*Eğirdir Su Ürünleri Fakültesi Dergisi*
*Cilt:2-3; Sayı:1-2; 37-45 ( 2006-2007)*

# The Feeding Habits and Assimilation Efficiencies of Three Cyprinid Species in Lake Gölköy (Bolu-Turkey)

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**ABSTRACT**

The feeding habits and assimilation efficiencies of three cyprinid species (*Tinca tinca* (L.), *Cyprinus carpio* L. and *Carassius carassius* (L.)) living in Lake Gölköy were studied. Digitalized area estimation method was used to analyze for the diet of cyprinids. The diets of cyprinid species were not uniform throughout the year, consisting of detritus, plant and animal materials, diatoms and filamentous algae. The results of this study demonstrated that the diet composition of the cyprinids ranged among the seasons. Generally in three cyprinid species, a high percentage of organic detritus were found in autumn months and a high percentage of plant materials in summer months. The food of tench, *T. tinca,* was high level of diatoms, crustaceans and algae in summer. Although the food of common carp, *C. carpio,* consisted of high level of plants materials and crustaceans during summer and autumn months, the Crucian carp, *C. carassius,* ingested mainly algae from August to November. Estimation of assimilation efficiency by using ash as a marker of digestion in cyprinids also varied seasonally in Lake Gölköy. Higher assimilation efficiency was estimated when tench fed on diatoms, common carp on macrophytes and the Crucian carp on algae.

**Key words:** Feeding habit, assimilation efficiency, Lake Gölköy, cyprinids

# Gölköy Gölü'nde (Bolu-Türkiye) Yaşayan Üç Sazangil Türünün Beslenme Alışkanlıkları ve Asimilasyon Etkinlikleri

**ÖZET**

Gölköy gölünde yaşayan üç sazan türünün (*Tinca tinca* (L.), *Cyprinus carpio* L. ve *Carassius carassius* (L.)) beslenme alışkanlıkları ve asimilasyon etkinlikleri araştırılmıştır. Sazangillerin beslenme analizleri için dijital ortamda alan tahmin metodu kullanılmıştır. Sazan türlerinin yıl boyunca beslenmeleri tekdüze olmayıp diyetler organik döküntü, bitki ve hayvan materyalleri, diatomlar ve filament algleri içermiştir. Sazangillerin beslenme kompozisyonunun mevsimsel olarak değiştiği gösterilmiştir. Genel olarak üç sazan türü içinde; yüksek oranda organik döküntü kış aylarında, bitki materyalleri de yaz aylarında bulunmuştur. Kadife balığının, *T. tinca,* besini yazın yüksek oranda diatomlar, kabuklular ve alglerdir. Sazan balığının, *C. carpio,* besini yaz ve sonbahar aylarında yüksek oranda bitki materyalleri ve kabuklular içermesine rağmen, havuz sazanı, *C. carassius,* Ağustos ayından Kasım ayına kadar alg tüketir. Gölköy gölündeki sazangillerde sindirimin belirteci olarak kullanılan kül ile tahmin edilen asimilasyon etkinliği de mevsimler olarak değişmiştir. Kadife balıklarının diatomlarla, sazan balıklarının bitki materyalleri ve havuz sazanlarının da alglerle beslendikleri zamanlarda asimilasyon etkinlikleri daha yüksek olarak tahmin edilmiştir.

**Anahtar kelimeler:** Beslenme alışkanlığı, asimilasyon etkinliği, Gölköy Gölü, sazangiller

## INTRODUCTION

Fish are a key element in many natural food webs and an important source of food and recreation. They have impacts on the physicochemical properties of the system in which they occur and affect plankton, macrophytes and other aquatic organisms (Wootton, 1990). They also can serve as environmental indicators. Changes in the composition of a fish assemblage often indicate a variation in pH, salinity, temperature regime, solutes, flow, clarity, dissolved oxygen, substrate composition or pollution level (Wootton, 1990). The gain or loss of certain species is a common consequence of environmental change. Since fish are ecologically important, there are often intense commercial and recreational interests surrounding their study.

