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# Feeding Ecology of the Topmouth Gudgeon *Pseudorasbora parva* (Temminck and Schlegel, 1846) in the Gelingüllü Reservoir, Turkey

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**Abstract**

*Pseudorasbora parva* (Temminck and Schlegel, 1846) is widely distributed in rivers and lakes of Turkey owing to accidental introductions. Turkey is rich in biodiversity of freshwater fish and has a high level of endemicity of native ichthyofauna, which is vulnerable to such introductions. The Gelingüllü Reservoir located on the Kızılırmak drainage in Central Anatolia has rich ichthyofauna with native and introduced fish species, including endemic species. The contents of the foregut of *P. parva* samples collected between Summer 2003 and Summer 2005 were examined. Seasonal and ontogenetic changes in feeding intensity were determined. *P. parva* mainly feeds on zooplankton such as Cladocera, Copepoda, and Rotifera. Members of the Bacillariophyta and Cyanobacteria were identified in high proportions in the foregut contents of *P. parva* particularly during summer. The feeding traits of this invasive fish may have an influence on the establishment of a successful population in Gelingüllü reservoir.

*Keywords*: Ecology, feeding, Gelingüllü, invasive, *Pseudorasbora parva.*

**Türkiye'de Gelingüllü Barajı'nda Yaşayan *Pseudorasbora parva* (Temminck and Schlegel, 1846) Bireylerinin Beslenme Ekolojisi**

**Özet**

*Pseudorasbora parva* (Temminck and Schlegel, 1846) Türkiye'deki göl ve akarsulara istenmeden karışarak geniş bir dağılım gösterir. Türkiye tatlı su balık çeşitliliği bakımından doğal ihtiyofauna elemanları arasında bu şekildeki istilacıların hassaslaştıracağı çok sayıda endemik tür içerir. Gelingüllü Barajı Orta Anadolu'da Kızılırmak üzerinde yer alır ve endemik türler de dahil olmak üzere doğal ve istilacı türler ile zengin bir ihtiyofaunaya sahiptir. *P. parva* örneklerinin ön bağırsak içerikleri 2003-2005 arasında toplanan örneklerde incelendi. Beslenme şiddetindeki mevsimsel ve ontogenetik değişiklikler belirlendi. *P. parva* bireyleri başlıca Cladocera, Copepoda ve Rotifera gibi zooplanktonlarla beslenmektedirler. Yaz boyunca *P. parva* bireylerinin ön bağırsaklarında yüksek oranda Bacillariophyta ve Cyanobacteria üyelerine rastlandı. Bu istilacı balık türünün Gelingüllü Barajında başarılı bir populasyon kurmasında beslenme özellikleri etkili olabilir.

*Anahtar Kelimeler*: Ekoloji, beslenme, Gelingüllü, istilacı, *Pseudorasbora parva.*

## Introduction

The topmouth gudgeon *Pseudorasbora parva* (Temminck and Schlegel, 1846), a small cyprinid, is native to East Asia. Since the 1960s, the distribution area of *P. parva* has rapidly expanded to Europe and North Africa. Populations of this species were recorded throughout the western region of Turkey only during the past 20 years (Ekmekçi and Kırankaya, 2006). *P. parva* has been regarded as a pest, which competes with native species for prey and habitat (Carpentier *et al*., 2008; Britton *et al*., 2007). Therefore, investigations regarding population control of this species have been undertaken in Europe (Britton and Brazier, 2006; Britton *et al*., 2009). Turkey has many endemic freshwater fish species and a rich biodiversity (Fricke *et al*., 2007). Therefore, the freshwater ichthyofauna of Turkey is vulnerable to invasive species. The rapid dispersion of *P. parva* throughout Anatolia may cause a threat to the endemism and diversity of the ichthyofauna in this region (Ekmekçi and Kırankaya, 2006). Characterization of the feeding ecology of an exotic invasive species collected from the natural habitat may facilitate the development of reliable solutions to mitigate undesirable effects on the natural ecosystems. Knowledge about the feeding traits of this species may provide valuable information about feeding competition among native and non-native fish species. The feeding intensity, breadth of diet, variability with regard to prey organisms, and intra-specific competition may provide valuable data about the biological flexibility of a prominent invader. Among the biological capacities of the invasive species, feeding flexibility is an important factor (Williamson and Fitter, 1996). Information about the feeding habits of *P. parva* is scarce (Wolfram-Wais *et al*., 1999). A detailed study may contribute to our knowledge about the feeding ecology of this invasive species. The purpose of this study was to examine the diet composition, feeding intensity, and the ontogenetic and seasonal diet composition of *P. parva* at the reservoir of the Gelingüllü Dam in Turkey.

