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The feeding habits of *Mugil cephalus* (Linneaus, 1758) inhabiting in Gökova Bay (Muğla)

Gökova Körfezi (Muğla)'nde yaşayan Mugil cephalus (Linneaus, 1758)'un beslenme alışkanlıkları

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ABSTRACT

In this study, the feeding habits of the striped mullet, Mugil cephalus inhabiting Gökova Bay, were determined by the investigation of stomach contents. For this aim, 120 Mugil cephalus samples were caught between June 2007 and May 2008. As a result, it was determined that the stomach content of *Mugil cephalus* was consist of 33 various genus which of 26 belonging Plantae and 7 belonging Animalia. Total feeding it was determined that nutrition, 97,33% was *Bacillariophyta*, 0,35% was *Chlorophyta*, 0,22% *Cyanophyta* and 2,09% was animal organisms.

Keywords: *Mugil cephalus,* Stomach contents, Gökova Bay

ÖZET

Özet: Bu çalışmada, Gökova Körfezin (MUĞLA)'de yaşayan Mugil cephalus türlerinin mide içerikleri incelenerek, beslenme alışkanlıkları ortaya çıkarılmıştır. Bu amaçla Haziran 2007 ve Mayıs 2008 tarihleri arasında 120 *Mugil cephalus* balık örneği yakalanmıştır. Araştırma sonunda, Mugil cephalus'un mide içeriğinin 26'sı bitkisel 7'i hayvansal olmak üzere toplam 33 farklı cinsin oluşturduğu, toplam besinin %97,33'ü Bacillariophyta, %0,35'i Chlorophyta, %0,22' si Cyanophyta, %2,09'unu hayvansal organizmaların oluşturduğu tespit edilmiştir.

Anahtar sözcükler: *Mugil cephalus,* Mide içeriği, Gökova Körfezi

1. Introduction

Production of fisheries is an important production branch developing rapidly in the recent years. Therefore, many countries work on this area to meet the protein needs of their populations. Production becomes possible under the appropriate conditions (Alpbaz and Hoşsucu, 1996). Due to the mass growth of population in the world, water products production has become more important. People have recognized the importance of healthy diets; thus, water products have become more important because of their high protein content and for easy digestion. Fish is consumed more widely for these reasons and water products production increased accordingly.

It is important to know the feeding dietary of the fish to be produced. Therefore, it is necessary to know the digestion system of fish to determine its nourishment needs. It is necessary to know the natural nutrients consumed by fish and whether these nutrients are available in satisfactory amounts in the environment.

Economically important, fish may grow fast in shorter periods. This will assist both countries and producers progress economically. Potential fish existence in rivers

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and lakes is related to environmental conditions as well. The most important thing among these conditions is the nourishment capacity of the environment (Ekingen, 1983).

2. Material and Method

In this study, the feeding habits of the striped mullet, *Mugil cephalus* inhabiting Gökova Bay-Akyaka (Mugla) have been determined by the investigation of stomach contents. For this aim, 120 *Mugil cephalus* samples have been collected from Gökova Bay in the South Aegean Sea between June 2007- May 2008. The total 120 specimens have been examined in this study.

Gökova Bay, which is located in Mugla in Turkish Aegean Sea, has total area of 52000 hectares, including 24500 hectares territorial waters. This area is one of the eight protected marine areas in Turkey which has been protecting since 1989 (Cihangir et al., 1998). There is no stream entrance to the bay, however, because the land is karstic, rain water goes through the rocks and provides rich mineral input in coastal parts of the region. This rich mineral input from the sea bottom increases the biological productivity. Fish species examined in this research were collected by local gears and nets from Gökova Bay in the years of 2007– 2008 (Figure 1). Besides, during the study, Because of fishing generally concerning this area, it has been took help the fishermen which are members of Akyaka fisheries cooperative.