Feeding behaviors of fish is the major important factor affecting their nutrition and growth. Changing environmental conditions such as those resulting from eutrophication affect the fish species differently, because these changing conditions affect the availability of food types. Quantitative determination of the components of the diet, their nutritive value and seasonal availability are the basic parts for understanding of environmental impacts on the condition and growth of fish. Therefore, an understanding of fish diet and its influence on growth can be essential for understanding the ecological role and the productive capacity of fish populations (Bowen, 1982).

*Tinca tinca* (L.), *Cyprinus carpio* L. and *Carassius carassius* (L.) are the main introduced cyprinid species for the freshwater fisheries purposes in Turkey. The inquiry of the feeding biology in the fish will enable us to utilize them in a much more efficient way. The diet of the omnivorous cyprinids has been described for natural populations and cultured fish all around the world and Turkish freshwaters (Crivelli, 1981; Garcia and Adelman, 1985; Penttinen and Holopainen, 1992; Atasagun and Karabatak, 1995; Balık ve ark.., 2003). Previous works show a greatly varied diet in differing environments, ranging from larval chironomids and oligochaetes to seeds and plants.

Assimilation (absorption) efficiency reflects the capacity of an organism to metabolize the nutrients present in ingested food and is an important factor in its energy balance (Calow, 1985). Assimilation efficiency, also called apparent digestibility (Calow, 1985), is estimated according to Conover (1966) in the aquatic animals. The amount of organic material in the food and feces was compared against the amount of ash, which is assumed to be undigested. Changes in assimilation efficiency with different types of foods imply that each type of food is digested differently.

The food availability and utilization of fish community in Lake Gölköy have not previously been studied. Therefore, the purpose of this study was to investigate food composition and assimilation of the diet and to determine seasonal variations in the diet of three omnivorous fish species in Lake Gölköy.

## MATERIALS and METHODS

Lake Gölköy (40°41′ N, 31°31′ E, 840 m elevation) is a man-made lake, built in 1970 for irrigation, recreation and fishing purposes and located in the east of Bolu, Turkey (Figure 1). The surface area of the lake is 1,3 km$^2$ and maximum depth of 21,5 m. There are some agricultural activities around the lake and highly nutritious Abant creek and Mudurnu creek feed the lake throughout the year. The lake was stocked with *Tinca tinca* (L.), *Cyprinus carpio* L. and *Carassius carassius* (L.), the three main cyprinid species, by the General Directorate of State Hydraulic Works (DSİ) to build up the fish population to prevent the development of the aquatic vegetation.

Fish samples were collected monthly by 20 m trammel nets with 36, 50, 60 and 90 mm mesh sizes (stretched mesh of inner wall) from random sites of the lake (Figure 1). Nets were set for overnight and removed on the following morning.

Fish were immediately taken to the laboratory, dissected and their stomach and intestines isolated. Since there is no true stomach in cyprinid species, the foregut content, the anterior part of the alimentary canal, and the hindgut content, the posterior part of the alimentary canal, were considered as the food in the stomach and as the feces in the intestine, respectively. The stomach contents were divided in two parts for diet composition and organic matter analysis. About half of the contents of each stomach were placed in a plastic bag containing 10% formalin.

The preserved contents were identified to the lowest possible taxon by the relevant literatures (Altınayar, 1988; Lund and Lund, 1995; Demirsoy, 1990 and 1999).
Identification of stomach content of fishes is not easy since the food items are usually completely digested or unidentifiable. Therefore, area estimation method was used to summarize the feeding habits of three cyprinid species in this study. The diet composition of the stomach contents of cyprinids were determined by area estimation method (Ahlgren and Bowen, 1992). The preserved sample was suspended in a 25 ml beaker with a magnetic stirrer. A subsample was placed in a Sedgewick-Rafter (S-R) chamber and scanned through a light microscope (10x). The chamber holds 100 mm$^3$ of sample in 1 mm deep over an area of 50x20 mm. Two sets of 10 microscope fields in each food category were randomly selected for digital photographing. The utilization of photographic equipment (Nikon D40X digital camera) coupled to a compound microscope (Nikon Optiphot-2 Polarizing) presented perceptible images of the diminutive individuals. The relative areas of items were analyzed using the ImageJ software (Image Processing and Analysis in Java, Version 1.38, National Institutes of Health, USA) as a quantitative tool for measurements. The area of items of each food type (detritus, crustacean, diatoms, algae, macrophytes) is expressed as a percentage of the total area of ingested food for an individual fish (Figure 2).

