	7	15	8	2
Diet breadth (B)	8.07	4.16	4.92	4.05	2.46	5.05	10.90	1.61	4.15	5.82	7.87	3.05	2.25	1.02	1.00
Standardized diet breadth(BA)	0.14	0.12	0.14	0.50	0.36	0.31	0.33	0.15	0.21	0.12	0.18	0.14	0.10	0.01	0.00

	Sites								River and Dam Lakes			
	2	3	4	5	6	7	8K	8T	BLDAM	RESSU	RESHU	ABDAM
TL (Stomach Contents)	3.47	3.38	3.91	4.14	3.72	3.20	4.10	3.50	3.45	4.00	3.62	4.09
Number of Stomach examined	12	47	861	831	999	475	106	1	59	1692	1474	107
Number of Stomach full	11	28	409	308	399	179	59	1	39	717	578	60
Number of Stomach empty	1	19	452	523	600	296	47	0	20	975	717	47
TL (Isotope)	4±0.71	3.76±0.85	3.93±0.64	4.08±0.62	3.32±0.59	3.88±0.35	4.1±0.50	4.68±0.99	3.83±0.77	4±0.63	3.54±0.58	4.75±0.55
Fish lenght for isotope (mm)	95.75±20.85	104±14.51	117.59±44.31	136.06±46.79	113.83±44.94	179.36±73.34	130.75±44.56	165±49.50	102.12±17.71	125.9±45.81	138.69±64.77	137.6±45.78
?^{15}N	13±1.82	12.67±2.17	13.09±1.62	13.49±1.58	11.55±1.50	12.98±0.89	15.21±1.27	15±2.51	12.83±1.95	13.27±1.59	12.09±1.46	15.17±1.40
Number of samples for isotopes	8	9	22	18	18	11	8	2	17	40	29	10
Diet breadth (B)	1.30	2.10	6.21	4.79	10.04	4.24	1.61	1.00	1.45	6.51	12.46	1.63
Standardized diet breadth(BA)	0.04	0.09	0.14	0.18	0.31	0.21	0.04	0.00	0.02	0.14	0.38	0.04

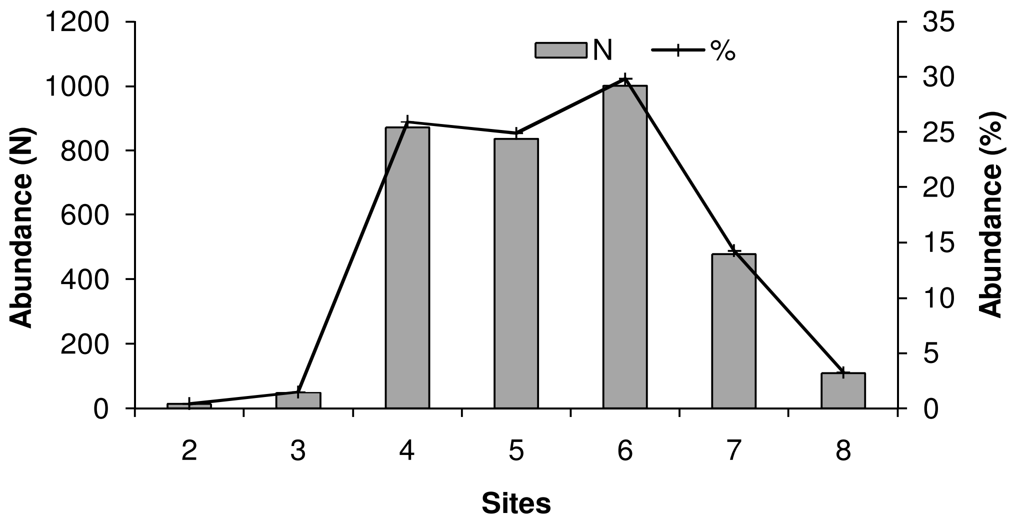
Figure 2. Summary of feeding indices of perch during the study. TL: Trophic level.

Standard length distributions of individuals were similar throughout the year. The mean length of individuals was lowest during June (115 mm) and highest (124.72 mm) in July. The differences in monthly length was statistically significant ($F_{4,4}$ = 10.44, P < 0.0001). Standard length of the individuals captured in RESSU and RESHU were highest with the values of 125.78 and 114.93 mm, respectively. The lowest length was obtained in the river sites with the value of 102.13 and 99.37 mm at ABDAM and BLDAM sites, respectively. This differences were also significant ($F_{13,3}$ = 52.7 6, P < 0.0001).

A total of 50 different food resources belonging to eight main categories were identified in the stomachs of the fish (Table 1). The fish in general had diet breadth of 8.07 corresponding to standardized diet breadth of 0.14. Evaluation of



A



B

Figure 3. Temporal (A) and spatial (B) variations in abundance of *Perca fluviatilis.* site 8 was the aggregation of site 8K and 8T.

frequencies of occurrence and volumetric percentages of diet categories from stomachs indicated that fish (47.78%) volumetrically were the most important prey item for this species. Fish as prey, however, were the second important prey item as revealed by PRIV (35.77%). Among the fish as prey, *P. fluviatilis* (8.14%), *Proterorhinus marmoratus* (4.64%) and Gobidae (4.48%) were important volumetrically but not important as revealed by PRIV values of 0.71, 0.25 and 0.60% respectively. Most of the fish encountered in the stomachs consisted of unidentified fish with the contribution f 10.47% to the total volume of stomach contents. The occurrence of unidentified fish in the stomachs, on the other hand, was higher (29.44%) making the PRIV value of 34.18%. The insects, on the other hand, were the most important by both volume (31.36%) and occurrence (74.03%). The PRIV of the insects was the highest with the value of 54.27%. Among insect diet category, chironomid and midge were the most important diet items for perch with the PRIV value of 23.32 and 26.78% respectively. The other insects were important volumetrically with the values of 12.26%, however, they were the least important with the PRIV value of 4.26. Among the crustaceans, the food resource

Table 1. Food resources utilized by Perch during the study period.

