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SPATIAL AND TEMPORAL VARIATION IN FEEDING HABITS *SQUALIUS CEPHALUS* LIVING IN SUAT UĞURLU AND HASAN UĞURLU DAM LAKES

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Abstract

In this study, spatial and temporal feeding habits of *Squalius cephalus* (L., 1758) sampled in the Suat and Hasan Uğurlu Dam Lakes and the river areas above and below the dams was investigated by stomach contents analysis. For that purpose, the sampling was performed at 4 different stations: The first station, the Dam Exit (DEX) river areas; the second, Suat Uğurlu Dam Lake (SUDL); the third, Hasan Uğurlu Dam Lake (HUDL) and the fourth, the Dam Entrance (DEN). A total of 332 individuals of *Squalius cephalus* were sampled during the four seasons. Empty stomach ratio was 54.41%. Accordingly, the highest number of empty stomach was observed in autumn (for 60 individuals). According to stomach contents analysis, a total of 37 different prey species belonging to 6 main groups were identified. Of the identified prey species, insects group was the most preferred feed source (39.5%), followed by Chlorophyta (12.48%), Bacillorophyta (9.93%), aquatic plants (8.04%), detritus (5.57%) and Crustaceae (1.27%), respectively. The dominant food item in spring were Bacillariopyhta (3.49 ml), Chlorophyta (4.52 ml) and insects (14.44 ml) while Chlorophyta (1.93 ml), insects (1.38 ml) and detritus (1.41 ml) in summer. It was determined that insects and aquatic plants predominated stomach of *S. cephalus* in autumn, whereas they mostly fed on insects and preferred plant originated Bacillariohyta group in winter. Dams caused changes in the number of fish and food sources along the river. *S. cephalus* fed on insects, Bacillariophyta and Chlorophyta in DEX and SUDL; detritus, insects, Bacillariophyta in HUDL and aquatic plants, Bacillariophyta in DEN. In conclusion, it was observed that *S. cephalus* preferred both animal and plant materials during four seasons. More *S. cephalus* were captured in the river areas at the outlet of the dams and the variety of food sources consumed has been characterized more in their SUDL and HUDL.

Keywords: Suat Uğurlu, Hasan Uğurlu, Dam, Stomach contents analysis, Spatial and temporal variation, Feeding habits

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1. Introduction

The nutrients and nutrition constitute the basis of energy flow and the balance of the ecosystem. Determination of nutritional strategies of fish, which has an important role in the food chain, provides useful information such as population dynamics of species, energy sources supporting the ecosystem and their transfer to food chain, feeding migrations, living environments, fauna and flora of a region, as well as better understanding of predators and other ecological processes. Feeding habits of fishes may vary depending on the quality, quantity, size and ontogeny of the feed as well as seasonal factors. Habitat type, biological stresses and prey-predator interactions can also influence feeding patterns of fish (Hajisamae et al., 2003, Cotta-Ribeiro and Molina-Urena, 2009). Spatial and temporal variations of food network structure can be easily determined by stomach contents analysis (Akın 2001).

The chub (*Squalius cephalus* (L. 1758)) is known as an omnivorous fish and is characterized by a wide feeding niche. Several studies were focused on the feeding habits of chub. Djinova (1976) reported that *S. cephalus* in the Turia River fed on diptera. Jankovic ve Trivunac (1978) performed a study in Skader Lake and they determined that it fed on Trichoptera and plant materials during summer and spring, respectively. Frankiewicz et al. (1991) investigated the food consumption of chub in two streams in the Hungarian Strait, where were predominated by zoobentoses. Nastova-Gjorgjioska et al. (1997) conducted a study in the Babuna River and reported that the chub is omnivore although its meal preference is plant-dominated. Balestrieri et al. (2006) reported that the food preference of chub in the Raganello River was plant materials and invertebrates. Ünver and Erkakan (2011) performed a study in Tödürge Lake and they stated that the prey items of *Squalius cephalus* was mainly composed of zooplankton (69.2%) while a wide spectrum of feeds including phytoplanton, nematodes, insects, fish, and plant and animal parts was also available.