Table 1. Plant and animal organisms identified in the stomach of three cyprinid species in Lake Gölköy.

| **Food Category** | **Organism** |
|---|---|
| Detritus | Non-living particulates and debris |
| Macrophytes | Vascular, amorphous plants, bits of stems, roots and fragments |
| Algae (Green and Blue-Green Algae) | *Anabaena* sp., *Oscillatoria* sp., *Scenedesmus* sp., *Pediastrum* sp., *Cosmarium* sp., *Spirogyra* sp., *Zygnema* sp., *Merismopedia* sp., *Microcystis* sp., *Euglena* sp., *Ankistrodesmus* sp. |
| Diatoms | *Gyrosigma* sp., *Cymbella* sp., *Navicula* sp., *Craticula* sp., *Tabellaria* sp. |
| Crustacea | *Gyraulus* sp., *Physa* sp., *Cyclops* sp., *Daphia* sp., *Bosmina* sp., *Alona* sp., *Diaptomus* sp., *Cyclops* sp., *Mysis* sp., *Cypris* sp., *Cypridopsis* sp., *Gammarus* sp., *Astacus* sp., *Chironomus* sp. |

The other half of stomach and full content of intestine were transferred into separate glass vials kept in an oven at 100 °C to dry. Due to the small amounts of material involved, the content from stomach and intestine for all samples were pooled. After drying, samples were pooled and used in the organic matter analysis for both stomach and intestine contents. Previously weighed dry samples were burned in a muffle furnace for 4 h at 550 °C, after cooling reweighed for ash weight (AW). The total organic matter (ash free dry weight, AFDW) from intestine and stomach content was then calculated with dry weight and ash weight (APHA, 1998).

Conover (1966) developed the ash-ratio method, which is perhaps the most widely used method for studying assimilation efficiency in herbivorous aquatic organisms such as copepod (Tande, 1985), bivalve (Zhuang, 2006), crustacean (Lasenby and Langford, 1973) and fish (Hofer and Schiemer, 1983; Getachew, 1987 and 1988; Larson and Shanks 1996). Since members of the family Cyprinidae consume a mixture of invertebrates, amorphous detritus particles and algae, this method can be applicable to measure assimilation efficiency in omnivorous fish also. That method involves measuring the increase in concentration of an inert, non-absorbed substance (ash) as it passes through the gut.

Assimilation Efficiency (AE) was calculated by; AE (%) = $(SC_{AFDW} / SC_{AW}) - (IC_{AFDW} / IC_{AW}) / (SC_{AFDW} / SC_{AW}) \times 100$ where $SC_{AFDW}$ is ash free dry weight of stomach contents, $SC_{AW}$ is ash weight of stomach contents, $IC_{AFDW}$ is ash free dry weight of intestine contents and $IC_{AW}$ is ash weight of intestine contents (Conover, 1966; Getachew, 1987 and 1988). In this calculation, organic matter in the stomach and intestine were compared to a reference material (AW) that is not digestible.

## RESULTS

The length and weight of fish ranged in this study were as follows: 17-38 cm, 350-1250 g in total number of 150 tench (*Tinca tinca* (L.)); 19-50 cm, 300-2000 g in total number of 70 common carp (*Cyprinus carpio* L.) and 15-26 cm, 280-550 g in total number of 63 Crucian carp (*Carassius carassius* (L.)). 11.3, 17.2, 19.2, 23.5, 28.4, 26.8, 19.4, 14.2 and 11.5 °C were the mean water temperatures in the lake from March to November, respectively.

Stomach contents of cyprinid fish were classified into five major categories based on organism from Lake Gölköy (Table 1). The food of tench consisted of mainly diatoms, in proportions ranging from 16% to 65%, detritus (12% to 44%), crustaceans (12% to 24%) and algae (6% to 22%) over the year, respectively (Figure 3). The contribution of macrophytes to diet was low throughout the year, except in March (13%) and May (19%).

The diet of common carp comprised macrophytes, detritus and various crustaceans (Figure 4). The percentage of macrophytes was correspondingly high (26% to 71%) throughout the year. In September, the consumption of macrophytes reached a peak (71%). From March to May, a very high percentage of the diet consisted of detritus (65%, 48% and 47%, respectively). The percentage of crustaceans rose over 15% from June to November.