Food resources	F	V	F%	V%	PRIV
Detritus	63	1.98	4.52	1.1	0.55
Aquatic vegetation	34	1.37	2.44	0.76	0.21
Bacillariophyta	20	0.5	1.43	0.28	0.01
Synedra sp.	7	0.1	0.5	0.06	0*
Navicula sp.	5	0.15	0.36	0.08	0*
Gamphonema sp.	1	0.03	0.07	0.02	0*
Nitzschia sp.	2	0.02	0.14	0.01	0*
Fragilaria sp.	1	0.01	0.07	0.01	0*
Melosira sp.	1	0.03	0.07	0.02	0*
Diatoma sp.	1	0.01	0.07	0	0*
Amphora sp.	1	0.08	0.07	0.04	0*
Cocconeis sp.	1	0.08	0.07	0.04	0*
Chlorophyta	1	0.2	0.07	0.11	0*
Ulothrix sp.	1	0.2	0.07	0.11	0*
Crustacea	424	27.24	30.42	15.13	7.38
Copepod Nauplii	41	1.05	2.94	0.59	0.19
Copepoda	54	2.63	3.87	1.46	0.63
Daphnia sp.	112	5.9	8.03	3.28	2.92
Other Cladocera	20	0.85	1.43	0.47	0.08
Amphipoda	44	1.05	3.16	0.58	0.2
Gammaridae	83	3.96	5.95	2.2	1.45
Mussel	57	6.82	4.09	3.79	1.72
Brachyura sp. (Crabs)	9	4.88	0.65	2.71	0.19
Other Crustacea	4	0.1	0.29	0.06	0*
Nematoda	1	0.3	0.07	0.17	0*
Nematodes	1	0.3	0.07	0.17	0*
Annelida	69	5.97	4.95	3.32	1.82
Oligochaetes	69	5.97	4.95	3.32	1.82
Insecta	1032	56.49	74.03	31.36	54.27
Chironomid larva	297	17.78	21.31	9.87	23.32
Midge pupa	365	16.62	26.18	9.23	26.78
Zygoptera (Damselfly)	64	7.15	4.59	3.97	2.02
Ephemeroptera (Mayfly)	56	1.37	4.02	0.76	0.34
Lepidoptera	1	0.06	0.07	0.03	0*
Plecoptera (Stonefly)	5	0.44	0.36	0.24	0.01
Anisoptera (Dragonfly)	11	0.92	0.79	0.51	0.04
Riffle beetle L.(Coleoptera)	9	2.27	0.65	1.26	0.09
Hemiptera (Notonectidae)	14	0.5	1	0.28	0.03
Coleoptera (Histeridae)	1	0.01	0.07	0.01	0*
Forminadea (Coleoptera)	1	0.01	0.07	0.01	0*
Passalidae (Coleoptera)	2	0.12	0.14	0.07	0*
Other Coleoptera	8	0.17	0.57	0.09	0.01
Phoridae (Diptera)	1	0.04	0.07	0.02	0*
Diptera	1	0.06	0.07	0.03	0*
Thrips (Thysonoptera)	1	0.01	0.07	0	0*

Table 2. Contd.

Other Ephemeroptera	50	1.34	3.59	0.74	0.29
Odonata nymph	4	2.5	0.29	1.39	0.04
Hymenoptera	19	0.43	1.36	0.24	0.04
Hydrophilidae	62	1	4.45	0.55	0.27
Unidentified insects	60	3.71	4.3	2.06	0.98
Fishes	185	86.06	13.27	47.78	35.77
Perca fluviatilis	11	14.66	0.79	8.14	0.71
Rhodeus amarus	3	0.93	0.22	0.52	0.01
Proterorhinus marmoratus	7	8.36	0.5	4.64	0.26
Gambusia sp.	1	1	0.07	0.56	0*
Gobidae	17	8.08	1.22	4.49	0.61
Unidentified fish	146	53.03	10.47	29.44	34.18

F: Frequency of occurrences, V: volume of stomach contents (ml), F%: percentage of frequency of occurrence, V%: percentage of volume of stomach contents, PRIV: percentage of relative importance. *less than 0.001.

