



## The Gut Contents of the *Squalius cii* in a Permanently Interrupted River System, the Karamenderes River

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### Abstract

The goal of this study was to determine the temporal and spatial distribution of the gut contents of *Squalius cii* specimens in a permanently interrupted Karamenderes River. The specimens were sampled at seven distinct locations along the Karamenderes River in summer 2012, autumn 2012, and spring 2013. The gut contents of a total of 157 specimens were examined. The data on the identified food organisms were quantified as the percentage of the index of relative importance (IRI%), niche breadth (BA), trophic level (TL), feeding intensity (Vacuity Index, VI), and food diversity (H'). In all seasons, the examined specimens were found to mostly feed on the members of the Insecta family in the river's upper section and on Bacillariophyceae and macrophytes in the lower section. The feeding intensity was found to be the highest in spring 2013, while the food diversity was realized to exhibit the highest value (2.21) at the Karaköy 1 site in summer 2012. The niche breadth of the examined specimens varied between 0.01 and 0.73, whereas their trophic levels ranged between 2.01 and 3.48. The *S. cii* specimens were fed on high-quality foods in the upper section of the dam.

### Keywords:

Index of relative importance (IRI), niche breadth, trophic level, food diversity, feeding intensity.

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### Introduction

*Squalius cii* (Richardson, 1857), a Cyprinidae species found in the Marmara region's rivers, was identified as *Leuciscus cii* (Richardson, 1857) in the Nilüfer Stream near Gemlik, Bursa, Turkey

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and synonymized with *Leuciscus cephalus* (L., 1758) by Kottelat (1997) and Bogutskaya (1997). Molecular and taxonomic studies in recent years have recorded the current name of this species to be *S. cii* (Stoumboudi et al., 2006; Kottelat & Freyhof, 2007; Özuluğ & Freyhof, 2011; Geiger et al., 2014; Çiçek et al., 2020). Some biological studies feature this species previously reported as *Squalius cephalus* (Başdemir, et al., 2010) *L. cephalus* (Sarı et al., 2006).

The studies have been conducted on its distribution (Stoumboudi et al., 2006; Kottelat & Freyhof, 2007; Bakaç, 2018) and its biological characteristics by referring to its valid name. There are also studies on the *S. cii* taxon, found in Çanakkale, its gut content (Yalçın Özdilek & Jones, 2014; Yalçın Özdilek, 2017), and its feeding characteristics based on isotopic composition (Yalçın Özdilek & Jones, 2014; Yalçın Özdilek et al., 2019). All are focused on a particular section of the Karamenderes River, and there is insufficient data on how the feeding characteristics of this species vary across the streams which are located in the province of Çanakkale, Turkey, and permanently interrupted by reservoirs. The number of reservoirs along river systems has dramatically increased in the world not only for irrigation and flood control but also for energy generation by hydroelectric power plants (Baxter, 1977).

*S. cii* is a native, omnivorous, and generalist species, and because it has higher ecological tolerance compared to other native species, it is widely distributed along the Karamenderes River (Yalçın Özdilek, 2017). Therefore, this species may be ascribed as a model organism to observe impacts of reservoirs on the feeding behaviour of any species. The objective of this paper is to show the temporal and spatial shifts that potentially occur in the gut contents of the captured *S. cii* individuals along the Karamenderes River, which is interrupted by a reservoir. In addition, it is also intended to compare their current gut contents with their so-called previously reported as *S. cephalus* (*L. cephalus*) exhibiting a wide distribution in the province of Çanakkale.

## Materials and Method

### Study Area and Sampling

The Karamenderes River originates from Kaz Mountain and Ağı Mountain in Çanakkale and is disrupted by small barriers along with the Bayramiç Reservoir Lake. It measures 110 km (Baba et al., 2007). The Bayramiç Reservoir's surface area is 6.07 km<sup>2</sup>, and its depth is 56 m. The sampling was carried out at seven different stations (Kumkale: KK, Kalafat: K, Sarımsaklı: S, Ahmetçeli: A, Mollahasanlar: M, Karaköy1: K1, Karaköy2: K2) on the Karamenderes River in summer 2012, autumn 2012, and spring 2013 (Figure 1). The map of the sampling stations was generated with ArcGIS 10.5. The specimens were collected with various fishing gears depending on the habitat type. Besides an electrofishing device, SAMUS 725G, gill nets with 18mm, 22mm, 25mm, and 32mm mesh sizes were used.

