LIMNOFISH-Journal of Limnology and Freshwater Fisheries Research 5(1): 6-16 (2019)

Journal of Limnology and Freshwater Fisheries Research

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http://www.limnofish.org

Ontogenetic Diet Shift of Invasive Gibel Carp (*Carassius gibelio*, Bloch 1782) in Karamenderes River (Turkey)

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ABSTRACT

The ontogenetic diet shift of invasive *Carassius gibelio* (Bloch, 1782) was investigated in Karamenderes River, Turkey. The fieldwork was performed during summer 2012, autumn 2012 and spring 2013. The fishes were caught by electrofishing and using gill nets. Nine fork length groups were used in order to assess the ontogenetic diet shift. The gut contents were assessed by the index of relative importance that was calculated from the frequency of occurrence, numerical abundance, and volumetric analyses. The most abundant length groups of *C. gibelio* were 18-20 cm, 6-8 cm, and 27-29 cm length groups during summer 2012, autumn 2012 and spring 2013, respectively. The feeding intensity was the lowest in the length groups of 15-17 cm during summer 2012, in 3-5 cm length group in autumn 2012 and in 24-26 cm length group in spring. Seasonal variations were observed in the ontogenetic diet shift of *C. gibelio*. Large specimens consumed more animal materials during summer and more algae in autumn. There was not any significant niche overlap recorded between small and large specimens except summer. Any niche overlap between small and large specimens might be advantageous for the establishment success of invasive Gibel carp in Karamenderes River.

Keywords: Gut contents, feeding intensity, diet overlap, IRI

ARTICLE INFO

RESEARCH ARTICLE

Received : 20.09.2018
Revised : 10.12.2018
Accepted : 12.12.2018
Published : 25.04.2019

DOI:10.17216/LimnoFish.461758

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Karamenderes Çayı'nda (Türkiye) İstilacı Gümüşi Havuz Balığının (*Carassius gibelio*, Bloch 1782) Beslenmesindeki Ontogenetik Değişim

Öz: Bu çalışmada Karamenderes Çayı'nda bulunan istilacı *Carassius gibelio* (Bloch, 1782) türünün beslenmesindeki ontogenetik değişimin belirlenmesi amaçlanmıştır. Arazi çalışmaları Yaz 2012, Sonbahar 2012 ve İlkbahar 2013 mevsimlerinde gerçekleştirilmiştir. Balıkların yakalanmasında elektroşoker ile çeşitli ağlar kullanılmıştır. Beslenmedeki ontogenetik değişimi belirlemek için, balıklar çatal boylarına göre dokuz gruba ayrılmıştır. Balıkların sindirim kanalı içerikleri besin bulunma sıklığı, sayısal bolluk ve hacimsel oran kullanılarak nisbi önem indeksi ile hesaplanmıştır. *C. gibelio* bireylerinin mevsimlere göre bol olan boy grupları sırasıyla Yaz 2012 (18-20 cm), Sonbahar 2012 (6-8 cm) ve İlkbahar 2013 (27-29 cm) şeklindedir. Beslenme şiddeti Yaz 2012'de 15-17 cm, Sonbahar 2012'de 3-5 cm ve İlkbahar 2013'de 24-26 cm boy gruplarında en az olduğu belirlenmiştir. *C. gibelio* bireylerinin ontogenetik beslenme alışkanlığında zamansal ve mekânsal olarak farklılıklar gözlenmiştir. Büyük bireyler yaz mevsiminde daha çok hayvansal besin ve sonbahar mevsiminde alglerle beslendiği ve küçük bireylerle büyük bireylerin besinleri arasında yaz mevsimi haricinde önemli bir çakışma olmadığı belirlendi. Küçük ve büyük bireylerin besinleri arasında herhangi bir çakışmanın olmaması, gümüşi havuz balığının Karamenderes'de yerleşme başarısı için bir avantajı olabilir.

Anahtar kelimeler: Sindirim kanalı içeriği, beslenme şiddeti, diyet çakışması, IRI

How to Cite
Partal N, Yalçın Özdilek Ş, 2019. Ontogenetic Diet Shift of Invasive Gibel Carp (*Carassius gibelio*, Bloch 1782) in Karamenderes River (Turkey). LimnoFish. 5(1): 6-16. doi: 10.17216/LimnoFish.461758

Introduction

Carassius gibelio (Bloch, 1782) is one of the major invasive species which was introduced to Trace region first in the 1980s (Özuluğ et al. 2004; Ilhan et al. 2005) and spreaded over many freshwater systems rapidly throughout Turkey (Aydın et al. 2011; Ekmekçi et al. 2013). In general, this species is known as a generalist, it has opportunistic omnivorous feeding strategy and feeds on different foods in different environments (Sakai et al. 2001; Gaygusuz et al. 2006; Ekmekçi et al. 2013). It is obvious that high variety in food resources of this invasive species will affect many other indigenous species living in the same habitat (Goodell et al. 2000) and make it more advantageous among competitors. In addition to having advantages of this species in the interspecific relationship, the high variety of food resources may change during ontogeny and the intraspecific resource partitioning may another advantage of this species in the introduced ecosystems. There are many studies about ecological traits (Lockwood et al. 2013; Ekmekçi et al. 2013; Tarkan 2013), gut contents (Specziár et al. 1997; Rybczyk 2006; Yılmaz et al. 2008; Rogozin et al. 2011; Partal 2014; Partal and Yalçın Özdilek 2017) and feeding characteristics (Specziár et al. 1997; Rybczyk 2006; Yılmaz et al. 2008; Rogozin et al. 2011; Partal 2014; Yalçın Özdilek and Jones 2014; Partal and Yalçın Özdilek 2017) of this species. *C. gibelio* has been first recorded in Karamenderes river which is on the Northwestern part of Turkey in 2007 (Yalçın Özdilek 2008). There are some records on the feeding habits of *C. gibelio* from Karamenderes river (Yalçın Özdilek and Jones 2014; Partal and Yalçın Özdilek 2017), however, there is a gap in the knowledge about ontogenetic diet shift of this species. There is a limited study on the ontogenetic diet shift of *C. gibelio* and the data on this subject with the ontogenetic niche overlap and trophic position will serve to understand the establishment success of this species.