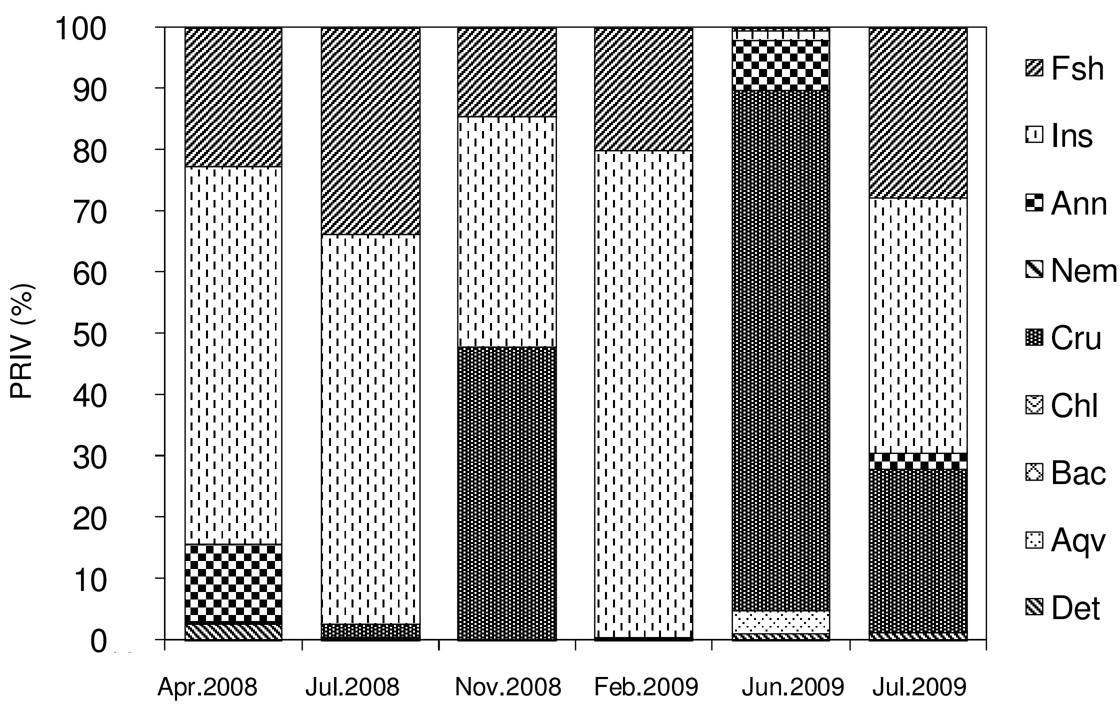


Figure 4. Temporal preference (PRIV) of food resources by *Perca fluviatilis*. Fsh: fish, Ins: insects, Ann: annelid worms, Nem: nematodes, Cru: crustacea, Chl: chlorophyta, Aqv: aquatic vegetation, Det: detritus.

category of crustacean mostly consisting of daphnia, zebra mussel and gammarids were volumetrically important with the value of 9.27%, but this group was not important as revealed by PRIV value of 6.09 (Table 2).

Temporal dietary pattern

The relative importance (both volume and occurrence) of dominant food items in stomachs revealed strong temporal variations (Figure 4) . Fish were the main diet items of fish during April (PRIV 22.85) and July (PRIV 33.83(2008); 27.91 (2009)), February (PRIV 20.05) and November (PRIV: 14.65). Among the fish, unidentified fish and *P. fluviatilis* were the two most important items preferred most. Insects were another main sources for fish nutrition. Consumption of this item was important during April (PRIV 61.68), July 2008 (PRIV: 63.85), November (PRIV: 37.57%), February (79.88) and July 2009 (41.62). Among the insects group, chrinomid was important during April (PRIV 57.60), July 2008 (PRIV: 14.34) and July 2009 (PRIV: 16.39), while midge larvae was more important, especially during July 2008 (PRIV: 47.66) and July 2009 (PRIV: 5.08). Other insect group was important during the November (PRIV: 37.02%). During this time period, Dragonfly dominated the diet of the fish. Consumptions of riffle beetle larvae was the most preferred item during February (PRIV: 73.67). In general, April and July 2008, November, February and July 2009 were the months of fish and insects as prey for this fish species, while crustacean (PRIV: 81.68) especially daphnia (PRIV:70.14) was important for the fish during June. In addition to consumption perch and insects during November, fish consumed mussel frequently during the November (PRIV 47.78%) (Figure 4).

Spatial feeding pattern

Aggregation of feeding data belonging to the sites below the RESSU indicated that fish mostly consumed chrinomid (PRIV 95.24) and other insects (PRIV 4.60) by volume and occurrence. The fish diet was dominated by the midge pupa (PRIV 52.68), chrinomid (PRIV 17.98) at the RESSU. In this lake, consumption of fish (PRIV 23.23%) was higher compared to riverine sites below RESSU (Figure 5). The fish occurring in RESHU mostly fed on crustacean (PRIV 51.51) consisting of daphnia (PRIV: 20.22) and mussel (PRIV 21.01), other insects especially damselfly (PRIV 17.67%), and Hydrophilidae (PRIV 4.41). The consumption of fish in this lake was much lower than that of RESSU. Fish (PRIV 99.48) dominated diet of *P.fluviatilis* at the river sites above the RESHU (Figure 5)

Ontogenetic diet habits

The length of the fish specimens was between 50 to 200 mm. In order to document diet shift of this species, we divided fish species into eight length classes; 0 to 80, 81 to 10, 101 to 120, 121 to 140, 141 to 160, 161 to 200 and 201 to 300 mm (Figure 5). The analysis of feeding data belonging to each length group indicated distinct ontogenetic variation in the diet. 0 to 80 mm length group fed mostly on daphnia (PRIV 12.88), insects (PRIV 1.29 and fish consisting mainly of unidentified fish (PRIV 77.25 %). The 81 to 100 mm length group consumed insects especially chrinomid (PRIV 23.11), damselfly (PRIV 28.74), mussel (PRIV 46.45 %) and fish (PRIV 19.70). The 101 to 120 mm length group, on the other, showed a shift towards to the consumption of fish (PRIV 41.05 mostly unidentified fish), insects (PRIV 33.68) mostly consisting of chrinomid and midge pupa (18.97 and 10.88, respectively), and crustacean (PRIV: 22.75) consisting of mostly daphnia (PRIV: 16.00). The 141 to 160 mm length group mostly preferred fish (PRIV: 79.97) consisting of Gobidae (PRIV: 48.52) and unidentified fish (PRIV: 30.55) and insects (PRIV: 17.41) consisting of midge pupa (PRIV: 16.03). On the other hand, fish (PRIV: 81.19) detritus (PRIV: 11.31) and Bacillariophyta (3.15) dominated foods of 161 to 180 mm group. The 181 to 200 mm group preferred fish (PRIV 99.87) consisting of mainly *P. fluviatilis* (PRIV: 99.42) (Figure 6).

Diet breadth

We calculated spatial, temporal and size dependent diet breadth for perch. The perch in the Dam Lakes consumed more diverse food items than the river (Table 1 and Figure 7). The diet breadth of the perch inhabiting in RESSU and RESHU were obtained as 6.51 and 12.46 respectively. On the other hand, fish occurring in the river sites had the lowest diet breadth with the values of 1.45 and 1.63 for BLDAM and ABDAM respectively. Temporarily fish relatively utilized more diverse food items during summer months compared to the winter, reaching the maximum in July 2009 (10.90) and February (2.46). Size dependent variation in the diet breadth exhibited a strong pattern of changes. Diet breadth of perch increased with increase in fish length until 121 to 140 mm (7.87) and declined again reaching the value of 1 for 201 to 300 mm fish group. The fish seemed to show more opportunistic feeding behaviour between 81 and140 mm length group (Figures 1 and 7).

