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Diet of Silver Crucian Carp *Carasssius gibelio* in Lake Eğirdir

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Abstract

Diet of silver crucian carp *Carassius gibelio* was investigated from 265 guts collected from Lake Eğirdir between March 2001 and March 2002. The results of this study showed that the feeding activity of the silver crucian carp ranged among seasons within year. The percentages of the non-empty guts were similar between summer (29.8%) and autumn (30.1%). This ratio was 16.3% and 47.1% in spring and winter, respectively. Twenty-three taxonomic categories were identified from the 3998 food items analyzed. The diet of the silver crucian carp were dominated by benthic and planktonic invertebrates such as Gastropods, Dipterans, Cladocerans, Copepods, and Ostracods. *Daphnia* sp. was found in 42.6% of the non-empty gut-samples. The frequencies of occurrence of several other food categories, such as *Chironomus* sp., *Cyclops* sp., Ostracods, Acarina, and *Bosmina* sp., were also relatively high.

Key Words: Diet, silver crucian carp, *Carassius gibelio*, Lake Eğirdir

Introduction

The silver crucian carp *Carassius gibelio* is distributed mainly in the former Soviet Union, Europe, Korea and north-east Chine (Zou *et al*., 2001). This species is an exotic fish species for Lake Eğirdir. The silver crucian carp were introduced into this lake in the early 1990s, and they became dominant fish species of the lake in a few years. Currently, the aquatic fauna consists of 10 species, with Cyprinids and crayfish *Astacus leptodactylus* being most abundant. The impact of invading species on the native fish communities is rarely positive and often catastrophic (Adams, 1996). Introduction of some fish such as crucian carp *Carassius carassius* causes a serious deterioration in the aquatic surroundings (Baer, 2001). The silver crucian carp was introduced into Lake Eğirdir about 10 years ago, but little is known about the ecology of this species, their feeding habits, and the interaction with other species. Such information is considered important if a rational strategy for the conservation of this species and other species in the lake is to be developed. According to some fishermen, the silver crucian carp in Lake Eğirdir consumed young crayfish. Therefore, crayfish population has been negatively affected by this species. However, there was no scientific information about this opinion. The purpose of this study was to analyze the diet composition and to determine seasonal variations in the diet of the silver crucian carp in Lake Eğirdir. Another goal of this study was to determine whether young crayfish were consumed by the silver crucian carp.

Materials and Methods

Diet of the silver crucian carp was assessed on the basis of the gut contents determined by dissection of fish collected from 4 different sites of Lake Eğirdir (Figure 1).

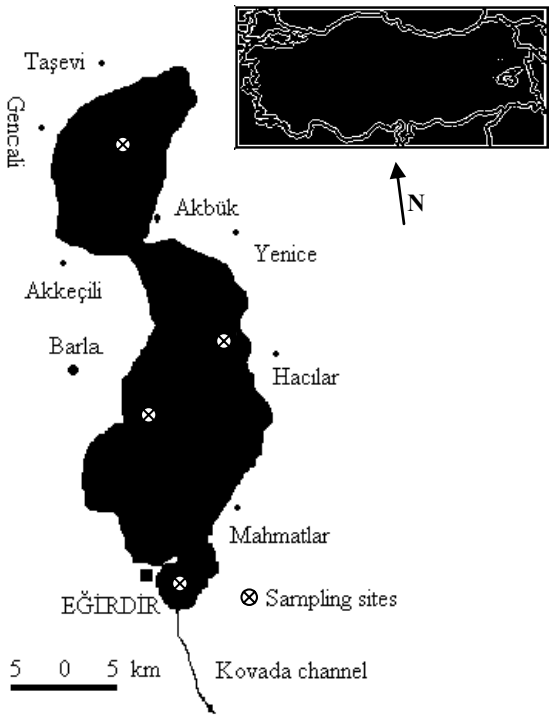

Figure 1. Sampling sites of fish specimens in Lake Eğirdir.

Sampling for dietary analysis was carried out monthly between March 2001 and March 2002. All fish samples were measured (fork length, mm) and weighed (g), and their guts were removed immediately and stored in formalin (4%) until the contents were analysed (Buije and Houthuijzen, 1992). Animal food items were later identified to the lowest possible taxon. The diet was analysed for "percentage composition by number" and "frequency of occurrence" as described by Windell and Bowen (1978). Percent composition by number is the percentage of the number of food items examined accounted for by a selected taxa. Frequency of occurrence describes the percentage of fish with non-empty guts that contained at least one of a selected food item. In calculations, unidentified food items were not used.