## Materials and Methods

### Study Area

The reservoir of the Gelingüllü Dam is located at an elevation of 1000 m on the Delice Stream of the Kızılırmak drainage in Central Anatolia (39º36′30″N 35º03′20″E), (Figure 1). The total surface area of the reservoir is 2.4 km$^2$ at the maximum water level. The average annual rainfall in central Anatolia is 380 mm (Ekmekçi and Kırankaya, 2004). The reservoir of the Gelingüllü Dam has a rich ichthyofauna with native and introduced fish species, including total number of five endemic species (Ekmekçi and Özeren, 2003; Ekmekçi and Kırankaya, 2004).

### Specimen Collection

*P. parva* specimens were collected by the local fisherman using scoop with a mesh size of 1 mm and by gill nets with a mesh size of 10 mm. Fisherman used the bread pieces for attracting the fishes. The specimens were immediately collected, killed and maintained on ice. We collect the specimens in the summer of 2003 (216), spring (56), summer (118) and fall (43) of 2004, spring (143) and summer (29) of 2005. The specimens were then weighed (to the nearest 1 mg), fork length, FL, measured (to the nearest 0.1 mm), and preserved in 70% alcohol in the laboratory. Then the entire gut was dissected and preserved in 70% alcohol until analyses. The intestine was removed and measured to the nearest 0.01 mm. The gut was weighed to the nearest 0.01 mg. The contents of the gut were removed, and the empty gut was reweighed (to the nearest 0.01 mg). The volumes of the gut contents were measured using a graduated measuring device (to the nearest 1 ml) (Hyslop, 1980) and 10 ml of 70% alcohol was added. Gut contents were identified using a dissecting microscope for macro-organisms. A Sedgewick–Rafter counting chamber was used to identify and count smaller organisms under the 4× and 10× binocular microscopes. Because of digestion, some food items could be recognized by small fragments, in that condition, the countable particular body parts resistant to digestion were counted (Hyslop 1980).

### Gut Contents Analyses

The gut contents analyses employed a number of

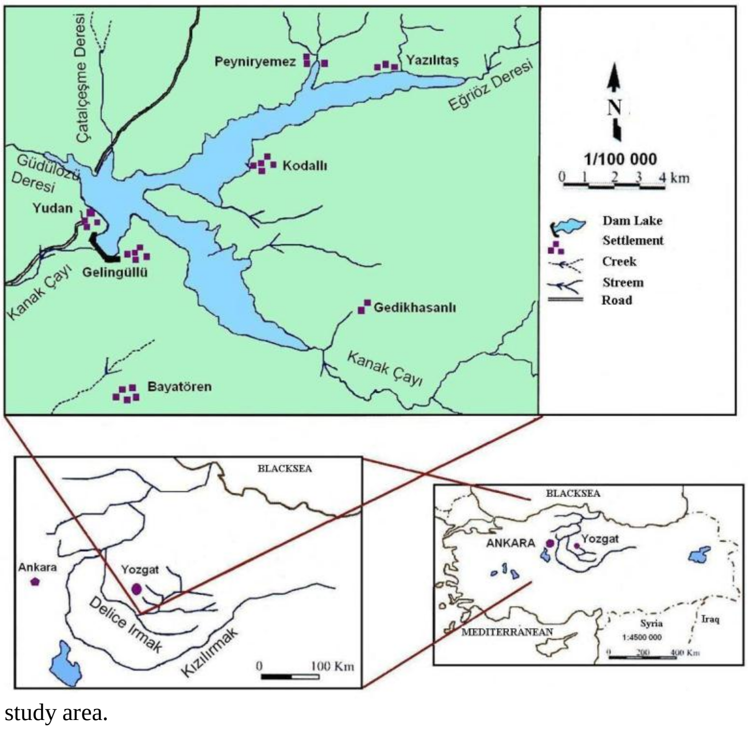


**Figure 1.** The map of study area.

measures. The vacuity index (%VI) is the percentage of empty guts. The number of guts containing at least one individual from each food category was recorded. This number was expressed as a percentage of all those containing food (%F). The percentage of abundance (%N) is the percentage of the total number of a particular prey item in relation to the total number of all prey items. The volumetric percentage (%V) is the percentage of volume of a particular prey item in relation to the total volume of all prey items. In addition, the index of relative importance and its percentage were calculated according to the formulas below (Hyslop, 1980; Cortes, 1997):