The dams, which convert water into a still water (lake), create two different habitats by affecting the physical, chemical and biological characteristics of the river areas. The first of these habitats are dam lakes with features such as sedimentation accumulation, thermal stratification, decrease in turbidity, accumulation of toxins, nutrient elements, and increase in productivity, the second is the entrance and exit of the dam where changes in the density, species diversity, feeding characteristics and morphological structures of living things are observed. As a result, changes are observed when the river areas at the exit of the dam are compared with the living communities in the lake area. In this study, the spatial and temporal variations in feeding habits of *Squalius cephalus* sampled in the Suat and Hasan Uğurlu Dam Lakes and the river areas at the entrance and exit of these dams were investigated by stomach contents analysis.

2. Materials and Methods

2.1. Study Area

Yesilirmak River is 2nd largest river (519 km) of Turkey. The river mainly consists of the merger of three branches, namely Tozanlı, Kelkit and Çekerek. The Kelkit is the biggest branch of the river. The alluviums carried by the river with its tributaries form Çarşamba Plain. Yeşilırmak, on which Almus, Ataköy, Hasan Uğurlu and Suat Uğurlu Dams are established, has an irregular regime (Anonymous, 2009). In this study, the sampling was performed at four stations; Dam Exit (DEX) river, site the Suat Uğurlu Dam Lake (SUDL), Hasan Uğurlu Dam Lake (HUDL) and the dam entrance (DEN) river site (Figure 1).

Figure 1. The stations in the study area.

2.2. Sampling and Analysis

The sampling was conducted at 4 stations during April 2008, July 2008, October 2008 and February 2009. For the sampling of dam lakes and deep river areas, trammelnets having 25, 30, 40, 50, 60 and 70 mm mesh size were used. Electroshoker and throw nets were also used in shallow river areas and lakes. Captured fish were first anesthetized with Clover Oil and then transferred to Gaziosmanpaşa University Fisheries Laboratory in 10% of formalin solution. In the laboratory, the number, standard lenght and weight of individuals belonging to each station were measured.

All food items in the stomach were removed and identified under binocular or light microscope depending on the size of the prey item. The taxonomy prey items was performed on the basis of the possible subspecies (Kruuk and Parish 1981, Campaioli et al., 1994, Harding and

Smith 1974). The prey items in the stomach were quantified by the volume measurement. The volume of a prey greater than 0.1 ml was determined by the amount of water caused to overflow by the prey, which was placed in a measuring cylinder containing a certain amount of water. The volume of a prey less than 0.1 ml was determined by visually comparing the volume with the determined drop of water with an automated pipette under a binocular microscope (Akın, 2001). The value obtained by multiplying the relative proportion of each prey species in the sample taken and the total volume of the stomach contents was recorded by the volume of the corresponding material in the stomach (Winemiller 1990).

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

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

Where pi 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).

3. Results

A total of 332 indivuals were sampled during the four seasons. According to the results given in Table 1, it was determined that the highest (96) and lowest (70) number of individuals were obtained in July and April, respectively. The highest number of individuals was intensively captured in SUDL and the exit of SUDL. Empty stomach ratio was 54.41% while the highest empty stomach (60 fishes) was detected in autumn (Table 1).

Table 1. Numbers of full/empty stomach according to the stations and months

Months	Station	Number of stomach examined	Standard length average (mm) and standard deviation	Average weight (g) and standard deviation	Number of full stomach	Number of empty stomach
April	1	66	84.96±29.01	14.01±18.08	50	16
	2	4	135.26±48.43	57.75±14.34	4	0
July	1	53	75.18±35.89	12.56±13.18	45	8
	2	36	124.86±55.61	48.24±36.19	30	6
	3	2	139.5±14.84	55±18.38	1	1
	4	5	99.2±14.68	18.49±6.53	5	0
November	1	63	75.02±22.29	9.47±9.56	13	50
	2	5	125.60±14.72	38.98±17.37	4	1
	3	15	213.93±21.19	193.08±57.58	6	9
February	1	59	68.01±27.82	7.53±10.71	47	12
	2	10	117.8±5.05	31.13±4.00	5	5
	4	14	40.85±5.85	1.05±0.51	4	10

A total of 37 different prey species belonging to 6 main groups were identified by stomach contents analysis. Among these identified prey species, the insects were the most preferred group (39.5%), followed by the groups of Chlorophyta (12.48%), Bacillorophyta (9.93%), aquatic plant (8.04%), detritus (5.57%) and Crustaceae (1.27%), respectively. It was determined that *S. cephalus* individuals collected from SUDL and the first station located in the exit of SUDL, HUDL and the rivers flowing into the dams fed mostly on Chlorophyta, Bacillariophyta and insects, individuals collected from SUDL fed on insects, Bacillariophyta, Chlorophyta and the individuals collected from HUDL fed on detritus, insects, Bacillariophyta. It was observed that the samples collected from the rivers flowing into the dam fed mostly on aquatic plants and Bacillariophyta (Figure 1). The food overlap index of this fish species living at all stations was determined to be relatively high which indicates that feeding habits of this fish species showed lower spatial variation (Figure 2).