The obtained samples were washed with fresh water immediately; after identifications, they were kept in percentage 70% of alcohol or 4% of formaldehyde solutions and had been brought to the laboratory immediately. Their stomach contents were examined under binocular microscope and their food organism were counted under microscope in the laboratory. The fish caught were weighed using a precision balance with an accuracy of ± 1 g and the lengths were determined on a fork length basis in millimeters using a millimetric scale. The age was determined by using the fish scales due to their practicality with preparations made according to the Lagler method (Lagler, 1956). In order to determine the feeding behavior of the fish, the digestive systems (stomach and intestine) of the samples were removed and placed in jars containing 4% formaldehyde. The full stomachs were weighed with an electronic balance after they had been dried with paper. In order to determine the type of nutrients and food eaten by each individual, the stomachs were then cut with a thin- edged knife and their contents were grouped according to food type.

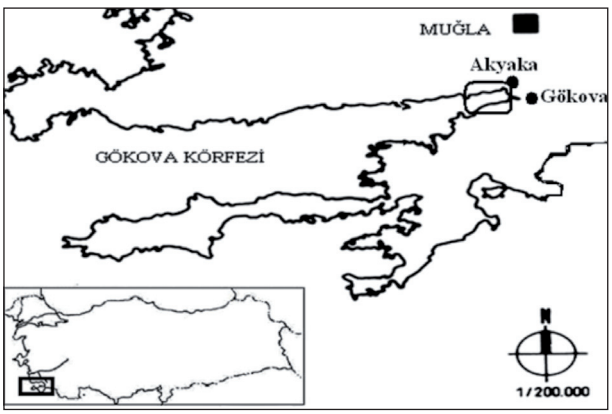

Figure 1: Research area (Gökova Bay-Akyaka (Mugla)).

The percentage of organisms found in the fish stomachs, the percentage of weight and the numerical percentage of each group were determined using the following formulae:

$$F = f.\ 100 / n,$$

$$W = f.\ 100 / W_{total,}$$

$$S = n_{org} 100 / s$$

Here, F is the percentage of encounters, f is the percentage of encounters of a specific organism, n is the total number of fish caught, W is the weight percentage, W_{total} is the total weight of the organisms, S is the numerical percentage, s is the total number of the organisms in the stomach and n_{org} is the number of organisms belonging to a specific species. Various sources were utilised to determine the organisms that emerged from the stomachs (Ulmer, 1961; Prescott, 1973; Lehmkuhl, 1979; Fitzpatrick, 1983; Nilsson, 1996). As species could not be recognized in the digestive system organisms, evaluations were made according to genera level in Lagler's formulas (Lagler, 1956).

3. Results

As a result, it was determined that the stomach contents of *Mugil cephalus* species were consist of 33 various genus which belonged to three different Divizios and two Phylums (Figure 2).

Bacillariophyta; *Amphora, Achnantes, Cyclotella, Coscinodiscus, Cymatopleura, Cymbella, Cocconeis, Diatoma, Diploneis, Entomoneis, Gomphonema, Gyrosigma, Melosira, Navicula, Nitzschia, Opephora, Pinnularia, Rhoicosphaenia, Synedra, Surirella, Stauroneis, Tabellaria* genera

Cyanophyta; *Anabaena* and *Oscillatoria* genera

Chlorophyta; *Pediastrum* and *Scenedesmus* genera

Arthropoda; 1 genus which belong to Insecta class and Crustacea (*Gammarus pulex*)

Mollusca; *Pisidium* genus which belong to *Bivalvia* class, (Limnaea, Planorbis, Valvata and Conus) genara which belong to Gastropoda class.

After feeding organisms found in stomach content of *Mugil cephalus* during feeding period had been counted, total of 14988 organisms were calculated in stomach content of *Mugil cephalus* during feeding period and their distributions according to Divizios and Phylums have been showed in figure 3. According to this; Total feeding it was determined that nutrition, (14651) 97.33% was Bacillariophyta, (53) 0.35% was Chlorophyta, (33) 0.22% Cyanophyta as vegetal nutrients and (72) 0.48% was Arthropoda, (179) 1.20% was *Mollusca* as animal nutrients. As a result, it was determined that feeding organism was consist of 33 various genus which of 26 belonging Plantae and 7 belonging Animalia. As a result, it was determined that the total feeding organism, (14737) 98.32% was vegetal origin and (251) 1.68% was animal origin.