Diet similarity among seasons was investigated using Schoener Overlap Index (Schoener, 1970) (C);

$$Cxy = 1 - 0.5 \sum \left| pxi - pyi \right|$$

Where; pxi and pyi are the proportions by number of prey type *i* in the diets of groups x and y (seasons), respectively. If the C value is bigger than 0.80, it means that the diet of the two group is similar.

The extent of the diet was calculated using the diversity index of Shannon-Wiener *(H)*:$H' = - \sum pi \log_2 pi$. Where pi is the proportion by the number of prey type *i*. This index has adequate sensitivity for detecting changes in species diversity and provides a general indication of the relative magnitude of trophic specialization (Berg, 1979).

Results

The gut contents of 384 silver crucian carp were examined to determine their diet compositions. The size of fish ranged from 9 to 33 cm fork length, and frequencies of their length classes are given in Table 1.

Of the 384 guts analysed, 69% contained food. The rate of the empty guts was least in spring. As shown in Table 2, this rate gradually increased from spring to winter.

Diet Analysis

Percent composition of diet

A total of 3998 food items in the 265 non-empty gut samples were identified, corresponding to 23 taxa from 14 major groups. These major groups are: Gastropoda, Cladocera, Diptera, Bivalvia, Trichoptera, Copepoda, Mysidacea, Odanata, Amphipoda, Ostracoda, Coleoptera, Acarina, Euciliata and Nematoda (Table 3). Cladocerans (mostly *Daphnia* sp.) were the dominant food category of the silver crucian carp in terms of percent numbers. Dipterans, Gastropods, Copepods and Ostracods were also common dietary items. The remaining categories contributed noticeably less to the diet.

In spring, the silver crucian carp fed commonly on Gastropods, Dipterans and Cladocerans. Of these food categories, Gastropods were the most important food items in this season. However, their importance decreased gradually from spring to winter. The most common food in summer was Cladocerans. Gastropods, Copepods and Ostracods were also abundant food categories. Dipterans, on the other hand, were less important in summer than they were in the other seasons. Cladocerans were the dominant food items in the autumn diet. In this season, Dipterans, Ostracods and Copepods were the primarily food items. In winter, the silver crucian carp fed commonly on Dipterans, Mysids and Copepods. In this period Cladocerans, Gastropods and Ostracods were less important in the diet of the silver crucian carp in contrast to other seasons. Odanates in the gut samples were observed only in summer. Trichoptera and Euciliata were not present in winter and Mysids

Table 1. Seasonal distribution of the silver crucian carp of different length classes examined

	Length class (cm)							
Season	8-12	12-16	16-20	20-24	24-28	28-32	32-36	Total
Spring	6	6	10	28	23	7	0	80
Summer	16	25	10	46	25	2	0	124
Autumn	8	9	22	17	29	7	1	93
Winter	12	19	8	24	19	5	0	87
Total	42	59	50	115	96	21	1	384

Table 2. Seasonal trends of the percentage of the empty guts

	Spring	Summer	Autumn	Winter	Total
No. of guts examined	80	124	93	87	384
No. of guts with food	67	87	65	46	265
% empty guts	16.3	29.8	30.1	47.1	31.0

Table 3. Percentage composition by number of the diet of the silver crucian carp in Lake Eğirdir