It was determined that the diet breadth was high in November and April while it was the highest in HUDL and DEN (Figure 3), which can be attributed to the consumption of various prey items by the fish.

During the spring, the dominant prey items of *S. cephalus* were Bacillariopyhta (3.49 ml), Chlorophyta (4.52 ml) and the insects (14.44 ml) while they were Chlorophyta (1.93 ml), the insects (1.38 ml) and detritus (1.41 ml) during the summer. It was also determined *S. cephalus* fed mostly on insects and aquatic plants during the autumn while they fed mostly on insects and plant originated Bacillariohyta. Overall, it was observed that *S. cephalus* preferred both plant and animal-based food items (Table 2).

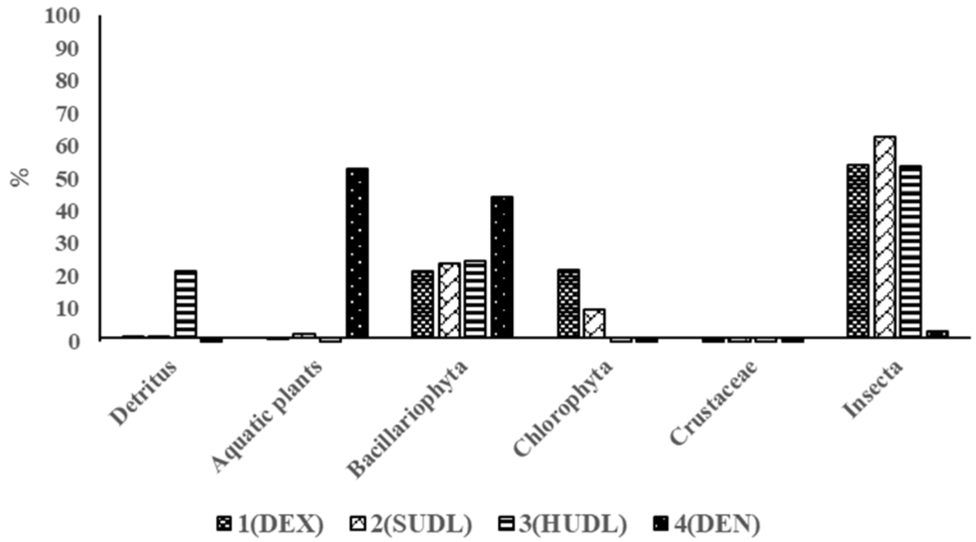

Figure 2. Food sources preferred by *S. cephalus* at different stations. Numbers are percentages.

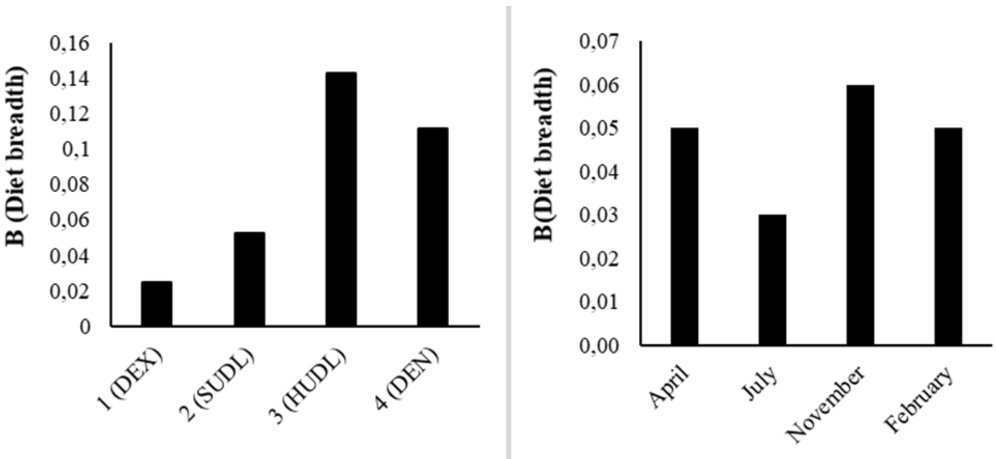

Figure 3. Diet breadth of *S. cephalus* according to stations and seasons.