The food of Crucian carp consisted mainly of detritus and algae (Figure 5). The percentage of detritus ranged from 28% to 79% March through November. One exceptional month was March, in which 3% algae was found, and the gut content comprised from 12% to 59% to the rest of the year. The intake of macrophytes, diatoms and crustaceans was low and constant throughout the year.

The assimilation efficiencies of organic material showed similar patterns in all cyprinid fish studied and increased during the summer months (Table 2). The data of this study indicate that a relationship exists between monthly food habits and assimilation efficiency. Higher assimilation efficiency is occurred in summer months when the cyprinids consumed more food such as diatoms in tench, macrophytes in common carp and algae in the Crucian carp, respectively (Table 2).

Table 2. Monthly variation of percentage of fish with full stomachs in the period of March and November. Ash free dry we and assimilation efficiency (AE) in stomach and intestine of fish pooled for each month.

| Months | Number of guts examined | Number of guts with food | Full stomach (%) | Mean AFDW (mg) (±SE) in stomach | Mean AW (mg) (±SE) in stomach | Mean AFDW (mg) (±SE) in intestine |
|---|---|---|---|---|---|---|
| | | | | *Tinca tinca* | | |
| March | 7 | 2 | 28.6 | 254.1 ± 7.4 | 9.5 ± 1.3 | 232.3 ± 6.3 |
| April | 12 | 8 | 66.7 | 378.3 ± 5.6 | 13.2 ± 1.7 | 352.1 ± 7.9 |
| May | 13 | 10 | 76.9 | 673.5 ± 9.1 | 19.2 ± 2.3 | 653.5 ± 15.1 |
| June | 28 | 21 | 75.0 | 725.1 ± 15.4 | 17.1 ± 3.9 | 612.3 ± 16.9 |
| July | 32 | 25 | 78.1 | 713.4 ± 19.7 | 21.3 ± 5.5 | 655.5 ± 21.5 |
| August | 23 | 18 | 78.3 | 486.1 ± 16.2 | 16.2 ± 4.6 | 462.1 ± 14.2 |
| September | 15 | 8 | 53.3 | 321.2 ± 11.5 | 8.1 ± 1.6 | 298.2 ± 10.2 |
| October | 11 | 7 | 63.6 | 362.5 ± 8.9 | 7.4 ± 1.9 | 331.1 ± 9.1 |
| November | 9 | 7 | 77.8 | 311.2 ± 10.2 | 7.2 ± 2.5 | 285.4 ± 8.0 |
| | | | | *Cyprinus carpio* | | |
| March | 6 | 4 | 66.7 | 210.8 ± 9.6 | 7.6 ± 1.8 | 182.1 ± 5.7 |
| April | 2 | 2 | 100.0 | 105.4 ± 6.1 | 3.2 ± 1.1 | 93.2 ± 7.1 |
| May | 9 | 7 | 77.8 | 369.2 ± 7.3 | 8.7 ± 2.6 | 341.2 ± 13.6 |
| June | 15 | 11 | 73.3 | 580.4 ± 12.5 | 11.2 ± 9.5 | 572.1 ± 15.2 |
| July | 13 | 8 | 61.5 | 421.6 ± 11.2 | 9.7 ± 4.9 | 403.2 ± 19.4 |
| August | 10 | 7 | 70.0 | 368.9 ± 17.1 | 8.2 ± 6.1 | 359.2 ± 12.8 |
| September | 4 | 3 | 75.0 | 189.1 ± 3.8 | 6.3 ± 3.2 | 165.5 ± 9.2 |
| October | 7 | 5 | 71.4 | 321.4 ± 9.1 | 9.0 ± 4.1 | 315.1 ± 8.2 |
| November | 4 | 2 | 50.0 | 83.1 ± 4.2 | 1.9 ± 0.9 | 79.5 ± 7.2 |
| | | | | *Carassius carassius* | | |
| March | 3 | 2 | 66.7 | 218.3 ± 10.2 | 7.6 ± 1.6 | 210.3 ± 12.5 |
| April | 7 | 6 | 85.7 | 586.4 ± 11.4 | 18.1 ± 1.0 | 554.1 ± 7.9 |
| May | 7 | 4 | 57.1 | 389.1 ± 9.7 | 12.6 ± 2.3 | 365.2 ± 9.5 |
| June | 10 | 6 | 60.0 | 655.3 ± 19.2 | 19.1 ± 8.6 | 596.0 ± 16.3 |
| July | 9 | 7 | 77.8 | 704.2 ± 26.4 | 23.8 ± 4.4 | 685.3 ± 14.6 |
| August | 11 | 8 | 72.7 | 756.9 ± 32.1 | 29.5 ± 5.5 | 721.6 ± 22.2 |
| September | 3 | 2 | 66.7 | 182.1 ± 8.5 | 6.1 ± 2.9 | 165.1 ± 4.9 |
| October | 6 | 4 | 66.7 | 426.3 ± 9.1 | 15.2 ± 3.7 | 412.3 ± 11.8 |
| November | 7 | 5 | 71.4 | 486.8 ± 7.6 | 17.1 ± 0.8 | 456.1 ± 5.5 |