Trophic level

The mean trophic level of this perch was determined to be 3.87 using stomach contents analysis, indicating carnivorous feeding habits (Table 1). Temporal analysis of trophic level calculated from stomach contents of indicated that perch had higher trophic level during April (4.18), July 2008 (3.83) and November (3.95) than those of February (3.73), June (3.14) and July 2009 (3.80). The lower trophic level obtained in June is largely due to little consumptions of fish. Trophic level calculated from stable isotopes also indicated a carnivorous feeding habits (TL= 3.91). Spatially, the individuals occurring in dam lakes (4.00 for RESSU and 3.62 for RESHU) slightly had lower trophic level as compared to ABDAM sites (4.09) but had higher than BLDAM site (3.45) (Table 1, Figure 7). Approximately the same trend of changes in trophic level was also obtained from stable isotopes for the sites. The largest trophic level calculated by stomach contents was obtained for181 to 200 mm (5.37) and 141 to 160 mm (4.26) length groups. On the other hand, stable isotope analysis indicated that 101 to 120 mm and 201 to 300 mm

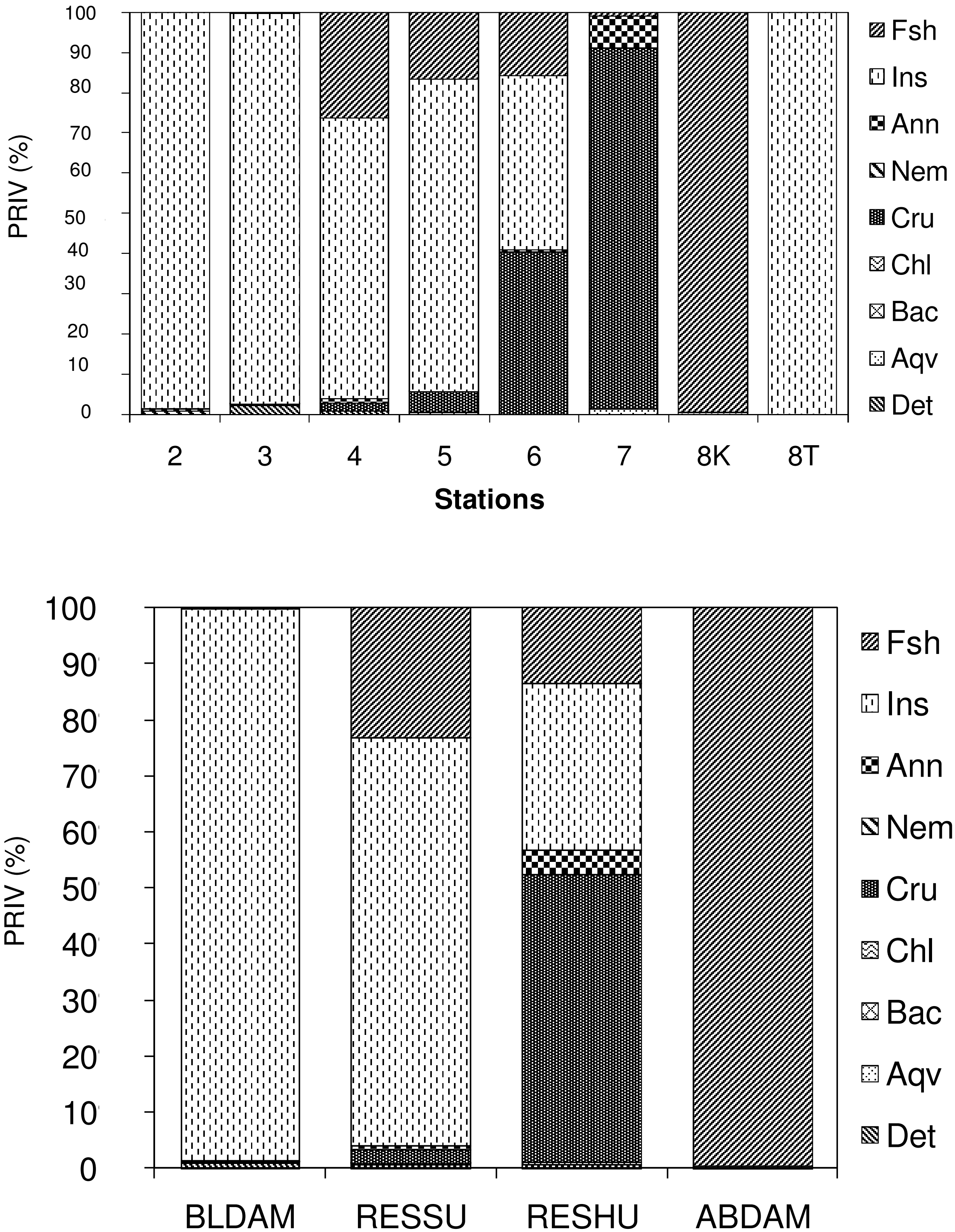


Figure 5. Spatial (upper panel-sites, lower panel-aggregation of site data-) preference (PRIV) of food resources by *Perca fluviatilis*. BLDAM: aggregation of feeding data belonging to river section below dam, RESSU: Suat Uğurlu Reservoir, RESHU: Hasan Uğurlu Reservoir, ABDAM: aggregation of feeding data belonging to river section flowing into Hasan Uğurlu Reservoir. Fsh: Fish, Ins: insects, Ann: annelid worms, Nem: nematodes, Cru: crustacea, Chl: chlorophyta, Aqv: aquatic vegetation, Det: detritus.