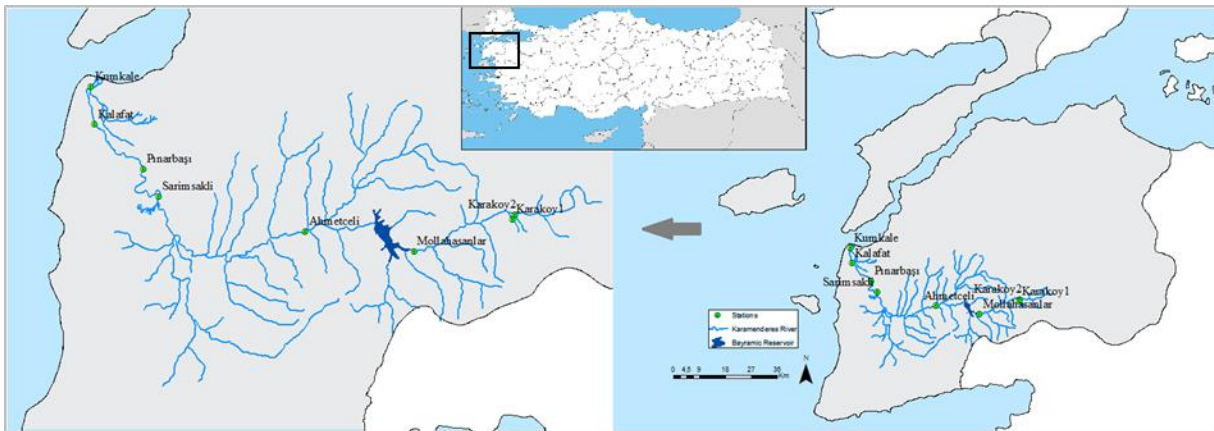


Figure 1. Sampling area and the stations.

Following the required measurements of fishes, the gut contents were collected and kept in 70% ethanol. The gut contents were diluted according to their densities. The numbers of the food organisms in the randomly selected squares were recorded in the Sedgewick-Rafter counting chamber under a microscope at 10x magnification in view of the density of the food organisms in the squares. For each sample, this procedure was performed in three replicates. The volumes of the organisms were calculated as described in Sun and Liu (2003).

### Data Analysis

The gut contents were identified by the Index of Relative Importance (IRI) (Hyslop, 1980), expressed as percentages. The IRI% values of the lowest taxonomic food category ( $i$ ) were found by calculating the percentage frequency of occurrence (F%) and the percentage of numerical (N%) and volumetric (V%) abundance. The IRI value was determined using the equation  $IRI = (N\% + V\%) * F\%$ , derived from the calculated F%, N%, and V% values. The index of relative importance was produced by calculating the IRI% value of each food category. The gut fullness ratio was calculated using the equation Vacuity Index (VI) = (The Number of Empty Guts \* 100 / Total Number of Guts) to assess the specimens' feeding intensities. The IRI% values of the specimens whose gut contents were examined were used to determine the diversity of food items. The equation;  $H' = -\sum p_i \ln(p_i)$ ;  $p_i = N_i / N$  was used to determine the diversity of food items (Shannon & Weaver, 194). The IRI% values determined from the contents of the guts were used to estimate the niche breadth for each station and season (Levins, 1968). The equation;  $B = 1 / \sum p_j^2$ ;  $BA = (B - 1) / (n - 1)$  was used to calculate the niche breadth (Levins, 1968), where  $B$ : niche breadth,  $p_j$ : IRI% values of prey items,  $BA$ : standardized niche breadth,  $n$ : prey items numbers. The trophic levels (TL) of the specimens at each station and in each season were determined using the equation  $TL_k = 1 + (\sum_{j=1}^n P_j \times TL_j)$  and by operationalizing the gut contents (Cortés, 1999; Vander Zanden et al., 1997). The *ggplot2*, *tidyverse*, and *viridis* packages in R and R Studio were employed to calculate and visualize the data (Wickham, 2011; Wickham, 2017; Garnier et al., 2018; RStudio Team, 2020).

To analyse the spatial variations among the gut contents, the multivariate statistical analysis was used because there are more than one variable for each specimen, and these variables have

different contributions to the species' feeding behaviour. The differences in the gut contents across the stations and seasons were tested with the permutational multivariate analysis variance (PERMANOVA) in R Studio by operationalizing the *vegan* package (Oksanen et al., 2013; RStudio Team, 2020). The N% and V% values were used to describe the spatial and temporal variation in the gut contents. In addition, the prey items' N%, V%, and IRI% values were grouped into seven prey groups (Cyanobacteria, Bacillariophyceae, Chlorophyta, Plants, Macroinvertebrates, Planktons, and Fish), and PERMANOVA was performed to understand whether the grouped preys varied spatially. The percentages were permuted 9999 times using a Euclidean distance matrix created from the square root transformed data. To test the station-based similarity between the IRI%, N%, V%, and F% values of the prey items, nonmetric multidimensional scaling (NMDS) was performed, the results of which were given visually (Oksanen et al., 2013). The analysis was conducted with the square root transformed data and the Wisconsin double standardized data based on the Bray-Curtis similarities. The NMDS analysis was performed on R Studio with the *vegan* package (Oksanen et al., 2013; RStudio Team, 2020).

## Results

The indices of relative importance (IRI%) concerning the gut contents of 157 specimens from the seven stations along the Karamenderes River over three seasons were calculated. The average weight of the studied specimens was  $37.7 \pm 78\text{g}$  (0.28-516.4g) and the average fork length was  $10.4 \pm 5.6\text{cm}$  (2.8-28.8cm). The Bacillariophyceae members were found in the gut contents of the specimens at nearly all of the stations and in all three seasons (Figure 2). The taxa *Cocconeis sp.*, *Fragilaria sp.*, and *Navicula sp.* were widely observed in each seasons. Apart from the Bacillariophyceae members, the indices of the relative importance of *Chaetomorpha sp.*, *Cladophora sp.*, and *Oedogonium sp.* of the Chlorophyta members varied across the sampling seasons and stations, while *Cladophora sp.* was more common in spring and summer. The IRI% values of the Insecta members were high at the upper stations of the reservoir (M, K1, and K2 stations) compared to the lower sites (Figure 2).