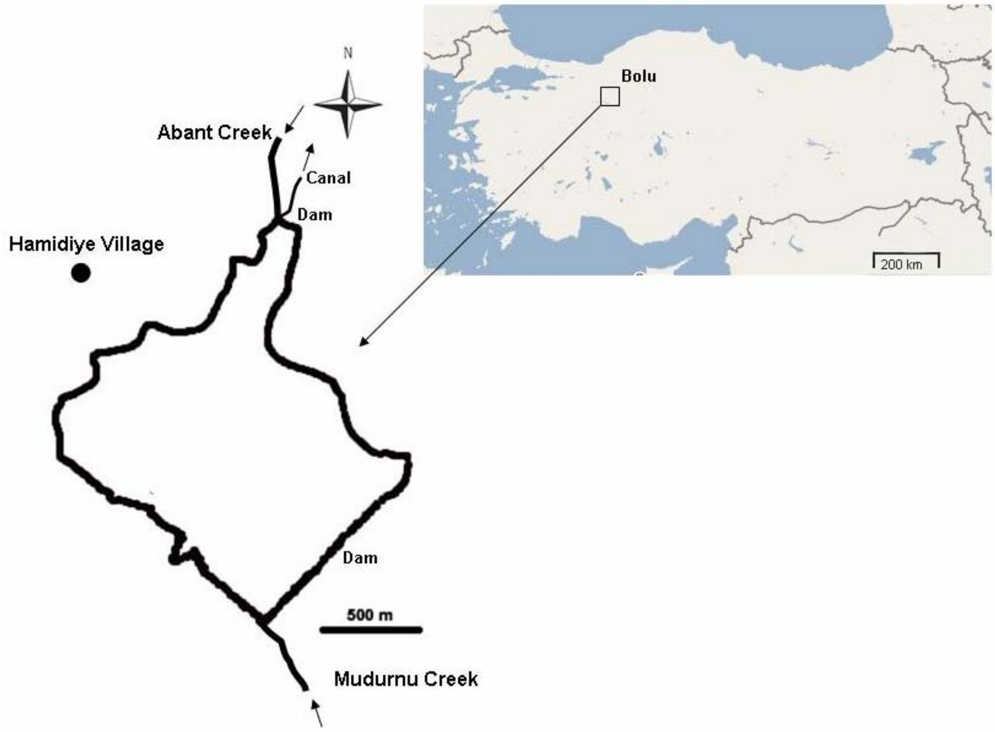


Figure 1. Map of Location of Lake Gölköy and its location.

