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The Feeding Behavior of Pikeperch (*Sander lucioperca* (L., 1758)) Living in Hirfanlı Dam Lake

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Abstract: This study is concerned with the feeding behavior of pikeperch (*Sander lucioperca* (L., 1758)) living in Hirfanlı Dam Lake constructed on the Kızılırmak River. There were 326 pikeperch caught between August 1996 and July 1997. The fork length and weight of the pikeperch caught ranged between 105 and 529 mm and 12 and 1520 g in the general population. Pikeperch are carnivorous and piscivorous and they eat their own species when nutrients are lacking. The smallest fish-swallowing length was determined to be 145 mm. A cannibalism rate of 40.5% among pikeperch of 145-378 mm in length living in the lake was observed. The stomach content of individual pikeperch was as follows: *Gammarus* (27.7%), Diptera larvae and pupae (22.7%), fish and fish remains (22.1%), Odonata nymphs (9.8%), organism remains (9.5%), *Mysis* (6.0%), Isopoda (1.9%) and fibrous algae (0.3%).

Key Words: Pikeperch, *Sander lucioperca*, feeding behavior, Hirfanlı Dam Lake

Hirfanlı Baraj Gölü'nde Yaşayan Sudak (*Sander lucioperca* (L., 1758))'in Beslenme Özellikleri

Özet: Bu çalışmada Kızılırmak nehri üzerinde bulunan Hirfanlı baraj gölünde yaşayan sudak (*Sander lucioperca* (L., 1758))'in beslenme özellikleri incelenmiştir. Ağustos 1996-Temmuz 1997 tarihleri arasında 326 adet sudak avlanmıştır. Populasyon genelinde çatal boy değerleri 105-529 mm, ağırlık ise 12-1520 g arasında değişim göstermektedir. Sudak karnivor ve piskivor bir balık olup besin azlığında kendi türlerini de yemektir. Populasyonda en küçük balık yutma boyu 145 mm olarak tespit edilmiştir. 145-378 mm arası boylardaki sudaklar arasında % 40,5 oranında kanibalizm görülmüştür. Sudak bireylerinin mide içeriklerinde bulunma sıklığına göre sırasıyla *Gammarus* (% 27,7), Diptera larva ve pupaları (% 22,7), balık ve balık parçaları (% 22,1), Odonata nimfleri (% 9,8), organizma parçaları (% 9,5), *Mysis* (% 6,0), Isopoda (% 1,9) ve iplikli alg (% 0,3) materyallerine rastlanmıştır.

Anahtar Sözcükler: Sudak, *Sander lucioperca*, beslenme, Hirfanlı Baraj Gölü

Introduction

The utilization of water products, especially freshwater fish, as a nutrient in the face of a lack of animal protein is of great importance. The nutrient value of the fish consumed is dependent upon whether they are fed in a balanced and regular manner. If growth is taken as the natural consequence of the feeding process, investigating the feeding behavior of fish becomes very important. Pikeperch (*Sander lucioperca*) is one of the most valuable fish in fresh waters (1). In its first period of growth pikeperch has a planktivorous feeding pattern (2). Pikeperch (maximum length is 90 cm) can eat fish up

to 30 cm in length (3,4). Although pikeperch are known as a typical freshwater fish, they can sometimes be encountered in waters between freshwater and saltwater environments (5). There are numerous studies on the feeding behavior of pikeperch (3,6-12). The feeding behavior and biology of *S. lucioperca* living in the Baltic Sea have been examined (13,14). The techniques used in breeding pikeperch in pools have also been investigated (15-17). However, the number of studies carried out in Turkey on this subject is not sufficient (18-22).

The purpose of this study is to establish a database for future pikeperch studies by examining the stomach

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content and feeding patterns of a pikeperch population living in Hirfanlı Dam Lake. The population living in this lake is economically important.