While the Bacillariophyceae members were the abundantly found prey items (N%) in all the seasons and at all the stations, the number of the macroinvertebrate and Chlorophyta members were found to be high at the K2 and A stations in the summer samples (Figure 2). In the autumn, it was determined that the macroinvertebrate ratio at the upper stations of the dam was higher than the ratios at the M station and the lower stations. In the spring, the rate of Bacillariophyceae members was generally high.

Moreover, the volumes (V%) of the macroinvertebrate members were determined to be high in all the three seasons (Figure 2). While the volumes of the macroinvertebrate members were high in the above-dam stations (K2, K1, and M) in almost all the three seasons, those of the planktonic organisms at the Mollahasanlar station in the spring were high. While the volumes of the macroinvertebrate and Chlorophyta members were high in the below-dam stations, those of the fish were observed to be high at the A station in the autumn.

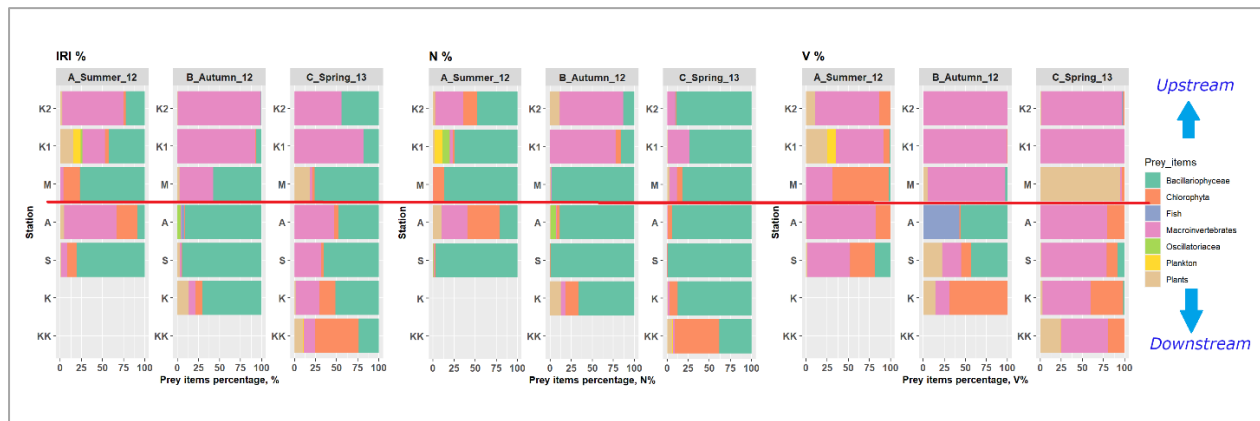


Figure 2. By-station and seasonal percentages of the prey items by IRI%, N%, and V%. The figure does not include the K and KK station data due to the missing values in summer 2012 and autumn 2012. The red line indicates the Bayramiç Reservoir's location.

The gut contents of 20 specimens in total were examined in two seasons at the K station. In the autumn 2012 sampling, *Cocconeis* sp. (28.6%), *Vaucheria* sp. (20.5%), and *Navicula* sp. (14.4%), as well as the plant materials (13.5%), were found to be important (Table 1). In the spring 2013 sampling, the IRI% value of the Bacillariophyceae members, especially *Fragilaria* sp. (32.7%), was notably high. In the same season, the IRI% values were revealed to be high in the Insecta (28.2%) and *Cladophora* sp. (18.8%) members as well.

The indices of relative index of relative importance of *Fragilaria* sp. (36.8%) and *Navicula* sp. (21.8%) were found to be high in the summer 2012 sampling at S station (Table 1). While *Melosira* sp. (44.8%) and *Navicula* sp. (35.5%) exhibited a high index of relative importance in the autumn 2012 sampling, *Fragilaria* sp. (46.4%) members had a high index of relative importance in the spring 2013 sampling. Unlike the other two seasons, the IRI% values of the Insecta (31.7%) members were found to be high in spring 2013 (Table 1).

The *Cladophora* sp. (22.4%), Amphipoda (31.5%), and Insecta members (27.1%) had high IRI% values in the summer sampling at the A station, whereas *Fragilaria* sp. (45.8%) and *Navicula* sp. (36.3%) had high IRI% values in autumn 2012. In the sampling of spring 2013, the *Tabellaria* sp. (14.6%), *Navicula* sp. (11.6%), and Insecta members (47.0%) had high IRI% values (Table 1). *Cocconeis* sp. (25.1%) and *Vaucheria* sp. (26.2%) yielded the highest IRI% values at the M station in summer 2012, whereas *Navicula* sp. (38.5%) and Insecta (39.7%) in autumn 2012 and, *Cocconeis* sp. (36.9%) and the plant materials (18.5%) in spring 2013 (Table 1). At the K1 station, the highest IRI% values were found as follows: the plant materials (14.6%) and the Insecta (26.6%) members in summer 2012, the Insecta members (89.2%) in autumn 2012, and the Insecta members (81.1%) in spring 2013 (Table 1). The K2 station produced the high IRI% values of 70.2%, 98.5%, and 55.6% for the Insecta members in summer 2012, autumn 2012 and spring 2013 respectively (Table 1).