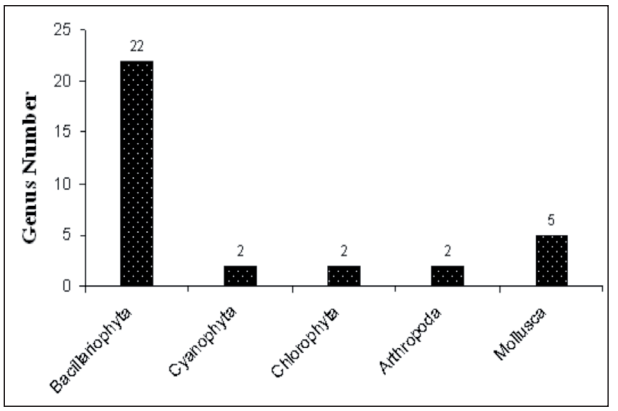

Figure 2: Feeding organisms' distributions determined in stomach content of *Mugil cephalus* during the feeding period according to Divizios and Phylums.

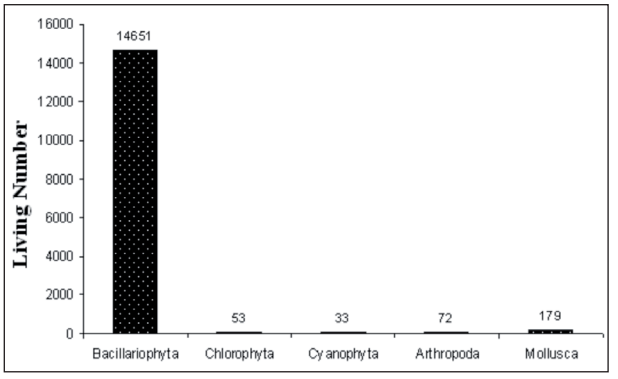

Figure 3: Total organism numbers' distributions were determined in stomach content of *Mugil cephalus* during the feeding period according to Divizios and Phylums.

Feeding organisms' numbers counted throughout research period have been determined by the total and each of genus percentage and their amounts according to importance rows within these nutriment groups have been showed below. According to this; Each of genus percentage have been determined as *Gomphonema* (14.98%), *Nitzschia* (14.74%), *Surirella* (14.43%), *Cocconeis* (13.29%), *Pinnularia* (9.38%), *Navicula* (6.61%), *Synedra* (6.11%), *Cymbella* (3.06%), *Diploneis* (2.68%), *Gyrosigma* (2.24%), *Diatoma* (1.93%), *Coscinodiscus* (1.43%), *Amphora* (1.16%), *Cyclotella* (1.19%), *Rhoicosphaenia* (0.92%), *Cymatopleura* (0.86%), *Tabellaria* (0.82%), *Opephora* (0.70%), *Bivalvia* (0.60%), *Gastropoda* (0.58%), *Entomoneis* (0.48%), *Gammarus* (0.32%), *Stauroneis* (0.26%), *Melosira* (0.22%), *Scenedesmus* (0.21%), *Achnantes* (0.16%), *Diptera* (0.16%), *Oscillatoria* (0.14%), *Pediastrum* (0.14%), *Anabaena* (0.07%). In the feeding of individuals who have different lengths according to different age groups have not been seen as an important diversity.

The feeding organisms' total numbers preferred by *Mugil cephalus* according to months have been determined and it has been showed in table 1 and figure 4. The feeding organisms' total numbers counted and determined according to months during the feeding period of *Mugil cephalus* have been showed in table 2. The feeding organisms' total numbers preferred by *Mugil cephalus* according to seasonal periods during the

Table 1: The feeding organisms' total numbers preferred by *Mugil cephalus* according to months.