Food category	Spring	Summer	Autumn	Winter	Total
Gastropoda (Total)	**27.5**	**17.6**	**7.2**	**5.1**	**15.7**
Gyraulus albus	6.7	2.2	4.7	4.3	4.2
Valvata naticina	1.2	0.6	0.5	0.0	0.6
Graecoanatolica sp.	19.2	14.5	2.0	0.8	10.6
Theodoxus heldreichi	0.5	0.0	0.0	0.0	0.1
Physa acuta	0.0	0.3	0.0	0.0	0.1
Cladocera (Total)	**20.9**	**34.6**	**34.8**	**10.1**	**25.6**
Daphnia sp.	14.4	15.9	19.7	4.9	13.7
Bosmina sp.	3.7	10.0	7.7	3.5	6.5
Chydorus sp.	2.8	8.7	7.4	1.8	5.4
Diptera (Total)	**22.7**	**7.0**	**24.0**	**28.8**	**18.6**
Chironomus sp.	21.7	7.0	24.0	28.8	18.4
Culicides sp.	1.0	0.0	0.0	0.0	0.3
Bivalvia (Total)	**0.9**	**1.9**	**1.9**	**5.6**	**2.5**
Dreissena polymorpha	0.7	1.5	1.7	5.6	2.2
Pisidium amnicum	0.2	0.4	0.2	0.0	0.2
Trichoptera (Total)	**4.2**	**0.3**	**2.0**	**0.0**	**1.6**
Leptocerus sp.	0.7	0.0	0.0	0.0	0.2
Stenophylax sp.	3.5	0.3	2.0	0.0	1.4
Copepoda (*Cyclops* sp.)	**2.9**	**12.9**	**9.9**	**19.2**	**11.3**
Mysidacea (*Mysis* sp.)	**5.2**	**1.8**	**0.0**	**28.7**	**8.4**
Odonata (*Onychogomphus forcipatus*)	**0.0**	**0.9**	**0.0**	**0.0**	**0.3**
Amphipoda (*Gammarus* sp.)	**1.3**	**0.2**	**0.0**	**0.0**	**0.4**
Ostracoda	**6.4**	**11.6**	**10.8**	**1.8**	**7.9**
Coleoptera (*Gyrinus* sp.)	**0.1**	**0.4**	**0.0**	**0.0**	**0.2**
Acarina	**4.4**	**6.6**	**6.0**	**0.2**	**4.5**
Euciliata (*Vorticella* sp.)	**2.9**	**3.5**	**2.4**	**0.0**	**2.4**
Nematoda	**0.7**	**0.6**	**1.1**	**0.6**	**0.7**

were not present in autumn. It was understood from Schoener Overlap Index values that there was no feeding similarity among seasons (C < 0.80). In addition, the least prey diversity was found in the winter diet (H' = 2.4232, 2.4280, 2.2370 and 1.8201 for spring, summer, autumn and winter, respectively).

Frequency of occurrence

During the study, *Daphnia* sp. was found in 42.6% of the non-empty silver crucian carp guts examined (Table 4). *Chironomus* sp. were the second most frequent occurring prey item found in the silver crucian carp guts. These prey items were followed by *Cyclops* sp., Ostracods, Acarina and *Bosmina* sp., respectively. It was determined that frequencies of occurrence of food categories showed seasonal variations. In spring, each of *Chironomus* sp., *Daphnia* sp., *G. albus*, Ostracods, *Mysis* sp., *Graecoanatolica* sp. and Acarina were found in more than 20% of the gut samples. *Daphnia* sp., *Cyclops* sp., Ostracods, *Bosmina*, Acarina, *Chydorus* sp. and *Chironomus* sp. occurred in at least 15% of the gut samples in summer and autumn. In winter, frequencies of occurrence of only *Chironomus* sp., *Cyclops* sp., *Mysis* sp. and *G. albus* were more than 15% in winter.

Discussion

Seasonal variations in the feeding activity of the silver crucian carp were observed. They had the least empty guts in spring, and the rate of the empty guts increased gradually from spring to winter. The seasonal trend in the feeding activity of silver crucian carp is related to water temperature and the typical reduction in foraging activity during the reproductive period (Rosenblum *et al*., 1994; from Lorenzoni *et al*., 2002). During this study, water temperature of the lake ranged between 4 and 26 ºC. It was about 4-5 ºC in winter, and increased up to 26 ºC in summer. Benthic food production is likely reduced by low winter temperatures, and standing stocks may become depleted as winter progresses (Hurst and Conover, 2001). In addition, it is generally known that feeding activity of Cyprinids decreases with decreasing water temperature (Penttinen and Holopainen, 1992). Likely, the feeding activity was the least in winter

Table 4. Seasonal variations of frequency of occurrence of food categories in the guts of the silver crucian carp in Lake Eğirdir