The morphological, physiological and behavioral changes during the developmental stage may result in ontogenetic diet shift (Wilbur 1980; Miller and Rudolf 2011; De Roos and Persson 2013; Nakazawa 2015). In addition, changes in foraging ability depending on the growth may cause the ontogenetic diet shift in fish (Bergman and Greenberg 1994; Jeppesen et al. 2003; Alcaraz and García-Berthou 2007; Nakazawa 2015). Shifting in feeding pattern is common with a function of age and length in many animal species (Wilbur 1980; Miller and Rudolf 2011; De Roos and Persson 2013; Nakazawa 2015). Data on the ontogenetic diet shift is very important for evaluating the ecological role of a species (Werner and Gilliam 1984; Post 2003). Intraspecific competition reduces the population growth particularly in the limited resource condition (Bolnick et al. 2011). The data on the ontogenetic diet shift of invasive *C. gibelio* may serve to take some measures related to mitigating the adverse effects of this invasive species. We aimed to reveal the food diversity in different length groups and the ontogenetic diet shift of *C. gibelio* quantitatively in this study. This study will serve to understand if this species has such advantage make it successive in establish and spread.

Materials and Methods

Study area and sampling

Karamenderes River, about 109 km in length, originates from the Kaz and Ağı Mountains and directs to West and North and flows into Çanakkale strait after watering Kumkale plate in Biga Peninsula, Çanakkale. There are two reservoirs along the river. One is in the Bayramiç province, which is about 86.5 cubic hectometer water capacity, and the other is in Pınarbaşı village, which is smaller than the other. These reservoirs are used for irrigation purposes (Figure 1).

C. gibelio is first recorded in Karamenderes at the lower part of the Pınarbaşı village after fish stocking studies on Bayramiç Dams by the activities of Directorate of National Water Affairs (Yalçın Özdilek 2008). The samplings were conducted in three seasons, during summer 2012 (July-August 2012), autumn 2012 (October-November 2012), and spring 2013 (May 2013). Sampling could not be performed in winter because of inconvenient weather conditions for sampling. The fish sampling has performed at 14 stations along the Karamenderes River from the upper parts of the dams to the river mouth. The names of the stations from up to down are Karaköy 1, Karaköy 2, Evciler, Evciler trout farm, Çırpılar, Mollahasanlar, Bayramiç-Çan road, Ahmetçeli, Sarmısaklı, Pınarbaşı, Kalafat, Kumkale bridge (3), Kumkale closed end (2), Kumkale open end (1) (Figure 1).

Different sampling device was used for fishing according to habitat characteristics. Fish were collected by scanning about 20 m lengths of the river during 20 minutes in every station by electrofishing (SAMUS) on the upper sites of Karamenderes. Gill nets in different mesh size (18 mm, 22 mm, 25 mm, and 32 mm knot to knot) and different lengths (160 m-2.5 m, 100 m-2 m, 15 m-2 m, and 30 m-1 m) were used for fishing (average of 24 hours) in the river mouth stations. In addition, fyke net composed of 8-37 sets each has 12 m long and a cast net, which has 10 mm mesh size and its radius 140cm were used for fishing in some stations. All the fish samples were transferred to the laboratory in an icebox and after identification, they preserved in a deep freeze with labeled.

Laboratory procedures

The gut contents of 215 specimens of totally 251 specimens could be examined. Before dissection, the fork length and weight were measured by the standard ruler (± 0.01 mm) and a balance (± 0.1g). After dissection, the total gut length from the esophagus to the anus was measured using the same ruler. The sex of the specimens was determined under a stereomicroscope. The gut contents were evacuated in a graduated cylinder, which contains 70 % ethanol. The total gut volumes were measured by the replacement of ethanol level.

Diluted gut contents in a Sedgewick- Rafter lam were examined under a stereomicroscope x10 magnitude. The number and sizes (Sun and Liu 2003) of each food category were recorded after the description of the taxon at the possible level.

The percentage of empty guts, vacuity index (*VI* %), were used to assess the feeding intensity (Hureau 1966). The feeding intensity was assessed taking into consideration the length groups, sex, season and stations. Vacuity Index (*VI*) was used for calculating the feeding intensity by using

VI = empty gut number x 100 / total gut number equation (Hureau 1966; Costa and Cabral 1999).

The percentage of the relative index (*IRI* %) was evaluated to assess gut contents data using the frequency of occurrence (*F* %), numerical (*N* %) and volumetric (*V* %) methods (Pinkas et al. 1971; Prince 1975; Hyslop 1980).

IRI = (*N* %+*V* %) x *F* %

F_i %= i prey items frequency of occurrence in the gut x 100 / total number of full guts

N_i %= i prey items total number x 100 / prey items total number

V_i %= i prey items total volume x 100 / prey items total volume

$$H = -\sum p_i ln p_i$$

$$p_i = N_i/N$$

equation. The trophic level was calculated as

$$TL_k = 1 + \left(\sum_{j=1}^{11} P_j \times TL_j \right)$$

in the equation (Cortés 1999). The *IRI* % values of each food category were used to calculate the diversity and trophic position.

Fish were grouped into nine-length class categories and the differences in *IRI* % value of each food category in each length group were tested by nonparametric Kruskal Wallis test.