Materials and Methods

Hirfanlı Dam Lake was constructed on the Kızılırmak River, 70 km south of Kırıkkale province, in 1959 (Figure 1). The altitude and total area of the lake are 856 m and 263 m², respectively. The depth and visibility of the dam lake range from 0 to 58 m and 2 to 6 m (23,24).

There were 326 pikeperch caught in the period between August 1996 and July 1997. Fishing nets with mesh sizes of 18 x 18 mm, 25 x 25 mm, 40 x 40 mm and 55 x 55 mm were used. The fish caught were weighed using a balance with an accuracy of ± 1 g and the lengths were determined on a fork length basis in millimeters using a millimetric scale. The age was determined by using scales due to their practicality with preparations made according to the Lagler method (25). In order to determine the feeding behavior of the fish, the digestive systems (stomach and intestine) of the samples were removed and placed in jars containing 4% formaldehyde. The full stomachs were weighed with an electronic balance after they had been dried with paper. The stomachs were then cut with a thin-edged knife and their contents were grouped according to food type in order to determine the type of nutrients and food eaten by each individual. The percentage of organisms found in the fish stomachs, the percentage of weight and the numerical percentage of each group were determined using the following formulae:

$$F = f \cdot 100 / n$$

$$W = f \cdot 100 / W_{total}$$

$$S = n_{org} \cdot 100 / s$$

Here, F is the percentage of encounters, f is the percentage of encounters of a specific organism, n is the total number of fish caught, W is the weight percentage, W_{total} is the total weight of the organisms, S is the numerical percentage, s is the total number of the organisms in the stomach and n_{org} is the number of organisms belonging to a specific species. Various sources were utilised to determine the organisms that emerged from the stomachs (26-28).

Results

Among 326 *S. lucioperca* whose stomachs were cut, 120 of them had no food in their stomachs (Table 1). In the stomachs of the remaining ones were found Amphipoda (*Gammarus*), Diptera (*Chironomus*) larvae or pupae, fish (*Sander lucioperca*, *Tinca tinca*, *Alburnus orontis*), fish remains (scales, bones and fins), Odonata (Zygoptera) nymphs, organism remains (insect extremities, etc.), *Mysis* and Isopoda species.

The total weight of the food and percentage of specific food found in the stomachs and intestines investigated are given in Table 2. It was found that the major part of the *S. lucioperca* diet is composed of fish (67.17%).

Table 2 lists the numerical values and their corresponding percentages of the food extracted from

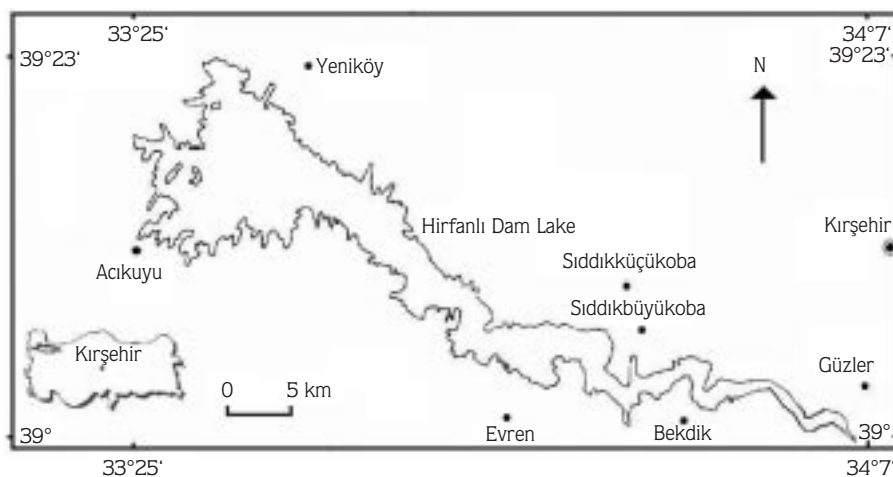


Figure 1. Map of Hirfanlı Dam Lake.

Table 1. Monthly variations in stomach fullness of pike-perch.