4. Discussion

This study shows spatial and temporal in feeding habits of *Squalius cephalus* captured in Suat and Hasan Uğurlu Dam Lakes and river areas at the entrance and exit of these dams. According to the River Continuum Concept (Vannote et al., 1980), processes occurring near the source of the river affect the subsequent parts of the river. This global mechanism causes some variations on the feed network along the river (Romanuk et al., 2006). This contiunity along the river is interrupted by some factors like dams which initialize the biotic community (Romanuk et al., 2006).

S. cephalus were mainly captured at Suat Uğurlu Dam Lake and the exit of the dam. *S. cephalus* tends to change their diet prey items in the corresponding environment. For instance, Winemiller (1990) showed that the consumption of aquatic invertebrates in tropical rivers during rainy season depends on the increasing amount of this prey item in the environment. Akın (2001) stated that the exessive consumption of gammarids during summer was due to the abundance of this prey item in this season. Similar findings were also obtained in this study.

Generally, the extreme consumption of the insects and Bacillorphyta is due to the abundance of this prey item in all environments. Additionally, it is known that the organisms such as phytoplankton and zooplankton which constitute the base of the food chain in lentic waters (Akın, 2010). However, it is thought that the predominance of prey item (aquatic plants and Bacillorphyta) at the entrance of the dam, which is 4th station was resulted from the local abundance of these prey items. Similarly, the consumption of Chrinomid larvae the river section and the consumption of copepods, rotifers and clodocera in the reservoirs are due to most abundance of these organisms in the environment.

Table 2. Food preference of *S. cephalus* by season

Food Sources		April		July		November		February		Total	
		Volume (ml)	%	Volume (ml)	%	Volume (ml)	%	Volume (ml)	%	Volume (ml)	%
Detritus		0.43	1.38	1.41	15.95	-	-	0.01	0.32	19.16	5.57
Aquatic plant		-	-	0.18	2.04	0.65	24.77	0.02	1.29	27.66	8.04
Bacillariophyta											
Cymbella sp.	0.32	1.03	0.06	0.68	-	-	0.01	0.58	2.10	0.61	
Synedra sp.	0.59	1.90	0.09	0.96	0.02	0.76	-	-	4.32	1.26	
Navicula viridula	-	-	0.10	1.09	-	-	-	-	1.18	0.34	
Navicula sp.	0.49	1.58	0.31	3.47	0.06	2.20	0.02	1.48	8.13	2.36	
Gamphonema sp.	0.42	1.34	0.07	0.74	0.02	0.76	0.02	1.35	3.36	0.98	
Fragilaria sp.	0.04	0.13	-	-	-	-	-	-	0.17	0.05	
Melosira sp.	0.12	0.37	0.02	0.17	-	-	0.01	0.64	0.68	0.20	
Pinnularia sp.	-	-	0.01	0.11	-	-	-	-	0.12	0.04	
Cymatopleura sp.	-	-	-	-	0.01	0.38	-	-	0.39	0.11	
Diatoma sp.	0.29	0.94	-	-	-	-	-	-	1.23	0.36	
Amphora sp.	-	-	0.04	0.45	-	-	-	-	0.49	0.14	
Cocconeis sp.	1.23	3.98	0.07	0.74	0.07	2.74	0.00	0.13	8.82	2.57	
Cyclotella sp.	-	-	0.26	2.89	-	-	-	-	3.14	0.91	
Total		3.49	11.29	1.00	11.29	0.18	6.84	0.07	4.19	34.15	9.93
Chlorophyta											
Spirogyra sp.	3.30	10.69	0.72	8.13	-	-	0.01	0.52	22.85	6.64	
Oocystis sp.	-	-	0.22	2.45	-	-	-	-	2.66	0.77	
Scenedesmus sp.	-	-	0.77	8.71	-	-	-	-	9.48	2.76	
Ulothrix sp.	1.22	3.95	0.22	2.52	-	-	-	-	7.91	2.30	
Total		4.52	14.64	1.93	21.81	-	-	0.01	0.52	42.90	12.48
Crustaceae											
Rotifera											
Synchaeta pectinata	-	-	-	-	0.10	3.80	-	-	3.90	1.13	
Cladocera		-	-	-	-	-	-	-			
Daphnia sp.	-	-	0.01	0.08	-	-	-	-	0.09	0.03	
Longispina sp.	-	-	-	-	0.01	0.38	-	-	0.39	0.11	
Total		-	-	0.01	0.08	0.11	4.18	-	-	4.38	1.27
Insecta											
Chironomid	0.44	1.44	0.20	2.27	0.02	0.76	0.08	5.22	5.21	1.52	
Stonefly	-	-	-	-	0.73	27.74	0.45	29.10	28.92	8.41	
Hemiptera	-	-	-	-	-	-	0.29	18.35	0.29	0.08	
Histeridae	-	-	0.20	2.27	0.50	19.00	0.05	3.48	22.02	6.40	
Forminadea	5.00	16.19	-	-	0.12	4.52	0.33	21.25	26.17	7.61	
Passalidae	-	-	0.05	0.51	-	-	-	-	0.55	0.16	
Coleoptera	-	-	0.17	1.95	-	-	-	-	2.12	0.62	
Phoridae(diptera)	1.10	3.57	0.20	2.27	0.01	0.38	-	-	7.53	2.19	
Thrips (Thysonoptera)	3.56	11.52	0.20	2.24	-	-	-	-	17.52	5.10	
Thysonoptera	0.02	0.06	-	-	-	-	-	-	0.08	0.02	
Ephemeptera	0.45	1.46	-	-	-	-	-	-	1.91	0.55	
Odonota nif	-	-	-	-	-	-	-	-	0.00	0.00	
Hymenoptera	0.90	2.92	0.32	3.67	0.02	0.80	0.05	3.22	8.68	2.52	
Hidrolifilidae	-	-	-	-	-	-	0.13	8.37	0.13	0.04	
Undefined insect	2.97	9.60	0.04	0.48	-	-	-	-	13.09	3.81	
Total		14.44	46.77	1.38	15.64	1.40	53.19	1.38	88.99	134.20	39.03