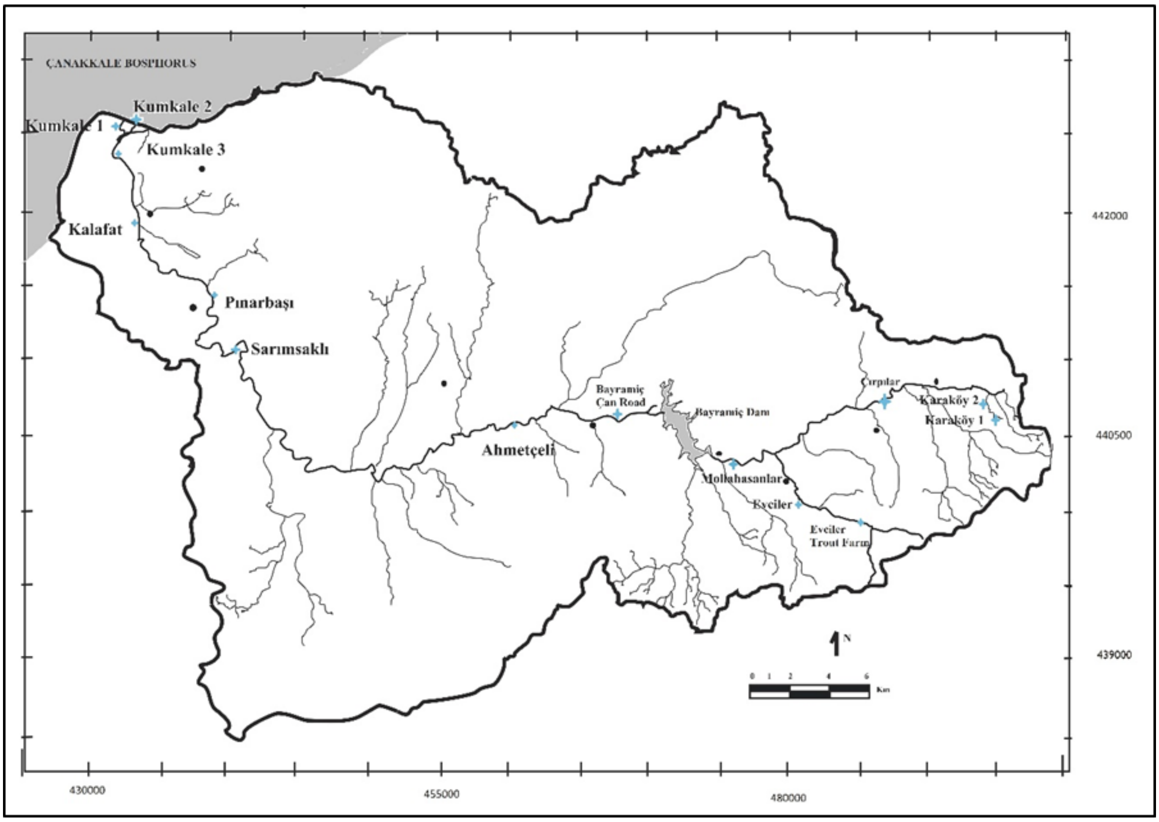


Figure 1. Sampling area (Partal and Yalçın Özdilek 2017 (adapted)).

Results

A total of 215 specimens were all caught at the lower stations of Bayramiç Reservoir. There were no specimens encountered at the upper stations of this dam. 62 %, 27 % and 12 % of the specimens were collected during summer 2012, autumn 2012 and spring 2013, respectively. The spatial and seasonal relative abundance of specimens indicates that the most abundant specimens were recorded at the Kumkale River mouth station in summer, Ahmetçeli station in autumn and Kumkale bridge (3) station in Spring with the percentages of 60.9, 14.9 and 16.1, respectively (Figure 2). The most abundant length group was 6-8 cm *FL* with the percentage of 16.7 in total. The 18-20 cm, 6-8 cm, and 27-29 cm *FL* groups were the most abundant length groups in summer, autumn and spring seasons, respectively (Figure 3).

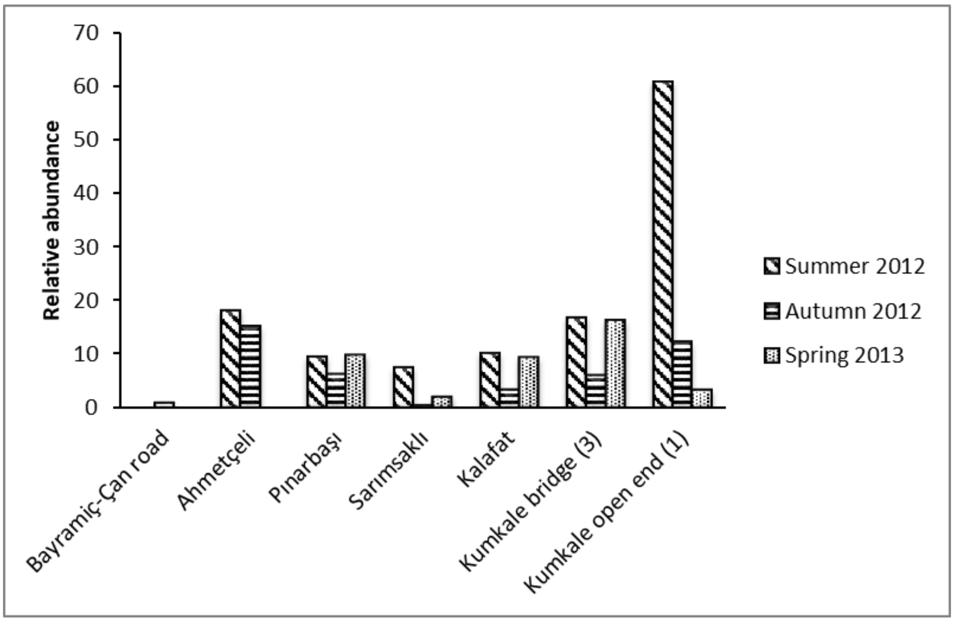


Figure 2. The distribution and relative abundance of C. gibelio specimens according to seasons and the station.