Months	Empty		Full		Range of length of fish with full stomachs (mm)
	N	%N	N	%N	
August	16	43.24	21	56.76	146-378
September	15	28.30	38	71.70	145-230
October	7	36.84	12	63.16	213-362
November	10	50.00	10	50.00	164-385
December	18	51.43	17	48.57	170-432
January	5	23.81	16	76.19	185-409
February	15	45.45	18	54.55	185-380
March	5	27.78	13	72.22	158-295
April	11	28.95	27	71.05	155-335
May	7	35.00	13	65.00	176-207
June	7	33.33	14	66.67	170-310
July	4	36.36	7	63.64	170-188
Total	120	36.81	206	63.19	

Table 2. The total weights, numbers and their chance of encounter in stomachs and the number of organisms per fish.

Organisms found in stomachs	<i>Gammarus</i>	Diptera	Odonata	Isopoda	<i>Mysis</i>	Fish	Fish remains	Organism remains	Algae	Total
Total weight (W,g)	51.45	53.26	3.25	0.46	9.10	209.96	56.68	12.68	0.13	396.97
%W (g)	12.96	13.42	0.82	0.12	2.29	52.89	14.28	3.19	0.03	100
Number of individuals (N)	904	2863	87	15	275	42	38	-	-	4224
% N	21.40	67.78	2.06	0.36	6.51	0.99	0.90	-	-	100
The number of stomachs where the organism was encountered (N)	88	72	31	6	19	38	32	30	1	317
% N	27.7	22.7	9.8	1.9	6.0	12.0	10.1	9.5	0.3	100
Number of organisms per fish	4.4	13.9	0.4	0.1	1.3	0.2	0.2	-	-	20.5

the stomachs of the pikeperch examined. There were 4224 organisms removed from the stomachs of the fish, with Diptera larvae and pupae being the most common with a total number of 2863 (67.78%).

The number of encounters of food and their corresponding percentages in the stomachs of the fish investigated are tabulated in Table 2. The most abundantly encountered food in the stomachs of the fish is *Gammarus* (88 times). In one stomach fibrous algae were found. The frequency of food encountered and the distribution of weight and the percentage of food

according to the months are given in Figure 2. February is the most important month as regards the weight of the organisms consumed.

The frequency of the food encountered in the stomachs of pikeperch and their respective numerical and percentage values are shown in Figure 3. April is the most productive period as regards the number of organisms while in February the lowest number of organisms was encountered.

In all months *Gammarus* species were found in the stomachs of the pikeperch investigated. Diptera larvae