Table 1. IRI% values of the *S. cii* specimens along the Karamenderes River (n: the number of specimen; KK: Kumkale; K: Kalafat; S: Sarımsaklı; A: Ahmetçeli; M: Mollahasanlar; K1: Karaköy 1; K2: Karaköy 2)

Prey items	Summer 2012					Autumn 2012						Spring 2013																								
	K2 (n=8)	K1 (n=7)	M (n=5)	A (n=8)	S (n=8)	K2 (n=10)	K1 (n=10)	M (n=10)	A (n=10)	S (n=10)	K (n=10)	K2 (n=10)	K1 (n=4)	M (n=10)	A (n=10)	S (n=10)	K (n=10)	KK (n=7)																		
<b>Cyanobacteria</b>																																				
Oscillatoria	2.09		0.21			4.13		0.003																												
<b>Bacillariophyceae</b>																																				
<i>Amphora</i> sp.	1.34		0.08		1.48		0.27		0.49		0.11		0.10		0.12																					
<i>Cocconeis</i> sp.	3.71		11.86		25.11		4.01		0.04		2.42		1.21		1.72		28.58		1.51		36.88		1.09		0.001		4.51		3.85							
<i>Cyclotella</i> sp.						0.004					0.01				0.06				0.003				0.01													
<i>Cymatopleura</i> sp.	0.03		0.01		0.04		0.27		0.001		0.00002																									
<i>Cymbella</i> sp.	0.01		0.51		1.61		1.16		3.16		0.004		0.65		1.19		0.10		0.48		0.51		3.33		0.69		0.85		0.36							
<i>Diatoma</i> sp.						0.07		0.03		0.04		2.31		0.06		0.005		5.80		1.47		0.05														
<i>Fragilaria</i> sp.	0.82		0.16		1.35		1.28		36.75		0.04		0.27		2.66		45.80		3.60		1.49		26.45		10.50		13.54		4.49		46.40		32.65		5.83	
<i>Gomphonema</i> sp.	0.07		0.33		0.02		1.16		0.34		2.83		0.01		0.03																					
<i>Gyrosigma</i> sp.	0.07		0.25		0.47		0.04		0.56		0.01		0.01		0.01		0.01		0.01		0.01		0.01		0.01		0.01		0.01		0.01					
<i>Licmophora</i> sp.	0.03		0.14		5.49		0.73		0.81		3.44		1.10		1.77		0.03		0.06		0.23		5.30		0.03		0.01		1.20							
<i>Melosira</i> sp.	15.86		11.14		1.24		2.93		10.53		0.55		11.78		0.17		44.79		1.02		4.81		4.70		6.55		1.21		0.36		0.29		0.03			
<i>Navicula</i> sp.	1.69		10.80		9.20		0.93		21.80		0.21		5.51		38.52		36.31		35.54		14.35		11.31		0.86		15.27		11.58		4.90		11.21		8.04	
<i>Nitzschia</i> sp.	0.07		0.89		6.47		0.34		0.03		0.11		1.42		0.11		0.01		0.10		0.10		0.10		0.10		0.10		0.10		0.10		0.10			
<i>Pinnularia</i> sp.	0.07		0.07		0.02		0.16		0.16		0.16		0.16		0.16		0.16		0.16		0.16		0.16		0.16		0.16		0.16		0.16					
<i>Rhoicosphaenia</i> sp.	0.07		5.33		0.10		0.48		0.26		0.001		0.11		0.01		0.93		0.93		0.93		0.93		0.93		0.93		0.93		0.93					
<i>Rhopalodia</i> sp.	0.07		5.33		0.10		0.48		0.26		0.001		0.11		0.01		0.93		0.93		0.93		0.93		0.93		0.93		0.93		0.93					
<i>Surirella</i> sp.	0.07		5.33		0.10		0.48		0.26		0.001		0.11		0.01		0.93		0.93		0.93		0.93		0.93		0.93		0.93		0.93					
<i>Tabellaria</i> sp.	0.07		5.33		0.10		0.48		0.26		0.001		0.11		0.01		0.93		0.93		0.93		0.93		0.93		0.93		0.93		0.93					
<i>Ulnaria</i> sp.	0.07		5.33		0.10		0.48		0.26		0.001		0.11		0.01		0.93		0.93		0.93		0.93		0.93		0.93		0.93		0.93					

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Table 1. IRI% values of the *S. cii* specimens along the Karamenderes River (n: the number of specimen; KK: Kumkale; K: Kalafat; S: Sarımsaklı; A: Ahmetçeli; M: Mollahasanlar; K1: Karaköy 1; K2: Karaköy 2) – Continued