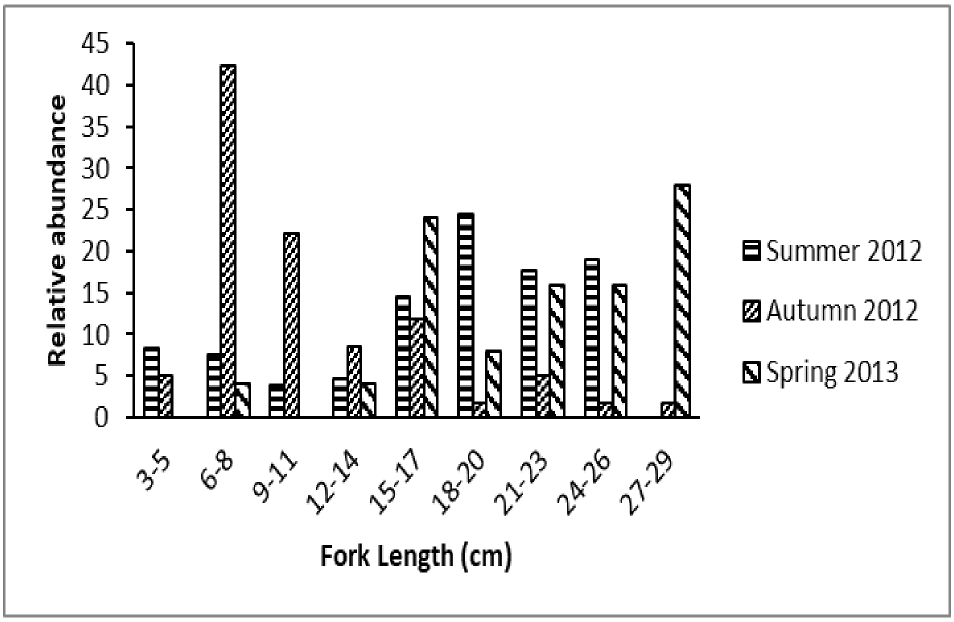


Figure 3. The distribution and relative abundance of the length groups according to the seasons.

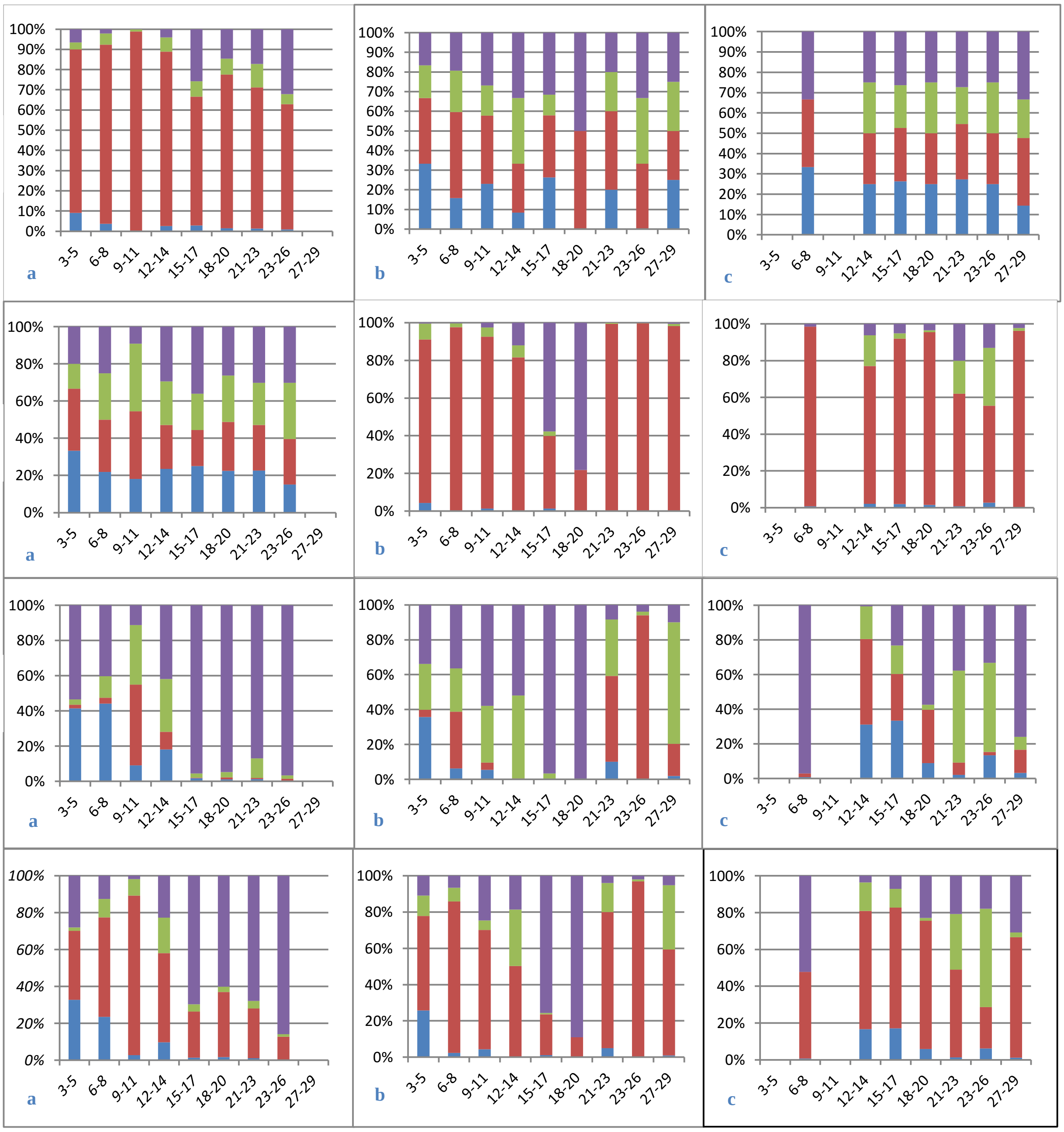
Table 1. Shannon-Wiener Diversity Index (SWI) and Vacuity Index (VI) values according to the length groups.