Fish Number (n)	Months	Varied feeding organisms' total numbers
10	June	2058 (13.73%)
10	July	572 (3.81%)
10	August	254 (1.69%)
10	September	710 (4.73%)
10	October	1838 (12.26%)
10	November	1321 (8.81%)
10	December	412 (2.74%)
10	January	744 (4.96%)
10	February	597 (3.98%)
10	March	1193 (7.95%)
10	April	2998 (20%)
10	May	2291 (15.28%)

feeding period have been showed in table 3. The feeding organisms preferred most by *Mugil cephalus* according to age group have been determined and it has been showed in table 4.

4. Discussion

There were no empty stomachs in the *M. cephalus* species caught during the research. However there were too few organisms in the stomachs of the *M. cephalus* species caught in July, August and September. Similar situations were seen in the stomach content analysis by Rueda (2002) and Wells (1984).

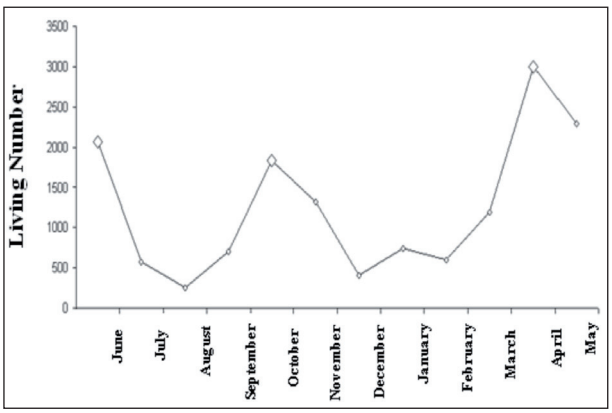

Figure 4: The feeding organisms' total numbers during feeding period of *Mugil cephalus* according to months.

Table 2: The feeding organisms preferred most by *Mugil cephalus* according to months

Months	Feeding organisms preferred most by *Mugil cephalus*
June	*Nitzschia, Pinnularia*, *Cocconeis, Gomphonema, Surirella*
July	*Nitzschia, Navicula*, *Cymbella, Cocconeis, Rhoicosphaenia*
August	*Nitzschia, Navicula*, *Cymbella, Coscinodiscus, Gomphonema*
September	*Synedra, Navicula, Cocconeis, Cymbella, Tabellaria*
October	*Gomphonema, Cocconeis, Surirella*
November	*Gomphonema, Cocconeis, Surirella*
December	*Synedra*, *Gomphonema*, *Navicula*, *Surirella*
January	*Surirella, Diploneis, Nitzschia, Navicula, Cyclotella*
February	*Pinnularia, Gyrosigma, Nitzschia, Navicula, Diploneis*
March	*Diploneis, Pinnularia, Gyrosigma, Nitzschia, Navicula*
April	*Nitzschia, Gomphonema, Synedra, Cocconeis*
May	*Nitzschia, Gomphonema, Cocconeis, Surirella, Pinnularia*

Table 3: The feeding organisms' total numbers preferred by *Mugil cephalus* for each one of the months according to seasonal periods during feeding.

The period found organism most as number	March (1193) April (2998) May (2291)
The period found organism least as number	July (572) August (254) September (710)
The period found organism most as variety	March (1193) April (2998) May(2291)
The period found organism least as variety	July (572) August (254) September (710)

Table 4: The feeding organisms preferred most by *Mugil cephalus* according to age group.

Age	Feeding organisms preferred most by *Mugil cephalus*
I	*Nitzschia, Navicula, Pinnularia, Surirella, Synedra*
II	*Nitzschia,Cocconeis, Gomphonema, Surirella, Pinnularia, Synedra*
III	*Nitzschia, Gomphonema, Surirella, Synedra, Cocconeis*
IV	*Pinnularia, Nitzschia, Gomphonema, Surirella, Cocconeis*
V	*Cymbella*, *Navicula, Gomphonema, Surirella, Synedra, Diploneis*

Many researchers have been reported that if temperature increases during summer term, the digestive systems of fishes can be fasted and hence there were more few organisms in the stomachs of the fish. Besides Yılmaz and Solak (2003) have been reported that temperature, digestion velocity and oxygen have limiting effects on feeding of fish. Our findings are similar as their investigations.