Prey items	Summer 2012					Autumn 2012						Spring 2013						
	K2 (n=8)	K1 (n=7)	M (n=5)	A (n=8)	S (n=8)	K2 (n=10)	K1 (n=10)	M (n=10)	A (n=10)	S (n=10)	K (n=10)	K2 (n=10)	K1 (n=4)	M (n=10)	A (n=10)	S (n=10)	K (n=10)	KK (n=7)
<b>Chlorophyta</b>																		
<i>Chaetomorpha</i> sp.														1.34			0.04	
<i>Cladophora</i> sp.	2.71	3.82	15.21	22.40	10.30	0.01	1.22		0.30	0.80	8.36	0.14		1.56	4.86	3.23	18.83	1.64
Chlorophyta				1.96	0.02													
<i>Closterium</i> sp.					0.03									0.00	0.22	0.08		
<i>Cosmarium</i> sp.		0.03			0.02													
<i>Microspora</i> sp.								0.20										
<i>Oedogonium</i> sp.		0.15			0.53			0.12						0.04	0.003			50.06
<i>Pandorina</i> sp.			0.04															
<i>Pediastrum</i> sp.			0.38															
<i>Scenedesmus</i> sp.			2.83						0.16									0.07
<i>Stigeoclonium</i> sp.								0.01										
<i>Spirogyra</i> sp.			0.81						0.003									
<i>Vaucheria</i> sp.			26.17								20.51							
<i>Ulothrix</i> sp.					0.61									0.03	0.002			
<i>Zygnema</i> sp.								0.02										
<b>Charophyta</b>																		
<i>Mougetia</i> sp.		0.73						0.19		0.16					0.06			
<b>Other plant and animal groups</b>																		
Plant material	2.19	14.58		2.96	0.67			2.71	0.001	3.08	13.49	0.05		18.48			1.30	10.68
Pollen	0.14			1.71		0.64						0.02	0.22	0.11		0.0002		
Cladocera	0.03	8.67													0.0001			
<i>Keratella</i> sp.																		0.02
Bryozoa																		0.21
Amphipoda		0.27	1.93	31.51	0.30													
Chironomidae							1.84					0.06		0.03	0.08		0.01	0.18
Copepoda			1.96	6.31				0.01										
Nematoda						0.03							0.34					
Ostracoda				1.53														
Other Insecta	70.19	26.62	1.90	27.07		98.46	89.21	39.68		1.54	7	55.57	81.06	0.87	47.00	31.68	28.21	2.02
Unknown	2.32	0.20	0.04		0.53	0.005	1.15		0.15	0.002	0.69		0.31	1.70	0.01	0.002		11.20
Fish									3.46			0.07			0.02			

The prey items were statistically compared in view of IRI%, N%, V%, F%, and the seven prey groups' N% and V% values and according to the stations and the seasons of sampling by employing PERMANOVA (Table 2). The table offers no statistically significant station-based and seasonal difference in the IRI% values ( $p>0.05$ ). However, there was a statistically significant difference between the stations and the seasons in terms of N%, V%, the seven prey groups' N% and V% values ( $p>0.05$ ). In this study, *P. strandjae*'s maximum age is 4, maximum total length is 90 mm and maximum weight is 7.92 g. On the other hand, Sac and Ozulug (2020) have reported maximum age as 6, maximum standard length as 72 mm and maximum weight as 10.596 g in Istranca creek. The reason of the maximum weight difference is that the Istranca population includes 6 years old individuals.

Table 2. PERMANOVA results concerning IRI%, N%, V%, F%, and the seven prey groups' N% and V% (Df: Degrees of freedom; SS: Sum of squares; MS: Mean squares; \*\*\*, \*: The statistically significant values)

Source of variation	Df	SS	MS	Pseudo-F	P-value	Unique perms
<b>IRI% values of prey items</b>						9999
Station	4	195.65	0.29735	1.0857	0.1502	
Season	2	101.92	0.1549	1.1311	0.1107	
Residual	8	360.42	0.54776			
<b>Number of prey items (N%)</b>						9999
Station	6	711.8	0.10087	2.6586	<b>0.0001</b>	***
Season	2	272.9	0.03867	3.0579	<b>0.0001</b>	***
Residual	136	6068.2	0.86001			
<b>Volume of prey items (V%)</b>						9999
Station	6	637.2	0.09031	2.32	<b>0.0001</b>	***
Season	2	198.3	0.0281	2.1655	<b>0.0001</b>	***
Residual	136	6225.9	0.88235			
<b>Frequency of prey items (F%)</b>						9999
Station	4	191.97	0.29809	1.1762	0.1692	
Season	2	125.6	0.19503	1.5391	0.0284	*
Residual	8	326.43	0.50688			
<b>Number of prey items in seven prey categories (N%)</b>						9999
Station	6	147.02	0.14585	4.0871	<b>0.0001</b>	***
Season	2	33.32	0.03305	2.7788	<b>0.0007</b>	***
Residual	136	815.34	0.80887			
<b>Volume of prey items in seven prey categories (V%)</b>						9999
Station	6	150.24	0.14904	4.1463	<b>0.0001</b>	***
Season	2	35.01	0.03474	2.8989	<b>0.0007</b>	***
Residual	136	821.29	0.81478			

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The NMDS figures calculated based on the nutrient similarities between the stations are presented in Figure 3. While the prey items were similarly abundant at the K1, K2, and A stations, similar abundance values were observed at the M and S stations. The analyses of the volumes (V%) generated the lower and upper section groups. However, in terms of the frequency of occurrences (F%), and IRI% of the prey items, the lower and upper stations of the reservoirs were not different from one another.