Food category	Spring	Summer	Autumn	Winter	Total
Gyraulus albus	31.3	10.3	15.4	15.2	17.7
Valvata naticina	9.0	1.1	1.5	0.0	3.0
Graecoanatolica sp.	23.9	17.2	6.2	4.3	14.0
Theodoxus heldreichi	1.5	0.0	0.0	0.0	0.4
Physa acuta	0.0	2.3	0.0	0.0	0.8
Daphnia sp.	47.8	56.3	30.8	26.1	42.6
Bosmina sp.	13.4	34.5	18.5	17.4	22.3
Chydorus sp.	10.4	31.0	15.4	6.5	17.7
Chironomus sp.	49.3	26.4	30.8	67.4	40.4
Culicides sp.	3.0	0.0	0.0	0.0	0.8
Dreissena polymorpha	4.5	3.4	6.2	13.0	6.0
Pisidium amnicum	3.0	3.4	1.5	0.0	2.3
Leptocerus sp.	4.5	0.0	0.0	0.0	1.1
Stenophylax sp.	16.4	2.3	6.2	0.0	6.8
Copepoda (*Cyclops* sp.)	16.4	42.5	29.2	50.0	34.0
Mysidacea (*Mysis* sp.)	26.9	4.6	0.0	30.4	13.6
Odonata (*Onychogomphus forcipatus*)	0.0	1.1	0.0	0.0	0.4
Amphipoda (*Gammarus* sp.)	6.0	2.3	0.0	0.0	2.3
Ostracoda	29.9	37.9	23.1	13.0	27.9
Coleoptera (*Gyrinus* sp.)	1.5	1.1	0.0	0.0	0.8
Acarina	22.4	33.3	21.5	4.3	22.6
Euciliata (*Vorticella* sp.)	9.0	13.8	6.2	0.0	8.3
Nematoda	6.0	4.6	4.6	6.5	5.3

because of low water temperature. Also, the silver crucian carp in Lake Eğirdir usually reproduce between April and August (Balık *et al*., 2004), and had the greatest feeding activity in spring. The results showed that during the reproductive period feeding activity of the silver crucian carp did not decrease. However, further work is required to determine fully the causes and implications of reduced gut with food observed in winter.

Diet of the silver crucian carp in Lake Eğirdir was dominated by benthic and planktonic invertebrates such as Gastropods, Dipterans, Cladocerans, Copepods and Ostracods. The most common item in the diet was Cladocerans (mostly *Daphnia* sp.) making up 25.6% and occurring in 42.6% (*Daphnia* sp.) of the non-empty guts. Dipterans were the second principal food category. These food categories were followed by Gastropods, Copepods, Mysids and Ostracods, respectively. The silver crucian carp in Lake Balaton also fed on similar animal food items. According to Specziar *et al.* (1998), diet of this species in Lake Balaton consisted of detritus (85.4%), benthic Copepods (7.2%), Cladocerans (3.2%), Amphipods (2.1%), Bivalves (1.4%).

In contrast to the claims of some fishermen, the diet of the silver crucian carp did not include crayfish. However, it is likely that there is food competition between the silver crucian carp and other species such as pikeperch *Sander lucioperca*, common carp *Cyprinus carpio*, baltic vimba *Vimba vimba* and crayfish. Unfortunately, there is a lack of information about feeding habits of common carp, baltic vimba and crayfish. On the other hand, Campbell (1992) examined the diet of the pikeperch in Lake Eğirdir in 1988 and 1989. He found that pikeperch also fed exclusively on invertebrates until they reached at least 30 cm total length. To evaluate the potential intensity of competition between the silver crucian carp and other species, the diets of the species must be simultaneously examined. Diet composition of crucian carp *Carassius carassius* differed with presence or absence of perch *Perca fluviatilis* (Paszkowski *et al*., 1996). In general, Gastropods, Cladocerans, Dipterans and Copepods presented higher percentage than the other food categories in the silver crucian carp guts in all seasons. Other food categories accounted for very small percentage of the diet. Only Mysids were one of the most abundant food categories in winter, but they were also scarce or absent in other seasons. The variability in seasonal trends of the various food categories is related to seasonal availability of the different food sources (Lorenzoni *et al*., 2002). Diet composition of silver crucian carp also reflected temporal changes in food resource levels (Greenberg and Dahl, 1998).

Consequently, although, the feeding activity of the silver crucian carp in Lake Eğirdir decreased gradually from spring to winter, they generally fed year around.

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