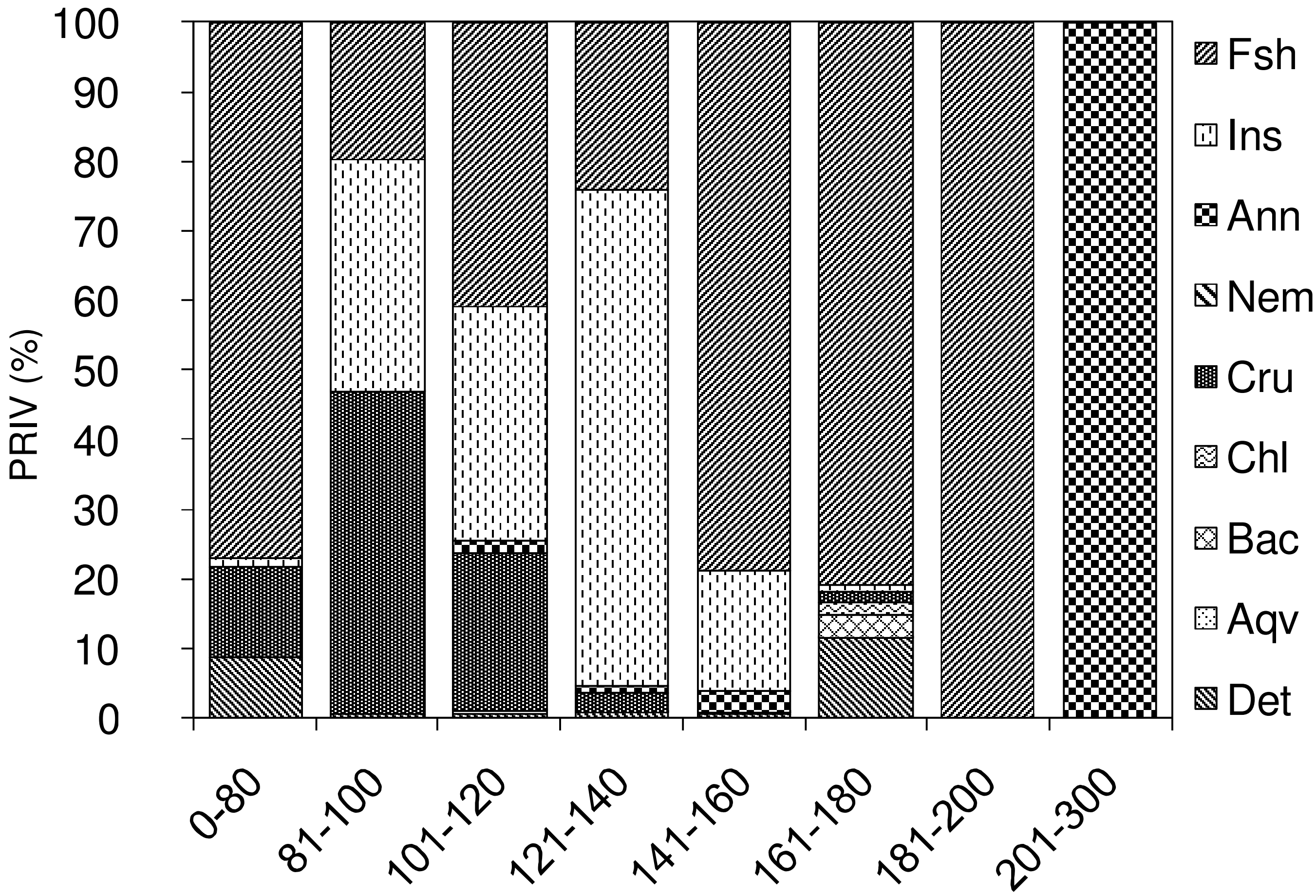


Figure 6. Ontogenetic preference (PRIV) of food resources by *Perca fluviatilis*. Fsh: fish, Ins: insects, Ann: annelid worms, Nem: nematodes, Cru: crustacea, Chl: chlorophyta, Aqv: aquatic vegetation, Det: detritus.

group had the higher trophic levels (4.43 and 4.20, respectively) (Figures 1 and 8)

Diet overlap

Low site specific overlap value indicated that fish exhibited changes in its diet spatially (Table 2). In general, the mean overlap value was 0.16 with the largest value (0.96) obtained between sites 2 and 3, which were the riverine sites below RESSU. Closer examination of diet items utilized in these sites by this species indicated that they consumed chrinomid larvae, midge and other insects in greater proportion. The next largest overlap value was calculated between site 5 and 8K, which was RESSU and riverine site above RESHU, respectively. The fish in these sites mostly consumed fish, insects and to lesser extent zooplankton. The overlap value between sites in RESHU were low (0.13). The perch consumed mostly insects, fish, and crabs at sites 6, while fish at site 7 consumed mostly indiviuals (Table 2).

Examination of overlap between fish occurring at different time period was also low with the highest obtained between the months of July 2008 and July 2009, which indicated a seasonal consistency of consuming same prey (Table 2). During these months fish shared chrinomids and fish as food items. Crustaceans were preferred most in July 2009 than July 2009, which may have caused depletion in overlap value between these months. The overlap values between other months except between April 2008 and July 2009 (0.63) were lower, which also indicated seasonal diet shift. Overlap value between ABDAM and RESSU was the highest (0.80), while the values obtained between other sites were again lower (range 0.09 to 0.54), indicating spatial diet shifts. Fish that are between 0 and 80 mm had highest overlap (0.97) with the fish between 161 to 180 mm. Both size classes preferred fish and detritus mostly. The diet overlap value indicated that fish less than 180 mm in length had relatively similar diet with the overlap value ranging from 0.27 to 0.97. Fish above 180 mm, had the lowest overlap values with the length groups less than 180 mm (Table 3).