Sampling Season	Length Groups (cm)																	
	3-5		6-8		9-11		12-14		15-17		18-20		21-23		24-26		27-29	
	SWI	VI	SWI	VI	SWI	VI	SWI	VI	SWI	VI	SWI	VI	SWI	VI	SWI	VI	SWI	VI
Summer 2012	2.23	9.1	2.51	0	2.34	20	2.46	33.3	1.76	55.6	2.26	37.5	1.86	34.8	1.39	44	-	-
Autumn 2012	1.69	33.3	2.05	0	2.23	23.1	1.78	20	1.56	14.3	0.89	0	1.7	-	1.47	0	1.57	0
Spring 2013	-	-	1.39	0	-	-	1.41	0	2.19	16.7	1.64	0	2.04	0	1.99	25	1.63	0

Gut Contents

The gut contents of *C. gibelio* consisted of siliceous algae, green algae, vascular plants, pine pollen, amphipods and chironomids (Table 2). Algae took an important part in the gut contents by frequency and abundance. As members of Bacillariophyceae, *Navicula* sp., *Fragilaria* sp. and partly *Cocconeis* sp. taxa were dominant organisms in nearly all gut contents. Some animal groups such as Oligochaeta members could not include in the gut content analysis due to rapid digestion. However, there were encountered Oligochaeta setae in nearly every size group in every season.

When the gut contents were grouped as four-diet categories (detritus, periphyton, macrophyte, and macroinvertebrate) periphyton dominate nearly all length groups except 15-20 cm length groups in autumn according to N% values (Figure 4). Particularly, macroinvertebrates were low values both abundance and volume in > 20 cm length specimens in autumn. The V% values of macroinvertebrates were low in <15cm and >20 cm specimens in spring and autumn, respectively.



Fifure 4. The occurrence (F %), number (N %), volume (V %) and Index of Relative Importance (IRI %) of prey items in the gut contents, in terms of the length groups and seasons (a: Summer 2012; b: Autumn 2012; c: Spring 2013. Blue: detritus; red: periphyton; green: macrophyte; purple: macroinvertebrate)

Table 2. Seasonal (SUM: Summer 2012; A: Autumn 2012; SP: Spring 2013) IRI % values of length groups.

		Seasonal *IRI* % Values of Length Groups									
		3-5		**6-8**			**9-11**		**12-14**		
	Prey Items	**SUM**	**A**	**SUM**	**A**	**SP**	**SUM**	**A**	**SUM**	**A**	**SP**
Cyanobacteria	*Oscillatoria* sp.		1.82		14.14			2.33			
Heterokontophyta	*Amphora* sp.	1.19	0.33	1.29	0.23		2.34	2.70	0.40	0.80	
	Cocconeis sp.	0.34		3.90	1.34	2.0	7.30	10.25	2.50	10.45	2.8
	Cyclotella sp.								0.19		
	Cymatopleura sp.	0.17		0.74	0.08		0.10		0.45		
	Cymbella sp.	0.22		5.26	0.19	0.7	15.65	1.17	5.54	3.52	
	Diatoma sp.	0.04		0.09	0.06		0.01				
	Fragilaria sp.	0.01	0.91	0.07	8.64		0.08		0.07	0.16	
	Fragilaria sp. (chain)	13.48	0.54	17.49	1.26	16.8	2.37	15.04	18.58	0.24	54.8
	Gomphonema sp.	0.35	1.95	0.12	3.96			2.18	0.13		
	Gyrosigma sp.	0.34	0.40	0.25	0.07	0.7	12.07	1.20	4.18	0.66	
	Licmophora sp.		1.44		6.70			1.10			
	Melosira sp.	5.82		8.79	0.30		12.49	0.93	5.95	2.44	
	Navicula sp.	8.98	41.69	11.54	43.19	15.4	16.94	28.45	6.71	31.54	6.1
	Neidium sp.								0.06		
	Nitzschia sp.	2.88		1.73			16.55		0.15		
	Pinnularia sp.		2.34	0.004	0.76			0.05	0.20	0.16	
	Rhoicosphaenia sp.	2.28	0.33	0.94	0.40		0.07	0.05	0.11		
	Stephanodiscus sp.	0.03	0.35	0.41	0.003				1.23	0.16	
	Ulnaria sp.	0.95		1.10	0.07	10.7	0.02	0.26	0.66		
	Vaucheria sp.				0.31						
Chlorophyta	*Ankistrodesmus* sp.										0.6
	Chlorella sp.				1.53						
	Chlorophyta			0.03							
	Cladophora sp.	1.10		2.06	0.56		2.70	0.46	6.80		
	Closterium sp.	0.19		0.06	0.15	0.8	0.70				
	Conjugatophyceae										
	Cosmarium sp.	0.02		0.02					0.02		
	Microspora sp.										
	Oedogonium sp.	0.01		0.19	0.05		3.51	0.03	0.16	0.25	
	Pandorina sp.										
	Pediastrum sp.			0.10	0.04				1.08		
	Scenedesmus sp.	0.01			0.02			0.06			
	Spirogyra sp.				5.78			1.002			
	Stigeoclonium sp.	0.39	0.73	0.06	0.99		0.33	0.61	0.38		0.7
	Ulothrix sp.				0.01						
	Zygnema sp.							0.14			
Animal and Plant Prey	Amphipoda	23.94		7.99	5.79		1.49	18.23	19.50	9.73	
	Chironomidae	0.11				52.3		0.25			
	Copepoda		11.04							0.56	
	Crustacea				0.29						
	Insecta	3.91		2.46							
	Keratella sp.								0.46		
	Nematoda										
	Ostracoda			1.94	0.53			6.21	2.72	8.31	
	Plant (seed)				0.01						
	Pollen	0.20	0.27	0.04	0.004		0.02				
	Plant	0.23	10.15	7.59	0.13		2.12	0.13	11.98		14.8
	Fish egg	0.04		0.10	0.04				0.03		3.6
	Animal Detritus	15.78		19.07					0.80		15.5
	Digested Detritus	0.41		0.02			0.32				
	Other organisms	16.58	25.71	4.41	2.39	0.7	2.44	4.37	8.97	0.13	1.2
	Cystic material				0.001				0.02		
	Bryozoa			0.03			0.38	2.82		30.87	
	Cladocera			0.10							