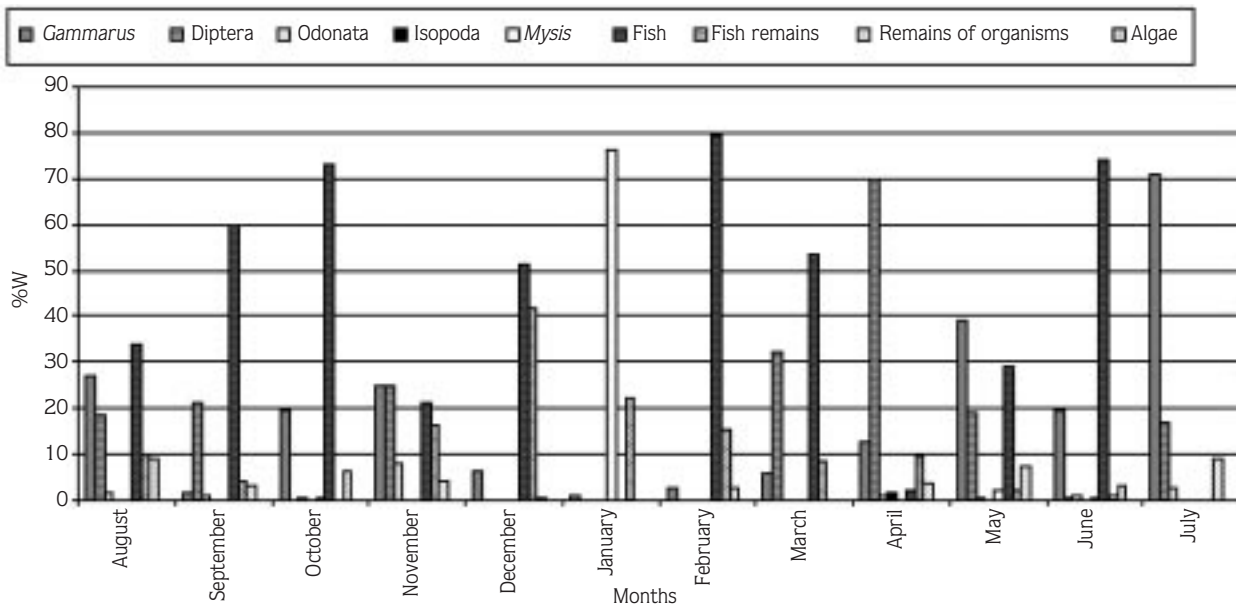


Figure 2. Percentage weight of the food found in the stomach of *S. lucioperca* individuals according to months.

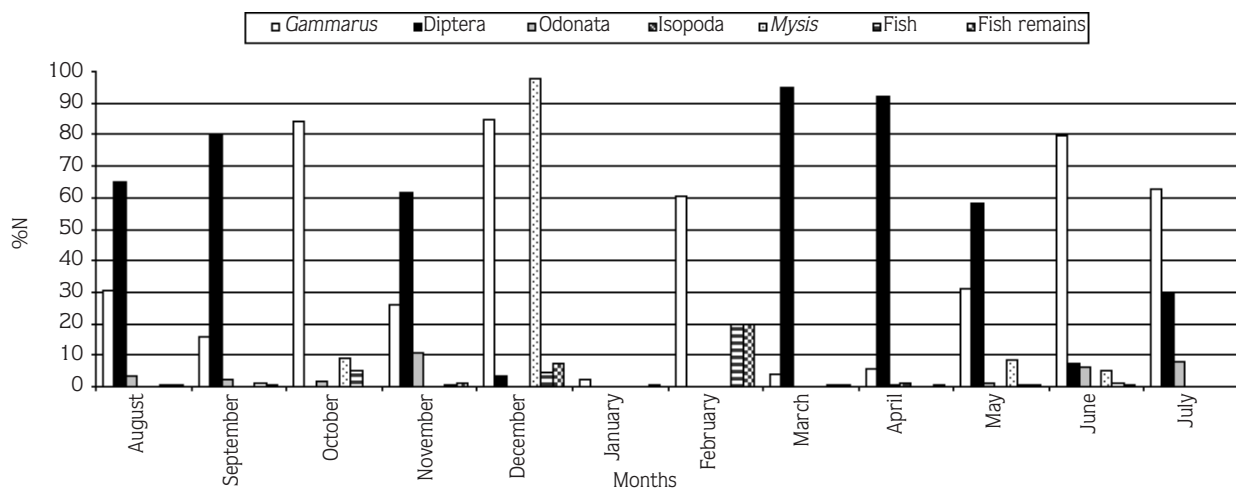


Figure 3. Distribution of the food from *S. lucioperca* individuals according to months.

and pupae were not encountered in October, January and February. Odonata nymphs were not found in December, January, February and March. Isopoda species were detected only in March and April. *Mysis* was observed in September, October, January, May and June. The fish and fish remains were observed in all months except July.

The study revealed that there were changes in the type of food consumed by the pikeperch according to fish length. The fork length of the fish caught varied between 105 and 529 mm. *Gammarus* and Diptera larvae and

pupae were observed in the stomach of fish longer than 153 mm. *Gammarus* was observed in the stomachs of fish between 153 and 312 mm long while *Chironomus* was seen in the stomachs of fish between 153 and 295 mm long. They were absent from the stomachs of longer fish. Odonata nymphs were observed in fish between 160 and 312 mm, *Mysis* in fish between 182 and 229 mm and Isopoda species in fish between 155 and 173 mm, and the fish and fish remains were encountered in the stomachs of the fish larger than 145 mm.

