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RESEARCH ARTICLE/ARAŞTIRMA MAKALESİ

Food overlap between *Vimba vimba* (L., 1758) and *Scardinius erythrophthalmus* (L., 1758) in Büyükçekmece Reservoir (Turkey)

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Abstract
The feeding habits of two omnivorous fish species, *Vimba vimba* (L., 1758) and *Scardinius erythrophthalmus* (L., 1758) from the Büyükçekmece Reservoir (Turkey) were investigated through stomach content analyses. Samplings were carried out monthly to describe the dietary composition of two species and to assess whether it overlapped. The diet spectrum of *V. vimba* consisted of eight prey categories: Diptera, Insecta extremities, plants, Cladocera, Bivalvia, Ostracoda, Pisces and detritus. Detritus has the highest value in terms of modified index of relative importance and it was followed by Insecta. The diet composition of *S. erythrophthalmus* consisted of four prey categories: Insecta extremities, plants, Bivalvia and detritus. Plant has the highest value in terms of modified index of relative importance and it was followed by detritus. No dietary overlap was detected, except for the fish collected in spring. Fractional trophic level (TROPH) and its standard error (SE) were estimated as 2.62±0.25 for *V. vimba* and 2.45±0.19 for *S. erythrophthalmus*.
Keywords: Diet, freshwater fish, omnivorous, feeding, lake

Introduction

Studying trophic relationships among fishes is important for better understanding the role of fish in the food network, prey-predatory interactions, fish farming and biomanipulation processes. Additionally, investigations of diet in fish assemblages in a particular area allow understanding the ecological mechanisms by which a several number of species are able to coexist in the same community and the manner in which food is shared (Novakowski et al., 2008).

Shallow lakes with a high surface area relative to their volume tend to be productive because frequently mixing of external and internal nutrients from top to bottom enriches its productivity (Drake et al., 2011; Peel et al., 2019). Within this context, they constitute important habitats for fish assemblages with complex trophic interactions. Especially omnivorous fishes living in the shallow and productive lakes are able to consume alternative food sources and may show large diet modification (Blanco et al., 2003).

Büyükçekmece Reservoir is located in the northwest of Turkey, and is one of the special shallow lake ecosystems with its drastic change from past to present; while it was a lagoon connected with the Sea of Marmara in the past, its sea connection was blocked by a dam construction in 1985, and this lagoon became a freshwater lake over time (Özuluğ, 1999). The main freshwater inlet is the Stream Karasu; other sources are some small-scale streams and surface waters. In this

reservoir, the species composition has also shown a rapid alteration in parallel with the drastic change of the environmental conditions. Freshwater fish species living in the tributaries of the reservoir has become dominant in the lake over time. However, marine species such as *Pomatomus saltatrix* (L., 1766) and *Engraulis encrasicolus* (L., 1758) has eliminated from the lake. Recently, the invasive gibel carp, *Carassius gibelio* (Bloch, 1782) has been introduced into the lake in the early 1990s (Özuluğ, 1999) and has increased its population in time (Saç & Okgerman, 2015).

One paper investigated the diet of zooplanktivorous *Clupeonella cultriventris* (Nordmann, 1840) in the Büyükçekmece Reservoir (Saç, 2012). To the best of author's knowledge, there have been no other studies in the lake, which demonstrate and/or compare the feeding of native fish. This paper, therefore, attempts to evaluate, for the first time, the ontogenetic and seasonal dietary patterns of native *Vimba vimba* (L., 1758) and *Scardinius erythrophthalmus* (L., 1758) and to investigate whether there is a significant overlap between their diet composition in the Büyükçekmece Reservoir, where the environmental conditions and the fish fauna have dramatically changed over time.

Material and Methods

Fishes were collected monthly from March 2009 to February 2010 from the Büyükçekmece Reservoir using gillnets with different mesh sizes (10×10 mm, 20×20 mm, 30×30 mm, 40×40 mm and 50×50 mm). Gillnets were hauled parallel to shore and the sampling was conducted in darkness approximately on a 10-12 h timescale. Immediately after capture, alive fish specimens were killed with an overdose of clove oil and then transferred to the laboratory in cold conditions (portable freezer, -18°C) for further examinations. Fish samples were measured to the nearest 0.1 cm for fork length (FL) and total body weight (W) was weighed on a digital balance with a 0.01 g accuracy.