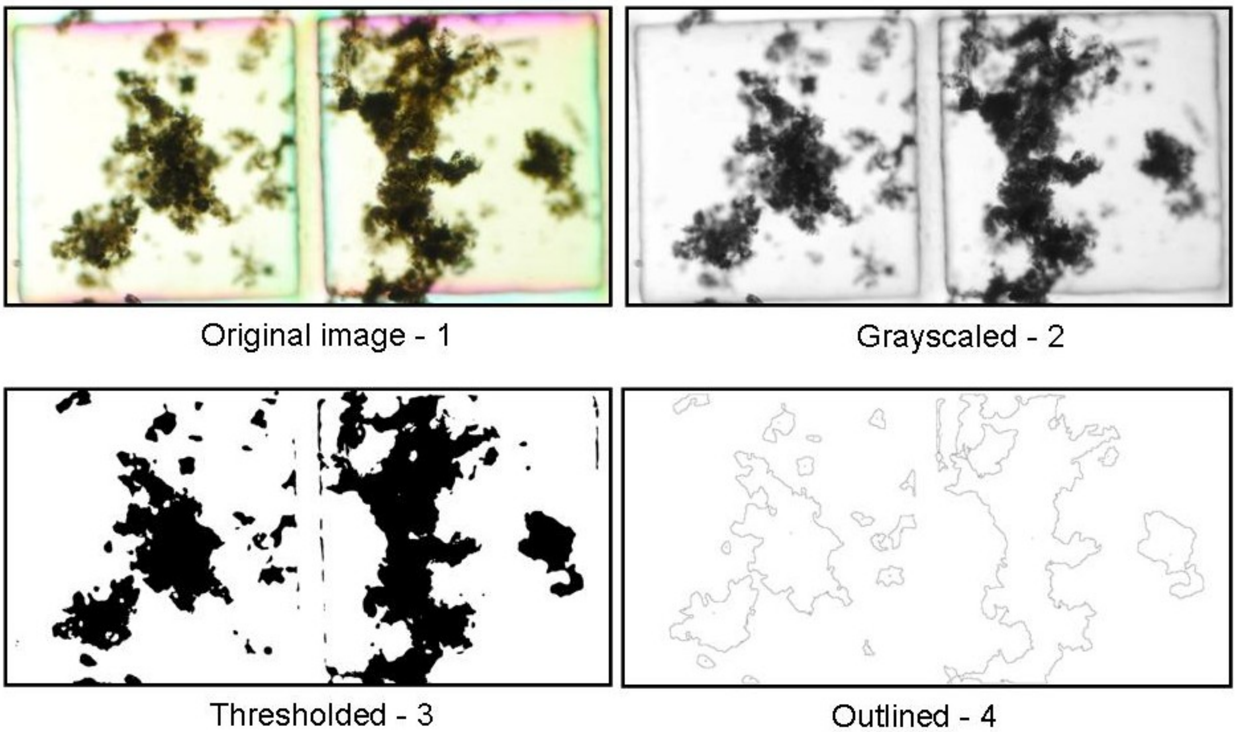


Figure 2. Detritus sample from a carp stomach is as an example for area estimation method by the ImageJ software in 2 $mm^2$ area of S-R chamber. Outlined area is calculated as 0,52 $mm^2$ and covers 26% of the total area.