Consequently, during the studies large amount of mud and Stone pieces were found in the stomach contents of *M. cephalus* specimens. According to Rueda (2002) and Wells (1984) the most important foods of these fishes are detritus. Because they have thin teeth and farinks, when they get to make fitler soft-organic detritus, they also swallow a litle amount mud.

M. cephalus species are omnivor fish. In their macroscopic and microscopic stomach content analyzes it has been found out less zooplankton such as Mollusca (*Bivalvia* (*Pisidium*)), Gastropoda (*Limnaea, Planorbis, Valvata, Conus*) and Arthropoda (İnsecta (*Diptera*))

larvas, Crustacea (Amphipoda (*Gammarus*) but much more phytoplankton such as (Bacillariophyta, Cyanophyta, Chlorophyta,). Similar situations were seen in the stomach content analysis by Rueda (2002) and Wells (1984).

In the result of stomach content analyzes of *M. cephalus* was determined that nutrition of the total food was 97.91% phytoplankton and was 2.09% zooplankton. Because in the result of stomach content analyzes of *M. cephalus* were phytoplankton much more than 90% that nutrition of total food. *M. cephalus* species swallow everything. Similar situations were seen in the stomach content analysis by Rueda (2002).

Undigested and unidentified organism pieces were found in stomach contents of *M. cephalus*. There are many reasons to have found these unidentified animal organism pieces and some spineless organisms in the stomach contents. The most important reason is that after it was caught, fish don't die fast and its digestion continued so it was impossible to detect nourishment organisms. At the same time, it should be remembered animal organisms be digested in shorter terms than plant organisms Polat and Yılmaz (1999).

Comparison of Food Choices According to Age Groups; *Nitzschia, Navicula, Pinnularia, Surirella* and *Synedra* were consumed most by Group of age I *M. cephalus* species. *Nitzschia, Cocconeis, Gomphonema, Surirella, Pinnularia* and *Synedra* were consumed most by Group of age *M. cephalus* species. *Nitzschia, Gomphonema, Surirella, Synedra, Cocconeis* were consumed most by Group of age III *M. cephalus* species. *Pinnularia, Nitzschia, Gomphonema, Surirella, Cocconeis* were consumed most by Group of age IV *M. cephalus* species. *Cymbella*, *Navicula, Gomphonema, Surirella, Synedra, Diploneis* were consumed most by Group of age V *M. cephalus* species.

Food variety samples found most in stomach contents of *M. cephalus* species according to months; In June month; *Nitzschia, Pinnularia*, *Cocconeis, Gomphonema, Surirella*, in July month; *Nitzschia, Navicula, Cymbella, Cocconeis, Rhoicosphaenia*, in August month; *Nitzschia, Navicula, Cymbella, Coscinodiscus, Gomphonema*, in September month; *Synedra, Navicula, Cocconeis, Cymbella, Tabellaria*, in October month; *Gomphonema, Cocconeis, Surirella*, in November month; *Gomphonema, Cocconeis, Surirella*, in December month; *Synedra, Surirella, Gomphonema, Navicula*, in January month; *Surirella, Diploneis, Nitzschia, Navicula, Cyclotella*, in February month; *Pinnularia, Gyrosigma, Nitzschia, Navicula, Diploneis*, in March month; *Diploneis, Pinnularia, Gyrosigma, Nitzschia, Navicula*, in April month; *Nitzschia, Gomphonema, Synedra, Cocconeis,* in May month; *Nitzschia, Gomphonema, Cocconeis, Surirella, Pinnularia* were consumed most by *M. cephalus* species.