To determine the diet composition, fish were dissected and the digestive tracts were removed and fixed in a 4% formaldehyde solution before examinations. The prey items were identified to the lowest possible taxonomic level under a binocular microscope, thereafter dried at 80˚C (2–4 h) and weighted to the nearest 0.0001 g. The modified index of relative importance (MI%) of each food items were calculated according to Castriota et al. (2005) as follows:

$MI\% = [(F\% \times W\%)/\Sigma(F\% \times W\%)] \times 100$, where F% is the percentage of frequency of occurrence [(number of digestive tracks containing a food item/total number of digestive tracks with food)×100], and W% is the percentage gravimetric composition. The index was estimated for both length classes (6.0–8.9, 12.0–14.9, 15.0–17.9, 18.0–20.9, 21.0–23.9) and seasons in two fish species. According to the literature, an average interval of 3 cm can represent age classes for both species (Czerniejewski et al., 2011; Gürsoy Gaygusuz, 2018). Fractional trophic level (TROPH) and its standard error (SE) were estimated for each of the seasons and length classes, using the ACCESS stand-alone application TROPHLAB (Pauly et al., 2000).

Schoener' Index (a) was used to assess dietary overlap among length classes and seasons (Schoener, 1970) as follows; $a=1-0.5(\sum(P_{xi}-P_{yi}))$, where P_{xi} and P_{yi} are the points proportions of food category *i*, in the diets group *x* and group *y*. The index ranges from 0 (no overlap) to 1 (total overlap); the overlap value of $a \geq 0.6$ is considered to be biologically significant in terms of prey items consumed by groups *x* and *y* (Macpherson et al., 2010). Considering the low individual numbers corresponding to each length classes, the samples were gathered into three length classes (15.0–17.9, 18.0–20.9, 21.0–23.9 cm) for food overlap analysis. Where appropriate, data are presented as the mean ± SD (standard deviation).

Results

Diet of *V. vimba*

During the sampling period, a total of 258 *V. vimba* specimens were captured from the reservoir. The fork length of the specimens ranged from 6.4 to 24.4 cm (mean 16.5 ± 3.9 cm) and the body weight from 3.66 to 269.4 g (mean 76.0 ± 53.6 cm).

Of the total stomachs, 163 (63.2%) were empty. The diet spectrum of *V. vimba* consisted of eight prey categories: Diptera, Insecta extremities (unidentified), plants (terrestrial plant and algae), Cladocera, Bivalvia, Ostracoda, Pisces (eggs and larvae) and detritus. Detritus has the highest value in terms of modified index of relative importance (69.02%), the percentage gravimetric composition (56.0%) and the percentage of frequency of occurrence (64.06%), and it was followed by Insecta with the values of 24.96% (MI%), 25.95% (W%) and 50.0% (F%) (Table 1). The values of the index of relative importance (MI%) among length classes and seasons

were given in Table 2 and Table 3. In all seasons and length classes, the major foods of *V. vimba* were detritus. The diversity of food items in the diet of fish has increased with an increase in fish length. Fractional trophic level (TROPH) and its standard error (SE) were estimated as 2.62±0.25 and the values for each of the seasons and length classes were given in Table 2 and Table 3.

Diet of *S. erythrophthalmus*

A total of 305 *S. erythrophthalmus* specimens were collected from the reservoir. The FL of the specimens ranged from 6.2 to 24.8 cm (mean 16.5 ± 3.4 cm) and the W ranged from 4.04 to 344.0 g (mean 95.3 ± 58.6 cm).

Of the total stomachs, 244 (80.0%) were empty. The diet spectrum of the species consisted of four prey

Table 1. The values of the modified index of relative importance (MI%), the percentage gravimetric composition (W%), the percentage of frequency of occurrence (F%) and the trophic index for *V. vimba* and *S. erythrophthalmus* in the Büyükçekmece Reservoir.