Table 2. (Continous)

		Seasonal *IRI* % Values of Length Groups													
			15-17			**18-20**			**21-23**			**24-26**		**27-29**	
	Prey Items	**SUM**	**A**	**SP**	**SUM**	**A**	**SP**	**SUM**	**A**	**SP**	**SUM**	**A**	**SP**	**A**	**SP**
Cyano-bacteria	*Anabaena* sp.				0.003										
	Merismopedia sp.				0.02										
	Oscillatoria sp.	0.001		1.28	0.002										
Heterokontophyta	*Amphora* sp.	3.94	3.65	0.02	3.29	1.82		2.35		0.07	0.01			0.17	0.1
	Cocconeis sp.	1.49	10.53	0.29	7.03	3.64	3.1	6.96	5.18	2.72	2.66	5.96	0.5		0.5
	Cyclotella sp.	0.01													
	Cymatopleura sp.	0.09	0.03	0.32	0.03		0.2	0.15		0.42	0.01			0.23	
	Cymbella sp.	0.34	1.22	2.02	6.38			3.09	0.27	0.37	0.23	12.8		1.48	0.3
	Diatoma sp.	0.01		0.36	0.003			0.01			0.001				
	Epithemia sp.				0.07										
	Fragilaria sp.		0.09	0.33	0.14			0.001							
	Fragilaria sp. (chain)	0.04	1.51	28	3.11	1.84	45.5	0.76	6.38	37.5	5.02	4.32	6.4	1.22	21.7
	Gomphonema sp.	0.01	0.21		0.08			0.04	0.11		0.02				
	Gyrosigma sp.	2.15	0.28	1.65	2.56			2.28	1.04		0.06	0.79		1.25	
	Melosira sp.	0.49	0.84	8.73	2.85			1.63	16.39	5.36	0.93	34.9	4.9	27.8	37.3
	Meridion sp.				0.004						0.003				
	Navicula sp.	8.7	3.34	16.6	5.32	1.82	15.3	6.34	44.46	0.86	1.12	38.2	6.4	26.1	3.2
	Nitzschia sp.	1.32		0.03	0.76			1.31			0.29				0.02
	Pinnularia sp.	0.01	0.11		0.02			0.003			0.002				0.03
	Rhizosolenia sp.				0.0001										
	Rhoicosphaenia sp.	0.72	0.72		0.10	1.82	2.03	0.39	0.87		0.06				
	Stephanodiscus sp.	0.13		0.01	0.60			0.03			0.01		1.6		0.2
	Surirella sp.				0.001										
	Ulnaria sp.	5.46		5.90	2.80		3.5	1.66	0.16	0.38	1.95		2.5		2.3
Chlorophyta	*Ankistrodesmus* sp.	0.003			0.001										
	Chaetomorpha sp.				0.02										
	Chlorophyta							0.03			0.01				
	Cladophora sp.	0.01			1.04			2.22		3.35	0.54				
	Closterium sp.	0.003		0.03	0.01			0.02							
	Conjugatophyceae				0.10			0.26		9.26	0.01		7.3		0.2
	Cosmarium sp.	0.01			0.09			0.003			0.01				
	Microspora sp.	0.13			0.13			0.08			0.07				
	Oedogonium sp.	0.01			0.51			0.05	15.81	0.66	0.01		3.4	1.65	
	Pandorina sp.				0.002										
	Pediastrum sp.	0.02			0.005				0.15						
	Scenedesmus sp.		0.03		0.001			0.001			0.0004				
	Spirogyra sp.			0.09				0.01		3.29					1.4
	Stigeoclonium sp.	0.02	0.08		0.24			0.07	0.18		0.03			0.21	
	Ulothrix sp.				0.35			0.003							
	Ulvales							0.05							
	Zygnema sp.				0.01			0.15							
Charophyta	*Mougetia* sp.				0.01										
Animal and Plant Prey	Amphipoda	51.62	38.70	0.38	21.45	76.1	0.9	52.42	4.04	0.46	59.97	2.003	13.9	0.22	27.5
	Chironomidae	0.91	0.0003	2.26	1.34		21.3	0.25						4.87	1.8
	Copepoda	0.52	0.0003	0.27	2.02	0.02		0.27			0.10				
	Crustacea	0.12	0.11		0.18			0.80			3.83				
	Gastropoda	0.001			0.01						0.08				
	Insecta	0.03	0.26	0.36	0.38			0.20		9.35	0.55				0.5
	Nematoda				0.003			0.0001							
	Ostracoda	16	36.47		34.48	12.9		13.79			20.89				1.03
	Pollen	0.005		0.01	0.11		0.1	0.17			0.25	1.12			
	Plant	3.80	0.14	10.1	0.38		1.4	0.95		13.7	0.39		42.8		0.98
	Fish egg	0.45		3.65	0.28		0.7	0.08		10.9	0.47		3.96	0.11	0.04
	Animal Detritus	0.01		1.67	0.002			0.001					3.7		
	Digested Detritus	0.77			0.07		1.97	0.23		1.19	0.14		1.6		
	Other organisms	0.59	1.09	15.5	1.58		3.9	0.86	4.95	0.15	0.20		0.9	1.02	1.1
	Plant (circle shaped)	0.06			0.03			0.001			0.06				
	Cystic material			0.23	0.01			0.02						0.12	
	Bryozoa		0.56											33.5	