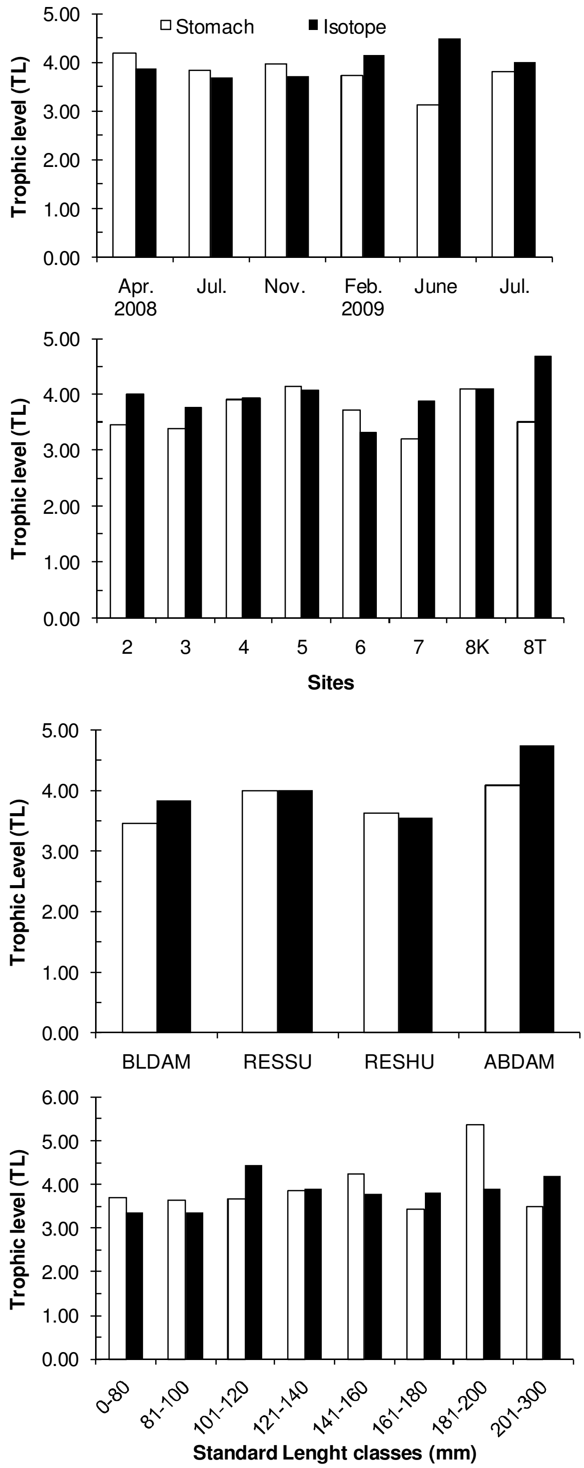


Figure 7. Temporal, spatial and ontogenetic specific trophic levels of *Perca fluviatilis* calculated using stomach and stable isotope data.

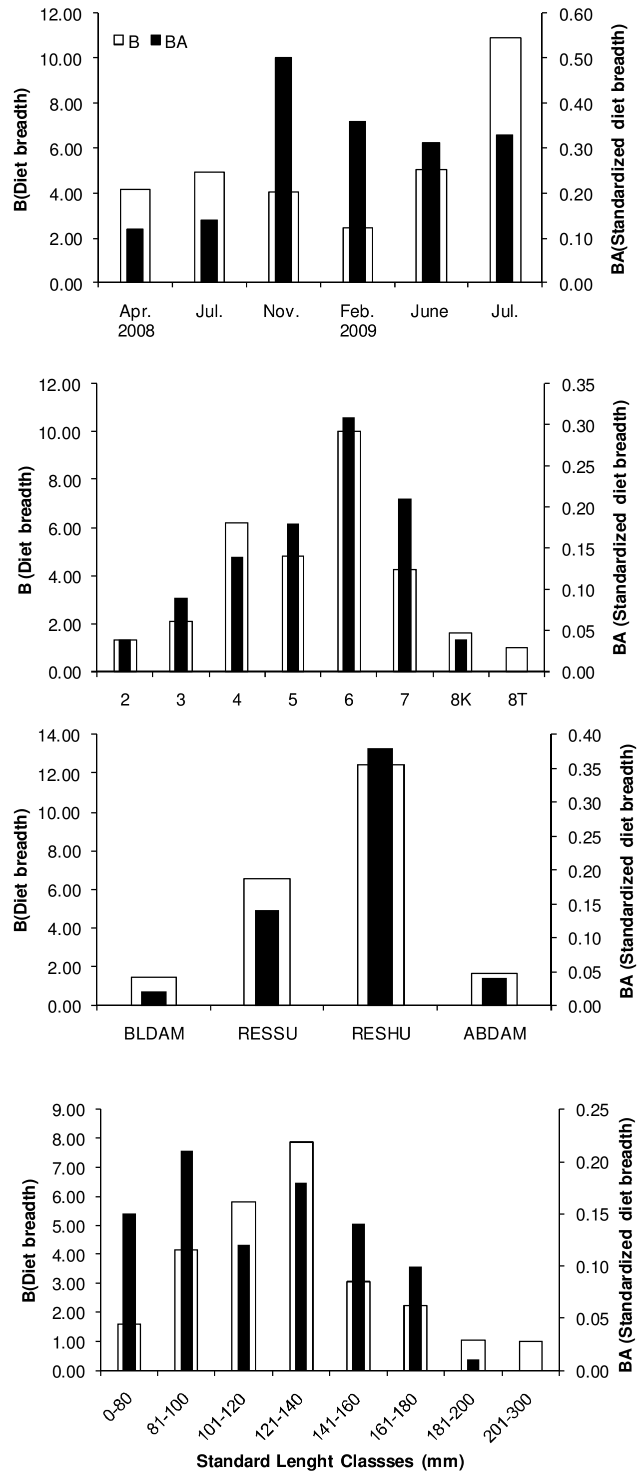


Figure 8. Temporal, spatial and ontogenetic specific diet breadth of *Perca fluviatilis* calculated using stomach and stable isotope data.