We observed that fish 145-253 mm long feed on a variety of foods. Fish above 325 mm were found to be largely piscivorous (Table 3).

The cannibalism rate was of 40.5% among pikeperch 145-378 mm long living in the lake. The highest rate of cannibalism was observed in fish between 218 and 378 mm in length.

Discussion

Among the 326 *S. lucioperca* caught in Hirfanlı dam lake 120 of them were observed to have no food (36.81%) and 206 had undigested or partly digested organisms in their stomachs (63.19%). The stomach contents of the fish investigated were *Gammarus* (27.7%), Diptera (*Chironomus* larvae and pupae) (22.7%), fish (*Sander lucioperca*, *Tinca tinca*, *Alburnus orontis*) and fish remains (22.1%), Odonata nymphs (9.8%), organism remains (9.5%), *Mysis* (6.0%), Isopoda species (1.9%) and fibrous algae (0.3%).

In Campbell's study on Lake Eğirdir Chironomid larvae and pupae, Gammarids, Isopodas, Mysids and fish species in the stomach contents of the pikeperch were investigated (18). He reported that although pikeperch consume fish in all seasons, this was particularly the case in autumn and winter. He reported that pikeperch consume *Vimba vimba* and *Cobitis taenia* species in their diet as well as their own species.

Hansson et al. (13) reported that the main diet of pikeperch living in Himmerfjorden Bay of the north Baltic

Sea was mainly constituted by fish and Crustacea. Among the Crustacea and fish consumed are Mysids, *Crangon crangon* L., herring (*Clupea harengus* L.) and gobies (*Pomatoschistus* sp.). Buijse and Houthuijzen (29) determined that the food present in the stomachs of pikeperch in the zero age group included zooplankton, Chironomids, *Neomysis integer* and fish. They also observed that the diet of pikeperch larger than 10 cm was mainly fish.

Lehtonen et al. (14) indicated that the species of the fish caught changed according to region, but the most important species were perch (*Perca fluviatilis*), roach (*Rutilus rutilus*), smelt (*Osmerus eperlanus*), ruffe (*Gymnocephalus cernuus*) and herring (*Clupea harengus*). They also stated that the feeding biology and ecology of the pikeperch living in the Baltic Sea were similar to those of their freshwater counterparts.

In Sari's (19) study on the feeding habits of pikeperch living in Demirköprü Dam Lake he noted that their diet was mainly composed of Chironomid larvae and pupae (65.55%), followed by fish (24.06%), Gammarid species (8.89%) and Insecta members (1.50%). Among the fish they consumed is the benthic-type *Knipowitschia*, except in summer months. In summer months their fish diet is composed of its own species and *Chalcalburnus chalcoides*.

In Türkmen's (20) study on Hirfanlı Dam Lake the stomach contents of the pikeperch living there were determined to be *Gammarus* and *Chironomus* pupae, Odonata nymphes, whole undigested fish and fish remains.

Table 3. Types of food and their ratios consumed by *S. lucioperca*.

FL (mm)	Number of Fish (N)	<i>Gammarus</i>		Diptera		Odonata		Isopoda		<i>Mysis</i>		Fish		Fish remains		Total
		N	%N	N	%N	N	%N	N	%N	N	%N	N	%N	N	%N	
145-181	74	333	12.31	2319	85.79	23	0.85	15	0.55	-	-	7	0.25	6	0.22	2703
182-217	74	345	29.87	519	44.93	59	5.10	-	-	216	18.70	7	0.60	9	0.77	1155
218-253	25	169	68.14	3	1.20	3	1.20	-	-	59	23.79	5	2.01	9	3.62	248
254-289	13	30	68.18	1	2.27	-	-	-	-	-	-	9	20.45	4	9.09	44
290-325	5	27	50.00	21	38.88	2	3.70	-	-	-	-	3	5.55	1	1.85	54
326-361	5	-	-	-	-	-	-	-	-	-	-	-	3	60.00	2	40.00
362-397	8	-	-	-	-	-	-	-	-	-	-	7	63.63	4	36.36	11
398-433	2	-	-	-	-	-	-	-	-	-	-	1	25.00	3	75.00	4
Total	206	904	21.40	2863	67.78	87	2.06	15	0.36	275	6.51	42	0.99	38	0.90	4224