Ontogenetic diet shifts

The ontogenetic diet shift indicated seasonal variation taking into consideration *IRI* % values. There was a significant difference among *IRI* % of various length groups in all three seasons (*X=27.003, P<0.01, df=7; X=20.603, P<0.05, df= 8; X=14.073, P<0.05, df= 6*). Heterekontophyta members were the most common food groups in nearly all length groups. While the small specimens (3-4 cm) feed on mostly Heterokontophyta members, the larger specimens consumed mostly animal foods such as Amphipoda and Ostracoda in all the seasons. Particularly, the *IRI %* value of Amphipoda members was more than 50 % in the large specimens in summer. *Navicula* sp. was the highest *IRI %* in the 3-11 cm *FL* group in autumn. According to three season data, the critical length group shifting diet from the herbivorous to carnivore dominated feeding strategy is 12 cm *FL*. However, the *IRI* % of Amphipoda members were 23.9 %, 18.2 %, and Copepoda members 11.0 % in autumn, Chironomidae members were high (52.3 %) in spring in smaller than 12 cm *FL* group (Table 2).

Relative gut length and feeding strategy

The mean relative gut length of *C. gibelio* is 3.47 ± 0.85 with the range of 1.22-5.66 (in summer) 2.60 ± 0.73 with the range of 1.03-3.84 (in autumn) 3.52 ± 0.56 with the range of 2.12-4.56 (in spring). *C. gibelio* specimens have omnivore feeding strategy according to their length groups. (Table 3). When group's specimens that were smaller than 12.0 cm length collected in three seasons combined, the mean *RGI* value of this combined group was 2.51 ± 0.77 that means carnivorous dominant omnivorous feeding strategy. The *RGI* values of 12.1-17.9 cm and larger than 18.0 cm length groups combined in three seasons were 3.38 ± 0.67 and 3.66 ± 0.69 respectively.

Table 1. Taking into consideration *RGI* types of feeding in different length groups (O: Omnivorous; H: Herbivorous; C: Carnivorous; N: Number of specimens; GL: Gut length; FL: Fork length; SD: Standart Deviation).

Length groups (cm)	N	Summer (GL/FL±SD)		N	Autumn (GL/FL±SD)		N	Spring (GL/FL±SD)	
3-5	11	2.47±0.97	O-C	3	1.55±0.34	C-O	-	-	-
6-8	10	2.69±0.43	O	25	2.47±0.81	C-O	1	3.16	O
9-11	5	3.15±0.92	O	13	2.40±0.56	C-O	-	-	-
12-14	6	3.65±0.75	O	5	2.85±0.36	O	1	3.13	O
15-17	20	3.52±0.73	O	7	3.24±0.26	O	6	3.21±0.79	O
18-20	23	3.69±0.74	O-H	1	3.33	O	2	3.67±0.95	H-O
21-23	22	3.70±0.78	O-H	3	3.01±0.38	O	4	3.58±0.71	O
24-26	25	3.73±0.76	O-H	1	3.04	O	4	3.81±0.36	H-O
27-29	-	-	-	1	3.62	O	7	3.64±0.19	O

Trophic level

The trophic level of all *C. gibelio* specimens ranged from 2.03 to 3.34. The trophic level was low and more or less steady state in spring comparing to summer and autumn. The trophic level is increasing at larger than 12 cm *FL* specimens both in the spring and summer seasons. The trophic level of larger than 20 cm *FL* specimens decreased dramatically in autumn. The minimum and maximum *TL*s of all groups are 2.06-3.29, 2.03-3.34 and 2.07-2.79 in summer, autumn, and spring, respectively (Figure 5).

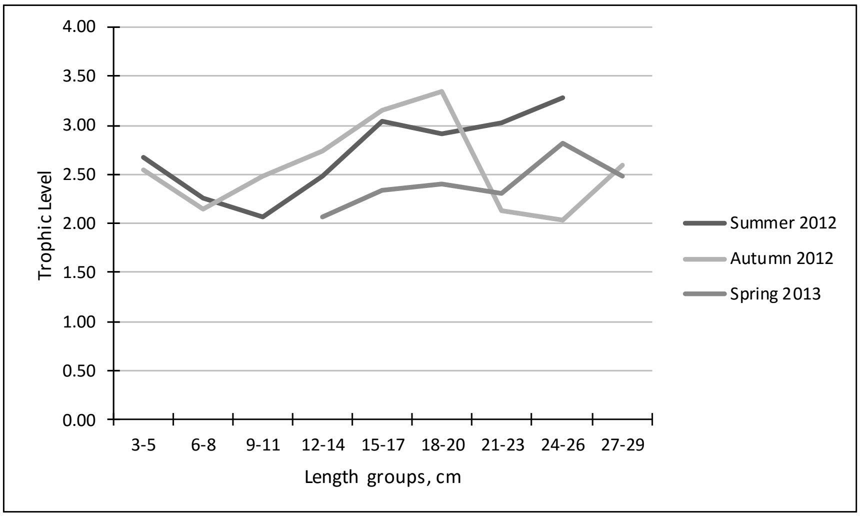


Figure 4. Trophic level of the length groups.