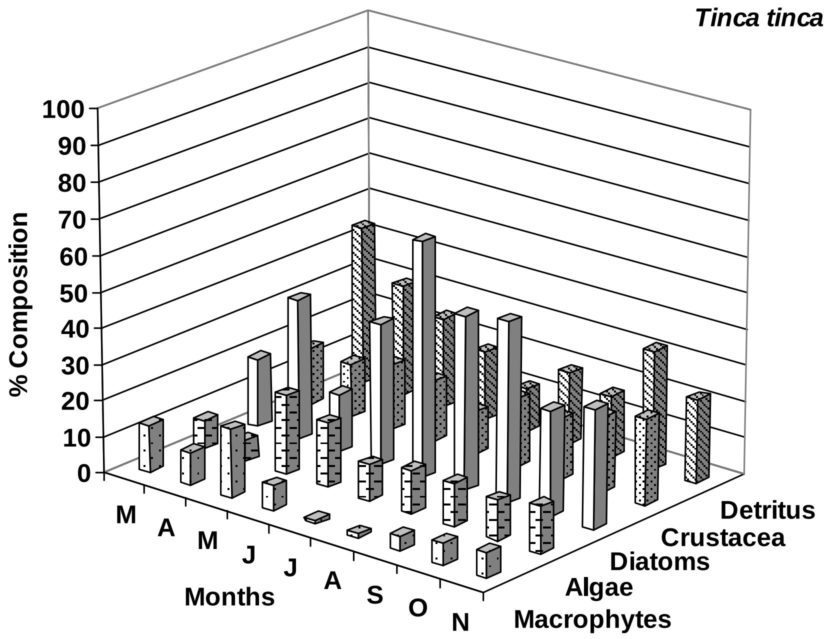


Figure 3. Stomach content of *Tinca tinca* from March to November

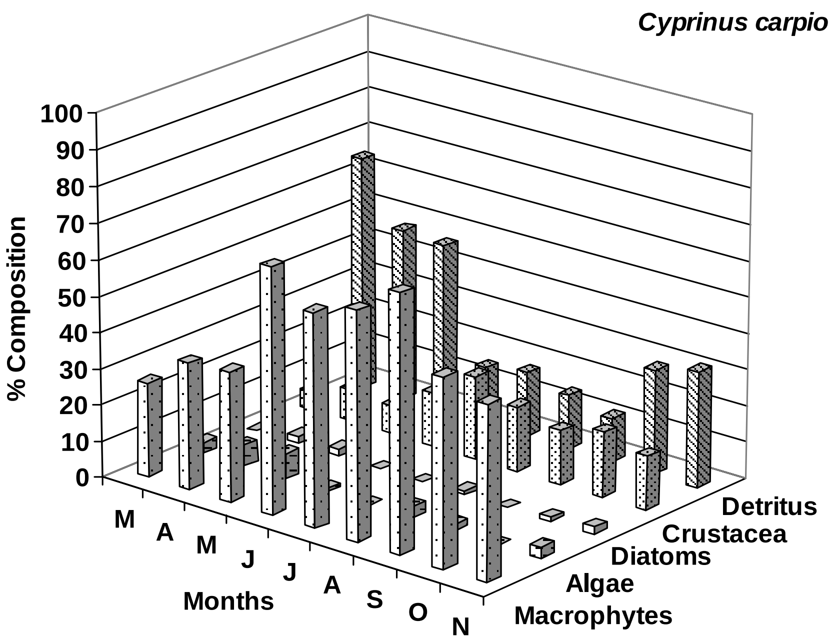


Figure 4. Stomach content of *Cyprinus carpio* from March to November.

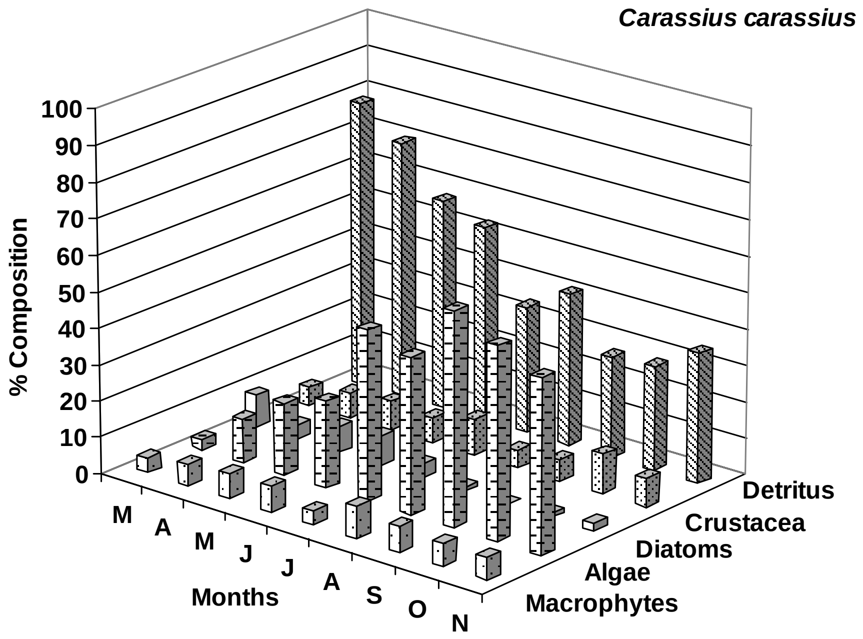


Figure 5. Stomach content of *Carassius carassius* from March to November

**DISCUSSION**

The seasonal trend in the feeding activity of cyprinid fish is related to water temperature. The feeding activity of the cyprinids in Lake Gölköy gradually decreased from August to November and increased March to June. Higher feeding activity for the cyprinids was also observed during summer within several studies in Turkish waters (Atasagun and Karabatak, 1995; Yılmaz ve ark.. 2007).