Balık (21) determined the diet of *S. lucioperca* as follows in a study he carried out in Beyşehir Lake: *Gammarus* sp. (77.5%), *Mysis* sp. (14.7%), Chironomidae (4.3%), pikeperch (2.7%) and other organisms (0.8%).

Linfield and Rickards (30) stated in their study they carried out in a relief cut channel in England that the dietary intake of the pikeperch of 28-71 cm in length were 71.2% fish, 12.6% Amphipodes, 2.3% Isopodas, 1.1% Gastropodes, 3.4% Bivalves, 4.6% Chironomid larvae, 1.1% Similium larvae, 1.1% Odonata nymphs and 2.3% macrophytes.

As understood from these data, the diet of the pikeperch is highly diversified. Although *S. lucioperca* is a piscivorous fish, (6-8,29) it also consumes other organisms. The same behavior also exists in Hirfanlı Dam Lake. The pikeperch population in this lake exhibits cannibalism and consumes Insecta species due to the lack of fish in the lake.

There are various studies reporting significant cannibalism in most pikeperch populations (10,14,19). However, cannibalism was not observed in the pikeperch population of Himmerfjorden Bay (13).

In the pikeperch population of Hirfanlı Dam Lake we observed that fish was the major part of their diet except in July and cannibalism was particularly dominant in the summer and autumn. We observed that there was cannibalism at a rate of 40.5% among pikeperch in the lake. They eat *Tinca tinca* and *Alburnus orontis* from the end of autumn and the start of spring. Fish was the dominant part of their stomach contents in late autumn and winter.

As *Gammarus* was observed in the stomachs of the pikeperch in every sampling period it can be concluded that *Gammarus* is a major part of their diet. Pikeperch were observed to feed on fish in each month of the year except for July. The reason why no fish in the stomach

contents of pikeperch in July were noted can be attributed to the low number and small size of the fish caught during this period.

The smallest fish eating length in the population was 145 mm. Türkmen (20) reports that no fish or fish remains were observed in the stomachs of fish smaller than 241 mm. Thiel (11), on the other hand, claims that the fish display piscivorous behavior mainly in summer and consume fish even when 20-30 mm long. Popova and Sytina (3) determined that the pikeperch bigger than 50 cm could eat fish bigger than 15 cm.

Hansson et al. (13) found that an increase in the length of a pikeperch increases the average fishing length. He states that the relation between pikeperch length and average fishing length is highly constant (approximately 30% of the pikeperch length).

It was determined that when feeding on fish, pikeperch shows, a decreased preference for other organisms. Fibrous algae were found in the stomach of the fish caught in December. However, after considering that there only 1 fish with algae was found among 206 fish caught, and that there is no literature that states the feeding of this fish was plant originated, it can be concluded that the algae were not taken for feeding purposes. However, Linfield and Rickards (30) reported that 2.3% of the food of a pikeperch population living in a relief cut channel in England was composed of macrophytes.

S. lucioperca is a carnivorous and piscivorous fish that will eat its own species when food supplies are inadequate. This study reveals that cannibalism, especially in summer and autumn, constitutes a serious threat to the pikeperch population living in the lake. This subject should be seriously considered and those factors, threatening the organisms in the lake and preventing their growth should be eliminated. This will make the pikeperch population living in the lake more productive.

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