***V. vimba* (n=65)**				***S. erythrophthalmus* (n=61)**			
Prey items	**MI (%)**	**W (%)**	**F (%)**	***Prey items***	**MI (%)**	**W (%)**	**F (%)**
Diptera	**0.50**	3.30	7.81	Insecta extremities	**1.75**	4.66	15.22
Insecta extremities	**24.96**	25.95	50.0	Plants	**61.70**	53.58	46.74
Plants	**1.45**	6.03	12.5	Bivalvia	**0.02**	0.42	2.17
Cladocera	**<0.01**	0.07	1.56	Detritus	**36.53**	41.34	35.87
Bivalvia	**4.07**	8.45	25.0				
Ostracoda	**<0.01**	0.03	4.69				
Pisces	**0.01**	0.17	1.56				
Detritus	**69.02**	56.0	64.06				
TROPH ± SE	**2.62±0.25**			**TROPH ± SE**	**2.45±0.19**		

Table 2. The values of the modified index of relative importance (MI%), the percentage gravimetric composition (W%), the percentage of frequency of occurrence (F%) and the trophic index among seasons for *V. vimba* in the Büyükçekmece Reservoir.

Prey items	**Spring (n=34)**			**Summer (n=5)**			**Autumn (n=18)**			**Winter (n=8)**		
	MI (%)	**W (%)**	**F (%)**	**MI (%)**	**W (%)**	**F (%)**	**MI (%)**	**W (%)**	**F (%)**	**MI (%)**	**W (%)**	**F (%)**
Diptera	**0.88**	3.97	11.76	**-**	-	-	**-**	-	-	**0.88**	6.36	12.5
Insecta extremities	**45.09**	32.44	73.53	**10.72**	13.61	40.0	**6.93**	16.57	22.22	**0.40**	2.91	12.5
Plants	**2.64**	7.92	17.65	**-**	-	-	**0.32**	3.05	5.56	**0.12**	0.86	12.5
Cladocera	**0.01**	0.11	2.94	**-**	-	-	**-**	-	-	**-**	-	-
Bivalvia	**1.61**	5.79	14.71	**25.65**	32.56	40.0	**14.12**	16.88	44.44	**0.05**	0.39	12.5
Ostracoda	**0.01**	0.04	0.36	**-**	-	-	**-**	-	-	**-**	-	-
Pisces	**-**	-	-	**-**	-	-	**0.09**	0.89	4.96	**-**	-	-
Detritus	**49.77**	49.73	52.94	**63.63**	53.84	60.0	**78.54**	62.60	66.67	**98.55**	89.48	100.0
Food category numbers	**7**			**3**			**5**			**5**		
TROPH ± SE	**2.50±0.25**			**2.52±0.23**			**2.41±0.22**			**2.12±0.12**		

Table 3. The values of the modified index of relative importance (MI%), the percentage gravimetric composition (W%), the percentage of frequency of occurrence (F%) and the trophic index among size groups for *V. vimba* in the Büyükçekmece Reservoir.

Prey items	**6.0–8.9 cm (n=4)**			**12.0–14.9 cm (n=16)**			**15.0–17.9 cm (n=16)**			**18.0–20.9 (n=13)**			**21.0–23.9 (n=16)**		
	MI (%)	**W (%)**	**F (%)**	**MI (%)**	**W (%)**	**F (%)**	**MI (%)**	**W (%)**	**F (%)**	**MI (%)**	**W (%)**	**F (%)**	**MI (%)**	**W (%)**	**F (%)**
Diptera	**-**	-	-	**-**	-	-	**-**	-	-	**0.19**	0.67	15.38	**2.63**	7.67	18.75
Insecta extremities	**-**	-	-	**28.77**	38.81	43.75	**9.59**	15.21	37.5	**73.85**	46.76	84.62	**13.19**	14.45	50.0
Plants	**-**	-	-	**1.75**	5.51	18.75	**0.01**	0.09	6.25	**-**	-	-	**5.95**	13.03	25.0
Cladocera	**-**	-	-	**0.06**	0.58	6.25	**-**	-	-	**-**	-	-	**-**	-	-
Bivalvia	**91.43**	21.95	25.0	**0.08**	0.37	12.5	**9.02**	14.30	37.5	**4.23**	14.72	15.38	**2.26**	3.97	31.25
Ostracoda	**-**	-	-	**0.07**	0.22	18.75	**-**	-	-	**-**	-	-	**-**	-	-
Pisces	**-**	-	-	**-**	-	-	**-**	-	-	**-**	-	-	**0.05**	0.41	6.25
Detritus	**8.57**	78.05	75.0	**69.27**	54.52	75.0	**81.38**	70.40	68.75	**21.73**	37.85	30.77	**75.92**	60.48	68.75
Food category numbers	**2**			**6**			**4**			**4**			**6**		
TROPH ± SE	**2.86±0.26**			**2.48±0.25**			**2.34±0.19**			**2.73±0.30**			**2.32±0.20**		