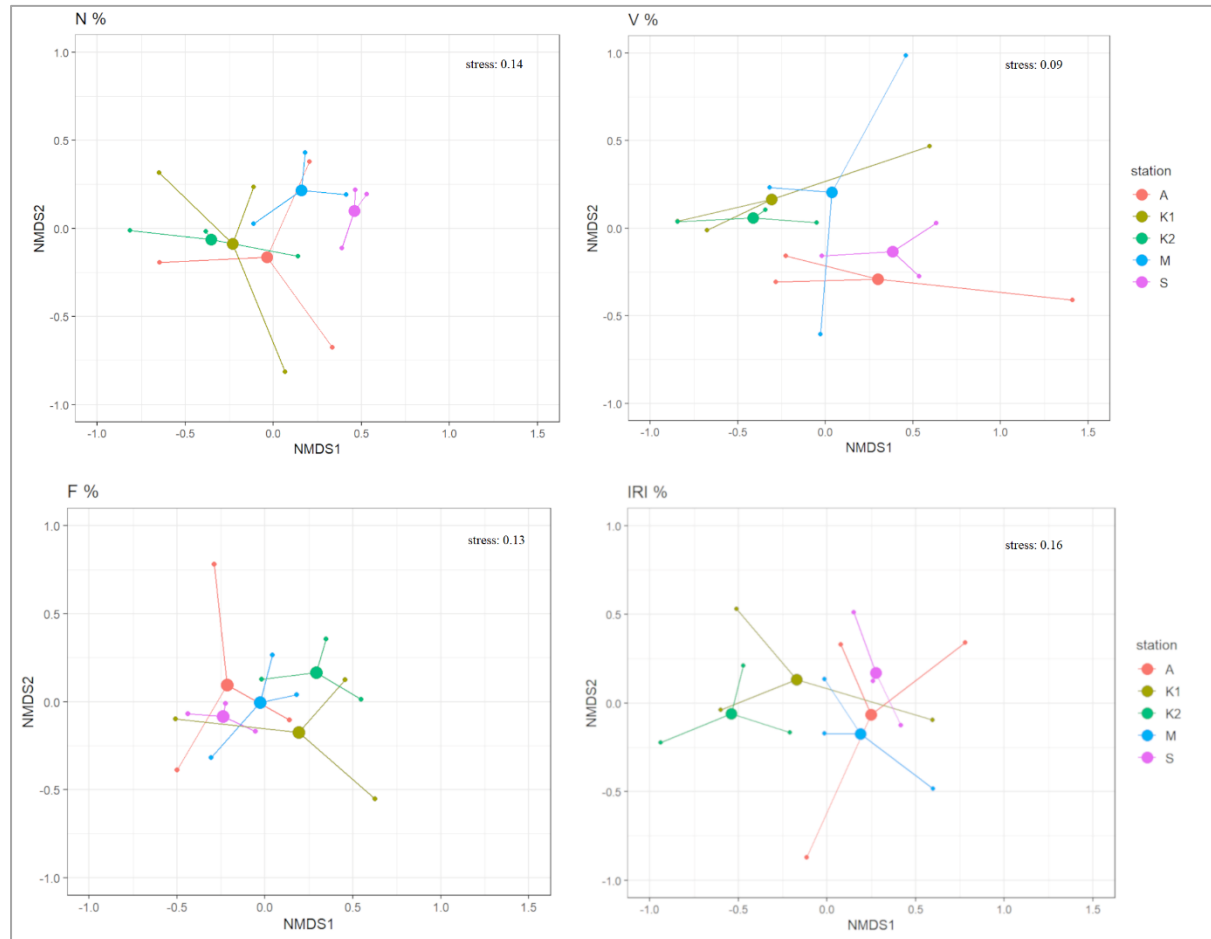


Figure 3. NMDS plot of the N%, V%, F%, and IRI% values in three seasons with by-station centroids.

The food diversity in gut contents of the *S. cii* specimens ranged from 0.10 to 2.21 (Table 3). In the summer, the highest food diversity was detected at the K1 (2.21) station and the lowest at K2 (1.08). In the autumn, the highest food diversity was determined at the K station (1.98) and the lowest at K2 (0.10). In the spring, the highest and lowest food diversity were found at the A (1.95) and K1 stations (0.74), respectively.

In terms of the VI, the feeding intensity was high at all the stations except the A station in the summer and spring (Table 3). In contrast, the feeding intensity was low in the upper section of the reservoirs, at the M and K1 stations in autumn.

In summer, the niche breadth (BA) of the specimens was the highest at the K1 station and the lowest at the S station (0.13) (Table 3). In the autumn, the highest BA value was observed at M (0.52) and the lowest at K2 (0.01). In spring, the highest BA value was determined at KK (0.61) and the lowest at the K1 (0.14) station.

In terms of the trophic level (TL), the highest trophic level was determined at K2 (3.09) and the lowest at the M (2.06) station (Table 3) in summer. In the autumn, the highest TL was determined at K2 (3.48) and the lowest at the S (2.02) station. The analyses of the spring samples produced the highest TL at K1 (3.23) and the lowest at the A (2.01) station.

Table 3. Levins' niche breadth (BA), trophic levels (TL), Vacuity Index (VI), and food diversity (H') along the Karamenderes River

Season	Station	BA	TL	VI	H'
Summer 2012	K2	0.18	3.09	0	1.08
	K1	0.49	2.54	0	2.21
	M	0.29	2.06	0	2.05
	A	0.40	2.93	20	1.81
	S	0.13	2.11	0	1.95
Autumn 2012	K2	0.01	3.48	0	0.10
	K1	0.09	3.38	40	0.50
	M	0.52	2.60	20	1.39
	A	0.04	2.09	0	1.41
	S	0.03	2.02	0	1.51
	K	0.30	2.12	10	1.98
Spring 2013	K2	0.20	2.84	0	1.16
	K1	0.14	3.23	0	0.74
	M	0.16	2.04	0	1.83
	A	0.30	2.71	20	1.75
	S	0.18	2.48	0	1.42
	K	0.41	2.42	0	1.65
	KK	0.61	2.20	0	1.73