According to these results; the permanent food organism of *M. cephalus* species were indicated below. *Nitzschia, Cocconeis, Gomphonema, Navicula, Pinnularia*, *Surirella*, *Cymbella, Rhoicosphaenia, Coscinodiscus, Synedra, Tabellaria*, *Diploneis* and *Cyclotella* continually were consumed most by *M. cephalus* species.

According to Rueda (2002); *Cyclotella*, *Cocconeis*, *Diploneis*, *Navicula*, *Nitzschia*, *Amphora*, *Tabellaria* were consumed constantly by *M. cephalus* species. According to Wells (1984); *Cocconeis*, *Fragilaria*, *Gomphonema*, *Melosira* were consumed constantly by *M. cephalus* species. These results are very similar with our results but there were some differences because of local and climate diversity.

The food organism's numbers and variety found most in stomach contents of *M. cephalus* species according to months and periods; The food organism's number and variety consumed by *M. cephalus* species have decreased in July, August and September months but have increased in April, May and June months. These results showed that if the water temperature increases, digestion and excretion can increase in fish besides food organisms' number and variety decrease because of unsuitable environment conditions such as high temperature and saltiness however in spring; because environment conditions are suitable for food organisms consumed by fish, the food organism's number and variety increase in this month. In addition to these; because the feeding period of *M. cephalus* species are between April and June months, food organism have been found intensively in this period. Similar situations were seen in the Stomach Content of *M. cephalus* researched by Wells (1984) and Rueda (2002). These results support our thesis to be similar with our results but the differences of food organism's number and variety seen in some months result in different locality.

The average food organisms' numbers of *M. cephalus* species according to months have been examined and some differences have been found. In spite of this; there has been seen similarity with the average food organisms' numbers of *M. cephalus* species examined according to

period. The average food organisms' numbers of *M. cephalus* species according to months have been showed below.

The average food organisms' numbers of *M. cephalus* species calculated within 1 cm^3 stomach content solution. Consequently the average food organisms' numbers have been found as in March 119.3, in April 299.8, in May 229.1, in June 205.8. The average food organisms' numbers have increased in these months but the average food organisms' numbers have been found as in July 57.2, in August 25.4, in September 71 and have decreased. This showed that the digestion system of fish speeds up during summer period. Moreover, the reproduction periods of *M. cephalus* species are during between June and August months. Hence, it has been thought that the food organisms in stomach content of *M. cephalus* species decreased in these months. However, because the feeding periods of *M. cephalus* species are during between March and June months, it has been thought that the food organisms have been found abundantly during between April and June months. Besides, food organisms increase in these months, because of suitable environment conditions. The average food organisms' numbers have been found as in October 183.8, in November 132.1. Food organisms again have increased in these months, because in autumn, environment conditions are suitable for fish and aquatic food organism. Then, the average food organisms' numbers have decreased as in December 41.5, in January 74.4, in February 59.7. Food organisms have decreased in these months, because of unsuitable environment conditions.

As a result, it was determined that the stomach content of *M. cephalus* species were consist of 33 various genus which of 26 belonging plantae and 7 belonging animalia. Total feeding it was determined that nutrition, 97.33% was Bacillariophyta, 0.35% was Chlorophyta, 0.22% Cyanophyta and 2.09% was animal nutrients.

Gastropod, Insecta, Bivalvia and Crustacea as stated by Wells (1984) and Rueda (2002)'s researchs have been seen as food varieties of *M. cephalus* species. Besides pieces of plants and algae have often been seen. However, Nematod and Polychate haven't been seen. As this reason; it has been thought that there are areas and climate differences. Stomach content analyses were made to examine food varieties. These analyses were used only in number and availability frequencies. These weren't wrong and reliable for finding food varieties of fish. At the same time, it is more suitable to carry on information on food varieties of fish and to calculate Geometric Index of Importance food varieties. As a result, zooplankton and phytoplankton organisms such as *Navicula, Nitzschia, Melosira, Cyclotella, Gyrosigma, Cymbella, Cocconeis* and *Crustacea, İnsecta, Bivalvia* should be available in the environment to grow *M. cephalus* species.