categories: Insecta extremities (unidentified), plants (terrestrial plant and algae), Bivalvia and detritus. Plant has the highest value in terms of modified index of relative importance (61.70%), the percentage gravimetric composition (53.58%) and the percentage of frequency of occurrence (46.74%), and it was followed by detritus with the values of 36.53% (MI%), 41.34% (W%) and 35.87% (F%) (Table 1). Table 4 and Table 5 show the values of the index of relative importance (MI%) for length classes and seasons. While detritus is the main food consumed by fish in the spring, the plant has become a primary food in all other seasons. The importance of plants in the diet of fish has increased with an increase in fish length. TROPH ± SE was estimated as 2.45±0.19 and the values for each of the seasons and length classes were given in Table 4 and Table 5. No significant overlap in food composition was observed except for the spring sample (Table 6).

Discussion

The results presented in this study are in agree with the previous studies which reported that the feeding of both of the species can be characterized as omnivorous (Ravera & Jamet, 1991; García-Berthou & Moreno-Amich, 2000; Okgerman et al., 2013). The high proportions of the empty stomachs for both species can be explained by the fact that the fish specimens remain alive for a while after being caught in gillnets and, the loss of dietary information due to post-capture digestion (Hammerschlag et al., 2010). Additionally, it may also be related to some factors such as the ability to obtain food from the environment, prey availability, nocturnal sampling, spatial or temporal behavior of fish and digestion rate (Labropoulou et al., 1998; Hammerschlag et al., 2010; Morote et al., 2010; El Qendouci et al., 2018).

Table 4. The values of the modified index of relative importance (MI%), the percentage gravimetric composition (W%), the percentage of frequency of occurrence (F%) and the trophic index among seasons for *S. erythrophthalmus* in the Büyükçekmece Reservoir.

Prey items	Spring (n=34)			Summer (n=5)			Autumn (n=18)			Winter (n=8)		
	MI (%)	W (%)	F (%)	MI (%)	W (%)	F (%)	MI (%)	W (%)	F (%)	MI (%)	W (%)	F (%)
Insecta extremities	**23.21**	29.74	41.38	**<0.01**	0.06	6.67	**-**	-	-	**<0.01**	<0.01	6.25
Plants	**2.47**	4.22	31.03	**94.88**	83.14	100.0	**95.84**	85.20	100.0	**59.69**	49.68	93.75
Bivalvia	**0.18**	2.70	3.45	**-**	-	-	**-**	-	-	**<0.01**	<0.01	6.25
Detritus	**74.14**	63.33	62.07	**5.11**	16.80	26.67	**4.16**	14.80	25.0	**40.31**	50.32	6.25
Food category numbers	**4**			**3**			**2**			**4**		
TROPH ± SE	**2.39±0.23**			**2.00±0.00**			**2.00±0.00**			**2.00±0.00**		

Table 5. The values of the modified index of relative importance (MI%), the percentage gravimetric composition (W%), the percentage of frequency of occurrence (F%) and the trophic index among size groups for *S. erythrophthalmus* in the Büyükçekmece Reservoir.