Gut contents are often a mixture of invertebrates, algae, plants and amorphous detritus particles too small to separate manually for counting and weighing (Ahlgren and Bowen, 1992). Therefore, percent composition by area method based on light microscopy with computerized digital technique provides fast and easy an alternative approach to gut content d in spring and autumn months in this study. However, diatoms in the stomach of tench, macrophytes in common carp and filamentous algae in Crucian carp were the dominant in the diet during the summer months. The following findings are consisted with this data. Benzer ve ark.. (2007) found that the digestive tract content of tench was dominated by phytoplantonic organisms (Cyanophyta, Chlorophyta, Bacillariophyta, Euglenophyta) during the summer and the fall in Hirfanlı Lake, Turkey. Similarly, plant food items, especially algae during summer months, was dominant in the stomach content of Crucian carp (Penttinen and Holopainen, 1992). The food composition of three analysis in this study. Frequency of occurrence is the most common approach to quantitative analysis and gives valuable insights for fish diets. However, there are limits to information it can provide. High frequency of occurrence does not mean that a given food type is of nutritional importance to the fish (Bowen, 1982). Detritus and higher aquatic plants, which are ingested bit by bit, are not found in discrete units of uniform size, and therefore, counts of these particles have little meaning (Bowen, 1982). Bergman and Greenberg (1994) also indicated that broad categories defined at the order or family level could be fully adequate when studying how competing fishes divide the available prey base.

High level of detritus was present in all stomachs observe species of cyprinids in Lake Gölköy indicates a wide adaptability to the habitat in which they live. The results of this study suggest that cyprinids in Lake Gölköy are primarily omnivorous, although they become herbivorous if the opportunity presents. The cyprinids in this study appear to be a relatively unselective and their diet varies seasonally. This result corroborated the finding of the earlier reports that the cyprinids can feed a wide range of food, including detritus, plant material, algae, diatoms and crustaceans whenever they are available. Proportions of food types in cyprinids' gut contents were similar to those of many other common carp, which consumed large amount of organic detritus. (Summerfelt ve ark.., 1970; Eder and Carlson, 1977; Dewan ve ark.., 1979; Panek, 1987; Petridis, 1990; Çetinkaya, 1992; Atasagun and Karabatak, 1995; Benzer ve ark.., 2007; Yılmaz ve ark.., 2007). Detritus is commonly a mixture of plant debris and amorphous organic matter; this is usually together with the associated heterotrophic and autotrophic microorganisms (Bowen, 1982). Detritivory feeding habit is a common form of omnivory, since detritus orginiates differently throught the trophic spectrum and does not form one homogeneous food source (Polis and Strong, 1996).

The calculation of assimilation efficiency was based on the ratio method proposed by Conover (1966), in which it is necessary to measure the concentrations of both the inert (non-absorbable) and the absorbable components in the food and feces. One limitation of this approach is the assumption that there is no selective ingestion of one component relative to the other. It is impossible to collect the specific food for chemical analysis when the feeding habit is based on organic detritus. Therefore, ingested materials in the stomach and digested ones in the intestine were taken for estimation assimilation efficiency. The estimation of assimilation efficiency of cyprinids is based on the ash content which is the inert matter of a natural diet.

The estimation of assimilation efficiency by using ash as a marker of digestion could produce an underestimation of real assimilation if a fraction of ash is absorbed by individual or lost in the feces during with the water contact (Montgomery and Gerking, 1980). High correlation was observed between the amount of highly processed plant detritus and the cellulase activity in Cyprinids (Prejs and Blaszczyk, 1977). Therefore, the estimation of low assimilation efficiency seems low for all three carp species when they generally feed on mostly plant originated organic detritus in Lake Gölköy. In addition, the great difference in assimilation efficiency of organic matter indicates a much better utilization of animal than of plant material itself. Since the collection of feces was made directly from the intestine, the minimum water contact was kept to avoid loosing fraction. This method also conform the estimation of assimilation efficiency in this study.

The results of the present study are consisted with the previous reports that the cyprinids are omnivorous and their diet varies seasonally. In general, it seemed that cyprinids can ingest a wide range of food including plant and animal material with detritus if available. In addition, assimilation efficiencies show that three cyprinid species can utilize organic matter efficiently in Lake Gölköy.

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