## Discussion

In this study, unlike the previous one (Yalçın Özdilek, 2017), multiple habitats were studied and the changes in the gut contents were determined to represent the Karamenderes River in its entirety from the source to the mouth, flowing into the sea. Although prey items identical to those reported in this study were detected in the gut contents of the *S. cii* species in the previous research conducted in the Karamenderes River, fungi were identified in the previous paper (Yalçın Özdilek, 2017), differently from the present one.,

The analyses of the IRI% values showed that the *S. cii* specimens predominantly fed on poor-quality preys in summer but on high-quality and high-energy preys in the spring season. It is known that freshwater fish consume high-quality preys, especially in preparation for the spawning period (Nikolsky, 1963; Gerking, 1994; Wootton, 1990). Considering that the spawning season of *S. cii* begins in spring (Altındağ, 1997; Hellawell, 1971a), the quality of the consumed prey items can be associated with the spawning season.

In the literature, there are several studies on the feeding characteristics and the food consumption of *S. cephalus* (*L. cephalus*) and *S. cii* species in different habitats. They report that *S. cephalus* (*L. cephalus*) feed on similar food items (Table 4). It was discovered in this study that the analysed *S. cii* specimens consumed items that are similar to those consumed by *S. cephalus* (*L. cephalus*) as reported in the literature (Table 4).

Table 4. Prey items of *L. cephalus*, *S. cephalus*, and *S. cii* in previous studies

Species	Study area	Habitat	Prey items	Reference
<i>S. cephalus</i>	Wye River (Lugg River and Afon Llynfi; Wales, UK)	River	Plant materials, Fish, Amphibia, Aquatic & terrestrial Insecta, Mollusca, Crayfish	Hellawell, 1971b
<i>S. cephalus</i>	Stour River (UK)	River	Insecta larvae, Crustacea, Fish, Macrophytes	Mann, 1976
<i>S. cephalus</i>	Akşehir Lake (Turkey)	Lake	Macrophytes, Zooplankton, Ostracoda, Chironomidae, Nematoda, Insecta, Algae, Fish, Detritus	Altındağ, 1997
<i>L. cephalus</i>	Babuna River (Macedonia)	River	Plant material, Plecoptera, Ephemeroptera, Chironomidae, Fish	Nastova-Gjorgjioska et al., 1997
<i>L. cephalus</i>	Međuvršje Reservoir Lake (Serbia)	Lake	Cyanobacteriophyta, Pyrrhophyta, Bacillariophyta, Chlorophyta, Macrophytes, Rotatoria, Nematoda, Mollusca, Oligochaeta, Cladocera, Oligochaeta, Copepoda, Odonata, Heteroptera, Coleoptera, Diptera, Insecta, Fish, Amphibia, Detritus	Markovic et al. 2007a
<i>L. cephalus</i>	Sava River (Croatia)	River	Plant material, Zooplankton, Fish, Benthic organisms, Insecta, Small vertebrates	Piria et al., 2005
<i>L. cephalus</i>	Sinni River Raganello River (Italy)	River	Plant material, Invertebrates, Gastropoda, Insecta, Ephemeroptera, Odonata, Trichoptera, Diptera, Hymenoptera, Arachnida	Balestrieri et al., 2006
<i>L. cephalus</i>	Zapadna Morava River (Serbia)	River	Cyanobacteriophyta, Pyrrhophyta, Bacillariophyta, Chlorophyta, Rotatoria, Nematoda, Mollusca, Oligochaeta, Amphipoda, Ephemeroptera, Odonata, Heteroptera, Coleoptera, Diptera, Trichoptera, Insecta, Bryozoa, Fish, Amphibia, Macrophytes, Detritus	Markovic, 2007b
<i>L. cephalus</i>	Inny River (Ireland)	River	Insecta, Fish, Plant materials, Detritus	Caffrey et al., 2008
<i>S. cephalus</i>	Tödürge Lake (Turkey)	Lake	Phytoplankton, Zooplankton, Nematoda, Insecta, Fish, Macrophytes, Detritus	Ünver & Erk'akan, 2011
<i>S. cii</i>	Karamenderes River (Turkey)	River	Nematoda, Oligochaeta, Amphipoda, Rotifera, Copepoda, Cladocera, Insecta, Fish, Bryozoa, Cyanobacteria, Fungus, Bacillariophyceae, Chlorophyceae, Bryophyta, Zygnemophyceae, Xanthophyceae	Yalçın Özdilek, 2017
<i>S. cii</i>	Karamenderes River (Turkey)	River	Cyanophyceae, Bacillariophyceae, Chlorophyta, Insecta, Fish, Zooplankton, Plant materials	This study

The percentages of the prey items and the results obtained from the NMDS charts support the results of the PERMANOVA analyses. Accordingly, the differences between the stations and the seasons were observed to result from the data obtained at the A station in summer. In river ecosystems with dams on them, floodgates are kept closed in summer to retain the water in the dam, which forms ponds and stagnant flow habitats in the lower part of the dam (Baumgartner, 2007; Qicai, 2011). Stagnant water and pond habitats provide suitable living conditions for macroinvertebrates and are inhabited by a high amount of biomass (Schlosser, 1982; Poff & Ward, 1990). *S. cii*'s abundant consumption of macroinvertebrate prey items at the A station supports this case. In autumn, a serious flow occurs with the opening of floodgates because of rainfalls. The

feeding characteristics of the *S. cii* species were also seen to change at the A station as a result of macroinvertebrate members drifting with the increasing flow.