DISCUSSION

P. fluviatilis is an introduced fish species in the system where this study was performed. The intention of this study is to demonstrate the feeding habits of perch in various habitats found in this riverine and lake system. The perch especially adults are known to prefer slow-flowing rivers, deep lakes and ponds; avoids cold, fast-

Table 2. Intraspesific temporal (A) spatial (B;C) and ontogenetic (D) dietary overlap values among the individuals of perch.

	A	Apr. 2008	Jul. 2008	Nov.2008	Feb. 2009	Jun.2009	Jul.2009		
Months	Apr.2008		0.36	0.17	0.19	0.13	0.63		
	Jul.2008			0.55	0.53	0.20	0.76		
	Nov.2008				0.37	0.08	0.57		
	Feb. 2009					0.08	0.46		
	Jun.2009						0.30		
	Jul.2009								
	B	**2**	**3**	**4**	**5**	**6**	**7**	**8K**	**8T**
Stations	2		0.96	0.24	0.10	0.08	0.01	0.00	0.00
	3			0.25	0.14	0.12	0.02	0.01	0.00
	4				0.71	0.47	0.28	0.81	0.00
	5					0.42	0.27	0.65	0.00
	6						0.13	0.47	0.01
	7							0.25	0.00
	8K								0.00
	8T								
	B	**BLDAM**	**RESSU**	**RESHU**	**ABDAM**				
Sites	BLDAM		0.21	0.09	0.00				
	RESSU			0.54	**0.80**				
	RESHU				0.51				
	ABDAM								
	C	**0-80**	**81-100**	**101-120**	**121-140**	**141-160**	**161-180**	**181-200**	**221-300**
Length classes (mm)	0-80		0.47	0.92	0.78	0.51	0.97	0.00	0.00
	81-100			0.63	0.57	0.27	0.53	0.00	0.02
	101-120				0.88	0.51	0.89	0.00	0.05
	121-140					0.59	0.79	0.12	0.07
	141-160						0.51	0.00	0.14
	161-180							0.00	0.00
	181-200								0.00
	221-300								

flowing waters but may penetrate into but not breed in such waters. Normally they are found lying close to or amongst obstacles in the water. The perch in our study system were also found in large quantity in lakes and streams bank under the obstacles such as boulder and large stone. The fish occurred in large quantity in RESSU and RESHU, and river sites of pooled region.

Fish during their life time increase their weight by three to eight orders of magnitude. This considerable increase in size results in several size-specific changes in their diet and feeding interactions. Shifting among resources during the ontogeny is a way to find optimal food in the size-structured prey community in all life stages, and thus to follow the increasing energy requirement during growth (Werner and Gilliam, 1984). The perch have been reported to show ontogenetic diet shifts during their life span. It has been reported that perch within 16 to 20 mm size range consumed planktonic microcrustaceans, while the 21 to 80 mm size range fed on macrocrustacea including chrinomid larvae. The fish ranging between 81 to 160 mm heavily consumed gammarus. The perch larger than 160 showed piscivorous feeding behaviour (Rezsu and Speczia´r, 2006). In another study, Treasurer et al. (2002) indicated that the fish larger than 28 mm largely were reported to consume bony fish with a greater proportion (Treasurer et al., 1992). Dörner et al. (2003) showed that invertebrates and age-0 fish were the main food components of large perch. They concluded that the prey fish availability was an important factor in determining the feeding behavior of large perch in two lakes. The perch in our study system showed similar trend of diet shift from crustaceans to benthic macro invertebrates and the fish. The length of the perch in our study system ranged from 50 to 250 mm. The fish between 0 to 80 and 141 to 200 mm fed dominantly on fish and the perch between 81 to 140 mm heavily preferred insects and crustaceans in addition to fish consumed with a lower degree of importance as compared to other length classes.

Some fish species intend to consume the available food resources in order meet nutritional demand. Consumption of heavy chrinomids was largely due to higher chrinomid density in the system. The chrinomids among the benthic invertebrates were the most abundant group in these systems. Fish occurring in the river site below RESSU consumed mostly chironomids and other insects with greater proportion. The fish below the RESSU especially were abundant at Site 3 which was located at the mouth of two small streams flowing into main channel. The increase in the proportion of fish that consume aquatic insect at this station agrees with the prediction of river continuum concept proposed by Vannote et al. (1980), since greater deposition of organic matters occurs in the lower regions of streams, facilitating the establishment of insects in substrate. Heavy consumption of insects in the RESHU also suggested River Continuum Concepts. The fish in RESHU especially at Site 6 were collected from the mouth of stream called Karasu which might have deposited organic material into the Hasan Ugurlu Dam Lake.

Diet breadth was lower in river sites as compared to lakes. The lakes, compared to riverine systems had the highest productivity in terms of phytoplankton, zooplankton and Chlorophyll a which supports the consumers of these areas by being food sources of prey of perch. That is to say, primary production is greater in the lakes, as expected, which supports many food sources for perch.

Dietary overlap between species occurring at different time period and sites, in general was low, which also indicated dietary shifts to available food sources. Diet overlap between sites towards downstream and 8 was extremely low, although the size of the fish did not change much. This indicated also diet shifts species from insects to the fish.

Trophic level calculated from gut contents and stable isotope data are concordant with each other. The gut contents based mean trophic level was 3.87, whereas stable isotope based calculated trophic level was 3.91. These values are also concordant with the literature data with the values of Quevedo and Olsson (2006). The analysis of trophic level spatially indicated that fish occurring within lakes had slightly lower trophic level than those of riverine sites. The highest trophic level was calculated for the fish occurring at the ABDAM, which indicated consumption of fish. Trophic level calculated from stable isotope data was also high at ABDAM site with the value of 4.75. These results indicated that the fish feeding habits changes spatially with the habitats they use.

Conclusion

The data suggested that this perch showed spatial and temporal diet changes to either abundant food resources or merely as a result of its ontogeny. The fish species in this system are extremely abundant especially at Lakes and diffused through river sites. This perch could have been the main threat to other fish species and themselves in this system through predation. The main food items of this perch are fish followed by insects. The insects were also the food sources of other fish species in the systems (Akin, unpublished data), the competition for this prey item are probably keen.