Discussion

C. gibelio were observed only the lower part of the Bayramiç Dam along the River Karamenderes. The spatial distribution of *C. gibelio* had seasonal variation along the River Karamenderes. While the specimens larger than 13.6 cm *FL* were abundant at the river mouth station, the specimens smaller than 8.8 cm *FL* were rich at the upper sites just below the Bayramiç dam in the summer and spring. The smaller specimens might escape from the Bayramiç Dam, which is regularly fished by aquaculture activities and the most available habitat for *C. gibelio* might be at the river mouth conditions.

A previous study based on a gravimetric method indicates that small specimens mostly feed on diatoms and large specimens consume animal materials such as copepods, beetles and chironomids in a Brackish Water Body in Southern Siberia (Rogozin et al. 2011). Another study, which is based on *F* % and *N* % indicates that small specimens consume zooplanktonic organisms such as copepods and cladocerans in Gelingüllü reservoir, Turkey (Kırankaya 2007). In addition, the phytoplankton was recorded as low frequency comparing to other food organisms in all age groups in Gelingüllü reservoir (Kırankaya 2007). There are no previous study recording gut contents as *IRI* % values, however, the results obtained from abundance and frequency in Karamenderes River were apart from the results of the previous records. Periphyton was important diet as frequency and abundance, as well as *IRI* %, in almost all length groups.

The amount of animal food might be enough only large specimens who are more capable to collect the animal materials comparing to smaller ones, so the smaller ones have to change their feeding characteristics into algae because of competition. This finding was supported by our high diet diversity in the gut contents of smaller specimens in Karamenderes River. There is no diet diversity in *C. gibelio* feeding patterns in the previous study, and our results indicated a decrease in Shannon diversity in food components of >12 cm *C. gibelio*. This indicated that gibel carp has a wide plasticity in every length group and this wide range on the capability of resource use give them a high advantage for surviving in even very limited resource conditions. In the other views, the food selection of specimens might be related to the abundance of resource users. While the abundance of large Gibel carp specimens were abundant in summer, the small ones were abundant in autumn and spring. In addition, the high amount of large specimens might exploit all favorable animal materials in summer.

In Karamenderes River, feeding intensity of *C. gibelio* had a seasonal variation with high feeding intensity reported by Kırankaya (2007) and Bobori et al. (2012). In general, the feeding intensity estimated based on a number of empty gut indicates seasonal variation, with low in hot summer season because of increasing enzyme activities and digestion metabolism. The seasonal and size depend variation in the feeding intensity might be related with the diet types. For example, in summer the specimens smaller than 8 cm *TL* feed mostly on plant materials and likely in autumn the large specimens consumed plant material. It is important that the digestion of plant material is hard when comparing to animal material and the retention duration of plant materials is longer than that of animal materials in the gut (Nikolsky 1978). In addition, the smaller specimens might feed on relatively small food and the retention duration of small animal materials as a diet would be relatively shorter time (Labropoulou et al. 1997) in gut content comparing to large animal materials which are presumably consumed by larger specimens. In other words, the feeding intensity might be explained by fish abundance. In small and large specimens was low abundance in summer and autumn, respectively (Figure 3). This indicates that when the population of *C. gibelio* low density, they prefer the most available and abundant plant materials as food. The small specimens mostly feed on siliceous algae and probably feed on the mats of periphyton, which are more abundant in the shallow, pooled, high vegetated stony and macrophytes dominant microhabitats along the river. This kind of habitat might be more suitable for small specimens serve them both food and shelter for escaping their predators. Yalçın Özdilek and Jones (2014) stated that the filamentous algae were important food components for about middle size (13.5-21.1 cm in FL) *C. gibelio* living in Karamenderes. However, *IRI* % results indicate that 12-21 cm length group members feed on animal prey items in overall stations in Karamenderes river in this study. This study supports that *C. gibelio* is an opportunistic feeder and the plasticity in its feeding strategy might be seasonal and ontogenetic.

C. gibelio has an omnivorous feeding strategy as indicated many studies (Specziár et al. 1997; Balık et al. 2003; Rybczyk 2006; Kırankaya 2007; Yılmaz et al. 2008; Yalçın Özdilek and Jones 2014; Partal and Yalçın Özdilek 2017). The trophic level based on *IRI* % and *RGI* data support this finding. The ontogenetic diet patterns taking into consideration, there was a conflict between *IRI* % and *RGI* results. Taking into consideration *RGI* carnivorous dominant feeding strategy was observed in smaller than 12 cm *FL* specimens' particularly in summer and autumn and herbivore dominant omnivore strategy was observed in larger than 18 cm *FL* specimens particularly in summer and spring. The *IRI* % values are indicative of instant feeding, so animal materials are digested faster, especially in hot summer and autumn seasons (Windell 1978).

The increase in the trophic level with increasing of the fish length was found in many studies as a natural process (Weber and Brown 2013). In this study, the finding that large specimens have high trophic level in spring and summer is an anticipated result. However, a decrease in the trophic level of larger than 20 cm in *FL* might be explained by food availability. During this season because of competition (Yalçın Özdilek 2017) and limited resources (Akbulut et al. 2009), the large specimens may supply their requirements with foods that have lower energy but that are more abundant in surroundings.

Acknowledgements

This research was supported by TUBITAK 111Y280 codded project. In field and laboratory studies we thank Ali Rahmi Fırat, Sait Gürsoy, Emine İnci Balkan, Gizem Yılmaz and the other team members of the project. This study was presented in FABA14: Symposium on Fisheries and Aquatic Sciences, 25-27 September 2014, Trabzon - Turkey by oral presentation.

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