Although no significant difference was detected in terms of the feeding intensity of the examined specimens, the full guts of the specimens captured in all the three seasons, except at some stations, indicate that the species' feeding intensity was not affected by the seasons. The reason for the low occupancy rate of the gut contents at the K1 station, especially in the autumn, suggests that the specimens at this station were specialist species and thus fed on a more limited diet than the ones in the other seasons and at the other stations. Likewise, it has been mentioned in previous studies that prey sources and food diversity (Nikolsky, 1963; Ünver & Erk'akan, 2011) are less in river habitats in autumn compared to the other seasons. Since lentic systems are more stable than lotic systems, preys are expected to be less varied (Schlosser, 1982; Dodds, 2002; Wang et al., 2019). In this study, it was determined that the prey items in the gut contents of the *S. cii* specimens differed spatially along the river. While carnivorous feeding was observed at the stations close to the source of the Karamenderes River, the stations located in the lower section of the Bayramiç Reservoir was observed to feature omnivorous feeding characteristics. Although the prey items showed no considerable seasonal differences, the differences in the stations could be clearly seen.

The related literature reports habitat-induced differences in food diversity of these two species (*S. cephalus* (*L. cephalus*) and *S. cii*). Accordingly, diversity of foods in river habitats is higher than that in lakes. The fact that river ecosystems are more dynamic and changeable compared to lake ecosystems brings about a more diverse feeding characteristics in fish (Nikolsky, 1963; Dodds, 2002).

Niche breadth is an important drive for the existence and abundance of a species in a region (Collins & Glenn, 1991). It was determined that there was no significant difference in the niche breadth along the Karamenderes River in the three seasons and at the seven stations. Niche breadths were found to be narrower at the stations above the dam (except for autumn) compared to the ones at the stations below the reservoir. The dam barrier caused a shift in the niche breadth, forcing specialist feeding at the stations immediately above and below the dam. On the other hand, it was observed that the specimens had the largest niche breadth in the other seasons, especially in summer and at the A station. The wide breadth of the niche can be accounted for by the abundance of preys in summer compared to that in the other seasons (Dhanasekaran et al., 2017; Vengadesh Perumal et al., 2009) or by the greater variety of food at the station. Another possible reason can be the interspecific competition at this station, which causes it to consume all kinds of nutrients in the habitat (Alanära et al., 2001; Schoener, 1974). In this way, the *S. cii* species can be considered to reduce the possibility of competitive exclusion and improve their survival strategy in this direction (Levins, 1968).

The trophic level varies depending mostly on food quality (Power, 1992). Each living organism prefers to generate the highest level of energy and avail of the more easily accessible food in its food web (Power, 1992). Therefore, the trophic levels were found to be proportionally high at the stations where the *S. cii* specimens fed on macroinvertebrates. In the literature, the trophic levels of *S. cii* have been calculated to be 2.33-3.59 (Yalçın Özdilek & Jones, 2014). In this study, it was determined that the values ranged between 2.01 and 3.48 at different station and in different seasons.

The features of the streams in the Mediterranean are generally unstable due to variable temperatures and flooding (Oliva-Paterna et al., 2003). The dams built on such unstable rivers cause an additional change in the flow regimes by reshaping habitats (Alexandre et al., 2013; Sánchez-Pérez et al., 2021). This also alters fish populations (Baumgartner, 2007; Branco et al., 2017; Sánchez-Pérez et al., 2021) and their natural feeding habits (Magoulick & Kobza, 2003). The results of the present study support these propositions by revealing that there was a variation in the feeding strategy of *S. cii* at the stations located in the upper and the lower sections of the dam on the Karamenderes River. A more carnivorous feeding was observed in the upper stations of the dam, while a more herbivorous and omnivorous diet in the lower parts. *S. cii* is an omnivore and feed on a high range of preys from algae to fish (Yalçın Özdilek, 2017).

In conclusion, over the years, many species' names have been changed, and they have been reclassified as new species. One of the aims of this study is to minimize the loss of biological data in a species whose biological name has been changed. In this study, the feeding characteristics of the *S. cii* taxon were compared with those of the *S. cephalus* and *L. cephalus* taxa, which are synonymized with each other and have a different and wider distribution area. It is crucial to consider the synonyms of the species in future studies while investigating their biological characteristics to prevent the time-dependent loss of data pertaining to the biological characteristics of the species. Besides this study discussed the effects of the dam on the Karamenderes River on the feeding habits of the *S. cii* taxon along the river. It is suggested that dams on a stream should be considered while studying the biology of fish

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### **Author Contributions**

N.P.: performed the field work and analysed the data. Both authors wrote the paper. Both authors read and approved the final manuscript.

### **Conflict of Interest**

The authors declare that they have no competing interests.

### **Compliance with Ethical Standards**

The animal study was reviewed and approved by the Institutional Review Board at Çanakkale Onsekiz Mart University (B.12.0BSÜ.0.01.00.00/140.03.03-460) and the Ministry of Food, Agriculture, and Livestock (65465693-605/20.08.2014).

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