In other studies, it was determined that feeding habits of *S. cephalus* may vary seasonally and it consumed the present prey items exist in all seasons abundantly (Hellawell, 1971; Altındağ, 1997; Nastova-Gjorgjioska et al., 1997). Ünver and Erkakan (2011) reported that there were age-related variations in winter feeding. They stated that the young individuals preferred phtoplankton while the older ones fed on mostly benthic organisms like insects and nematodes. In this study, it was observed that the preferred feeds were insects, and Chlorophyta and detritus in winter and summer, respectively.

Gastric repletion rate may indicate feed limitations in the habitat (Nikolsky, 1963). Any feed type was not obtained in the gastric content of 118 of the total 332 *S. cephalus* captured in this study. A wide variety of food items was determined in the stomach contents of all samples of *S. cephalus* caught in July while detritus and Chlorophyta in November and crustaceae in February were not found in the stomachs. Feeding intensity can be influenced by some factors such as temperature, oxygen level, light and abundance of predators (Lagler, 1956; Holcik, 1967; Geldiay and Balık, 1988; Demir, 1992). For example, Yılmaz et al. (2008) have exhibited in their research on the diet of *Carassius gibelio* (Bloch, 1782) in Lake Eğridir and Lake Bafra that the same species of different ecological characteristics in the habitat change their feeding preferences. In the digestive system of the pond fish caught from Lake Eğirdir, 35 kinds of plant and 11 kinds of animal nutrients were determined. However, in Lake Bafra sample, 38 of the vegetable and nine animal nutrients have been detected. Moreover, Yılmaz et al. (2007 a,b) have found out in the diet of Carassius gibelio that the nutritional variety of it in Lake Eğirdir and Lake Bafra is at the highest level in the spring season and the lowest in the winter season.

It has been determined that the individuals living in lakes had higher diet breadth compared to ones living in rivers. This can be attributed to higher concentrations of phytoplankton, zooplankton and chlorophyll-a in lakes than rivers (Aracı, 2009) and their direct or indirect contribution to fish feeding. The data can be considered as old since the study was conducted about ten years ago and the status of the lake could be changed to a certain extent due to the climatic factors. Therefore, these findings may serve as literature information rather than a database for the current fisheries management.

Conflict of interest

The authors declare that there is no conflict of interest.

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