Prey items	6.0–8.9 cm (n=4)			12.0–14.9 cm (n=16)			15.0–17.9 cm (n=16)			18.0–20.9 (n=13)			21.0–23.9 (n=16)		
	MI (%)	W (%)	F (%)	MI (%)	W (%)	F (%)	MI (%)	W (%)	F (%)	MI (%)	W (%)	F (%)	MI (%)	W (%)	F (%)
Insecta extremities	**-**	-	-	**-**	-	-	**14.82**	21.06	33.33	**3.34**	7.06	30.77	**-**	-	-
Plants	**-**	-	-	**10.19**	18.49	50.0	**29.48**	26.18	53.33	**87.87**	74.35	76.92	**60.98**	55.12	93.33
Bivalvia	**100.0**	100.0	100.0	**-**	-	-	**-**	-	-	**<0.01**	0.01	7.69	**-**	-	-
Detritus	**-**	-	-	**89.81**	81.51	100.0	**55.70**	52.76	50.0	**8.79**	18.59	30.77	**39.02**	44.88	73.33
Food category numbers	**1**			**2**			**3**			**4**			**2**		
TROPH ± SE	**3.10±0.30**			**2.00±0.00**			**2.25±0.18**			**2.09±0.11**			**2.00±0.00**		

Table 6. The values of food overlap in different length classes and seasons between *V. vimba* and *S. erythrophthalmus* in the Büyükçekmece Reservoir.

Seasons	*Schoener' Index value (a)*	*Length classes (cm)*	*Schoener' Index value(a)*
Spring	0.76*	15.0–17.9	0.50
Summer	0.31	18.0–20.9	0.50
Autumn	0.04	21.0–23.9	0.50
Winter	0.40		

*: Significant; a>0.6

Although *V. vimba* migrates from the lake to the tributaries for spawning in spring (Hänfling et al., 2009), both the number of individuals caught and the variety of food were the highest in this season. Similar results were also found in the spring feeding of *S. erythrophthalmus*, which shows a relatively narrower food spectrum. However, a seasonal change in the food preference was observed for both species; *V. vimba* fed mainly detritus in other seasons, while *S. erythrophthalmus* preferred the plant as the main food type. The relatively high food variety in the diet of a fish during the spring months might be attributed to the requirement of reserves prior to spawning (both rapid replacement of body mass following winter and for high energy demand) and to the increase of prey availability in their environment (Všetičková et al., 2014). The food overlap is mainly related to the fact that both fish changed their food preferences in spring and consumed the same food categories substantially.

Okgerman et al. (2013) reported an ontogenetic shift in the feeding of *V. vimba* in the Sapanca Lake in which the ostracods were consumed by only juveniles whereas Bivalvia was mostly eaten by the adults. Similar results are obtained in the present study as ostracods were consumed by only 12.0-14.9 cm size group. Although food preferences in most length classes of *V. vimba* mainly on detritus, the occurrence of relatively larger-sized preys such as fish in the stomach of adult fish is related to the fact that fish typically consume larger food items as the mouth gape increases. The ontogenetic difference in diet can be attributed to the mouth gape limitation of young or adult individuals' prey type (Probst & Eckmann, 2009; Klein et al., 2016). According to Ravera & Jamet (1991), *S. erythrophthalmus* was considered omnivorous fish with an evident preference on the plant as food and this preference has increased with the age. A similar ontogenetic difference in food preference was also observed in the diet of *S. erythrophthalmus*; while the plant is the main food item for the adult fish, fish smaller than 18.0 cm mostly preferred the detritus as food. Ontogenetic shifts in the diets may also be related to changes in microhabitat use (Alcaraz & García-Berthou, 2007; Nunn et al., 2012). The different food preferences in the different length classes of these two fish resulted in no significant food overlap values ($a<0.6$).

In conclusion, the findings with the present study have documented for the first time a detailed dietary study on two native fish from a shallow reservoir area. The results showed that the seasonal change in the food preferences of *V. vimba* and *S. erythrophthalmus* were affected by seasonal variations in the food supply. However, the ontogenetic difference in feeding seems to have resulted in the dietary segregation of length classes in both of the species. More detailed studies on the trophic interactions in Büyükçekmece Reservoir will be critical in the potential future management options.

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