ACKNOWLEDGMENTS

We thank Dr. Tom Maddox for analyzing the stable isotope samples at the University of Georgia. We also thank Mr. Yüksel Sarıoğlu and Mr. Ali Koç for logistic supports in their fishing boats. This manuscript is produced from a project (S.Akin, PI.) funded by The Scientific and Technological Research Council of Turkey (TÜBİTAK) (Grant No. TOVAG 107-O-519). We thank the staff of TÜBİTAK and Gaziosmanpaşa University for dealing with paperwork of the project.

REFERENCES

Adams SM, Kimmel BL, Ploskey GR (1983). Sources of organic carbon for reservoir fish production: a trophic-dynamics analysis. Can. J. Fish. Aquat. Sci., 40: 1480-1495.
Akin S, Winemiller KO (2008). Body size and trophic position in a temperate estuarine food web. Acta Oecologia, 33: 144-153.
Beeck P, Tauber S, Kiel S, Borcherding J (2002). 0+ perch predation on 0+ bream: a case study on a eutrophicgravel pit lake. Freshwater Biol., 47: 2359-2369.
Čech M, Kubečka J (2006). Ontogenetic changes in the bathypelagic distribution of European perch fry *Perca fluviatilis* monitored by hydroacoustic methods. Biol. Bratislava, 61: 211-219.
Cohen JE, Pimm SL, Yodsiz P, Saldana J (1993). Body sizes of animal predators and animal prey in food webs. J. Anim. Ecol., 62: 67-78.
Dörner H, Berg S, Jacobsen L, Hülsmann S, Brojerg M, Wagner A (2003). The feeding behaviour of large perch *Perca fluviatilis* (L.) in relation to food availability: a comparative study. Hydrobiology, 506(1): 427-434.
Grossman GD (1986). Food resources partitioning in a rocky intertidal fish assemblage. J. Zool., 1: 317-355.
Hjelm J, Persson L, Christensen B (2000). Growth, morphological variation and ontogenetic niche shifts in perch (*Perca fluviatilis*) in relation to resource availability. Oecologia, 122: 190-199.
Hoeinghaus DJ, Winemiller KO, Agostinho AA (2008). Hydrogeomorphology and river impoundment affect food-chain length in diverse Neotropical food webs. Oikos 117: 984-995.
Hulbert SH (1978). The measurement of niche overlap and some of its relatives. Ecology, 59: 67-77.
Levins R (1968). Evolution in changing environments, some theoretical explorations. Princeton University Press, Princeton, New Jersey, p. 115.
Marian S, Maccaroni A, Massa F, Rampacci M, Tancions L (2002). Lack of consistency between the trophic interrelationships of five sparid species in the two adjacent central Mediterranean coastal lagoons. J. Fish Biol., 61: 138-147.
Novakowski GC, Segatti HN, Fugi R (2008). Diet seasonality and food overlap of the fish assemblage in a pantanal pond. Neotrop. Ichthyol., 6(4): 567-576.
Nunn AD, Harvey JP, Cowx IG (2007). The food and feeding relationships of larval and 0+year juvenile fishes in lowland rivers and connected water bodies. I. Ontogenetic shifts and interspecific diet similarity. J. Fish Biol., 70: 726-742.

Persson L, Greenberg LA (1990). Optimal foraging and habitat shift in perch (*Perca fluviatilis*) in a resource gradient. Ecology, 71: 1699-1713.

Persson L (1988). Asymmetries in competitive and predatory interactions in fish populations. In: Ebenman, B. & Persson, and L., eds. Size-structured populations: ecology and evolution.Berlin: Springer-Verlag, pp. 203-218.

Pianka ER (1973). The structure of lizard communities. Annu. Rev. Ecol. Syst., 4: 53-74.

Post DM (2002). Using stable isotopes to estimate trophic positions: models, methods and assumptions. Ecology 83: 703-718.

Quevedo M, Olsson J (2006). The effect of small-scale resource origin on trophic position estimates in *Perca fluviatilis*. J. Fish Biol., 69: 141-150.

Reinthal PN (1990). The feeding habits of a group of herbivorous rock-dwelling cichlid fishes (Cichlidae: Perciformes) from Lake Malawi, Africa. Environ. Biol. Fishes, 27: 215-233.

Rezsu E, Speczia´r A (2006). Ontogenetic diet profiles and size-dependent dietpartitioning of ruffe *Gymnocephalus cernuus*, perch *Perca fluviatilis* and pumpkinseed *Lepomis gibbosus* in Lake Balaton. Ecol. Freshwater Fish, 15: 339-349.

Treasurer JW, Owen R, Bowers E (1992). The population dynamics of pike, *Esox lucius*, and perch, *Perca fluviatilis*, in a simple predator-prey system. Environ. Biol. Fish., 34: 65-78.

Urho L (1996). Habitat shifts of perch larvae as survival strategy. - Ann. Zool. Fennici, 33: 329-340.

Vander ZMJ, Cabana G, Rasmussen JB (1997). Comparing trophic position of freshwater fish calculated using stable nitrogen stable isotope ratios ($\delta^{15}N$) and literature dietary data. Can. J. Fish. Aquat. Sci., 54: 1142-1158.

Vannote RL, Minshall GW, Cummins KW, Sedell JR, Cushing CE (1980). The river continuum concept. Can. J. Aquat. Sci., 37: 130-137.

Werner EE, Gilliam JF (1984). The ontogenetic niche and species interactions in size-structured populations. Annu. Rev. Ecol. Syst., 15: 393-425.

Winemiller KO, Akin S, Zeug SC (2007). Production sources and food web structure of a temperate tidal estuary: integration of dietary and stable isotope data. Mar. Ecol. Progress Ser., 343: 63-76.

Winemiller KO (1990). Spatial and temporal variation in tropical fish trophic networks. Ecol. Monogr., 60: 331-367.