If *M. cephalus* species are grown according to age groups; *Nitzschia, Navicula, Pinnularia, Surirella,* and *Synedra* most should be available in the environment for I age *M. cephalus* species. *Nitzschia, Cocconeis, Gomphonema, Surirella, Pinnularia* and *Synedra* most should be available in the environment for II age *M. cephalus* species. *Nitzschia, Gomphonema, Surirella, Synedra* and *Cocconeis* most should be available in the environment for III age *M. cephalus* species. *Pinnularia, Nitzschia, Gomphonema, Surirella* and *Cocconeis* most should be available in the environment for IV age *M. cephalus* species. *Cymbella*, *Navicula, Gomphonema, Surirella, Synedra* and *Diploneis* most should be available in the environment for V age *M. cephalus* species. If these kinds of food are available in the environment, it is faster for fish to grow faster accordingly this will increase income.

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References

1. Alpbaz, A.; Hoşsucu, H., 1996: İç Su Balıkları Yetiştiriciliği, No: 12, Ders Kitapları Dizin No: 3, Ege Üniversitesi Su Ürünleri Fakültesi Yayınları, İzmir, 1–222.
2. Cihangir, B.; Benli, H. A.; Cirik, Ş.; Ünlüoğlu, A.; Sayın, E., 1998: Bio-Ecologic Characteristics of Gökova Bay (in Turkish). The Symposium of Environmental Problems in Bodrum Peninsula, Bodrum, pp. 647–662.
3. Ekingen, G., 1983: "Munzur Çayı Alabalığı'nın Doğal Beslenme Olanakları", E. Ü. Faculty of ScienceJournal Series B, C.1, 120–129.
4. Fitzpatrick, J., 1983: Freshwater Crustacea, U. S. A, 220 p.
5. Lagler, K. F., 1956: Freshwater Fishery Biology, WM. C. Brown Compony Publishers, Dubuque, Iowa, 1–421.
6. Lehmkuhl, M. D., 1979: How to Know the Aquatic Insects. W. M. C. Brown Company Publisher, Iowa, 168 p.
7. Nilsson, A., 1996: Aquatic Insects of North Europe (A Taxonomic Handbook) Volume I, Apollo Books, Stensrup, Denmark, 274 p.

8. Polat, N.; Yılmaz, M., 1999: Suat Uğurlu Baraj Gölün (Çarşamba-Samsun)' de Yaşayan *Chondrostoma regium* (Heckel, 1843) (Pisces: Cyprinidae) Populasyonunun Sindirim Sistemi İçeriği. Doga Tr. J. Zool. 23, Ek sayı 2, 679–693.
9. Prescott, G. W., 1973: Algae of the Western Great Lakes Area, WM. C. Brown WM. C. Brown Company Publishers Dubugue, Iowa.
10. Rueda, S. P., 2002: Stomach Content Analysis of *Mugil cephalus* ve *Mugil curema* (Mugiliformes: Mugilidae) With Emphasis on Diatoms in the Tamiahua Lagoon, Meksico Rev. Biol. Trop. 50 (1): 245–252.
11. Ulmer, G., 1961: Die Süsswasserfauna Deutschlves, Trichoptera, Berlin, 201 p.
12. Wells, R. D. S., 1984: The Food of The Grey Mullet (*Mugil cephalus* L., 1758)' in Lake Waahi and The Waikato River at Huntly. New Zealland Journal of Marine and Freshwater Research, Vol. 18: 13–19.
13. Yılmaz, F.; Solak, K., 1999: Dicle Nehrin' de Yaşayan *Capoeta trutta* (Heckel, 1843)' nın Beslenme Organizmaları ve Bu Organizmaların Aylara ve Yaşlara Göre Değişimleri. Doğa Tr. J. of Zoology, 23, Eksayı 3, 973–978.