$$IRI_i = (\%N_i + \%V_i) \times \%F_i$$

$$\%IRI i = 100\ IRI i / \sum_{i=1}^{n} IRI i$$

Niche breadth for utilization of prey resources was calculated according to the Shannon–Wiener index (Krebs, 1989):

$$H = -\sum p i \times ln\ p i$$

where p$i$ is the proportion of a specific prey category for 'n' categories of prey. Trophic diversity H' was calculated by using %IRI values (Carrason *et al*., 1992). In addition, the total number of species in the contents of the gut was counted as species richness (S). Evenness (E) was calculated using the following formula:

$$E = H/log( S )$$

The evenness is typically indicated on a scale ranging from near 0 to 1. Low and high evenness values indicate high single-species dominance and equal abundance of all species, respectively (Routledge, 1980; Alatalo, 1981; Stirling and Wilsey, 2001).

The diet specialization degree is indicated as diet breadth ($B_i$,) Ludwig and Reynolds 1988; Rosas-Alayola *et al*., 2002):

$$B_i = 1/\Sigma p_i^2$$

where ($p_i$) is the proportion in numbers of prey species (i). Low ($1 < B_i < 2$), medium ($2.1 < B_i < 3$), and high values ($B_i \geq 3$) represent specialized, less specialized, and generalist feeders, respectively.

For computation of the relative amounts of intra-specific competition, the Schoener index was used (Schoener, 1970):

$$PSI_{xy} = 1\text{-}0.5(\Sigma|P_{xi} - P_{yi}|)$$

where $PSI_{xy}$ is the present similarity index and $P_{xi}$ and $P_{yi}$ are the proportions of %IRI ($i$) in the diet of the groups being compared on the basis of length. The *P. parva* specimens were grouped into 9 size classes for the analysis of the intra-specific competition among various size classes. The index ranged from a value of 0.0 to 1.0 and was considered biologically significant when the index exceeded 0.60.

The mean FL of the specimens which have empty gut and the mean FL of the specimens which have full gut were compared using ANOVA. The Kruskal–Wallis test was applied to determine the presence of a statistically meaningful effect of %IRI with respect to sizes of the fish and the seasons (Sokal and Rohlf, 1995).

## Results

A total of 605 specimens were investigated. The values for mean fork length, weight, and gut length of the specimens (± standard deviation [with minimum-maximum]) were 49.0±21.0 mm (1.1-89.2), 71.9±12.2 g (23.1-89.2) and 50.7±14.4 mm (2.2-93.9), respectively (Table 1).

### Feeding Intensity

The %VI values for the female, male, immature specimens and all fish were 52.2%, 49.2%, 9.1% and 48.4%, respectively. There was not any difference between the fork lengths of the specimens which had empty guts and that of the specimens which had full guts ($F=0.18$; $P>0.05$).

The %VI of *P. parva* specimens changed seasonally (Table 2). In general, the %VI was high in summer months. The %VI was found to be the highest during the summer 2003 (67.1 %) in various size classes.

### Overall Diet Composition

Eighty-nine food organisms were identified and counted in the gut contents of *P. parva*. Some of the food organisms were found in small numbers. The species diversity of all samples pooled was calculated as 0.88 with an evenness value of 0.25. The overall

**Table 1.** The mean fork length, weight, and gut length of members of both the sexes

| | Fork Length (mm) | | Weight (g) | | Gut length (mm) | |
|---|---|---|---|---|---|---|
| | Female N = 23 | Male N = 562 | Female N = 23 | Male N = 562 | Female N = 10 | Male N = 298 |
| mean ± SD | 14.7±13. | 50.7±19.0 | 47.6±10.3 | 73.6±10.0 | 27.7±15.2 | 49.42±13.7 |
| min/max | 2.1-59.8 | 1.9-89.2 | 28.7-73.1 | 30.2-89.2 | 13.0-60.3 | 11.0-93.9 |

**Table 2.** Seasonal variation of vacuity index of specimens collected from the reservoir of the Gelingüllü Dam with respect to different size classes (number of specimens is given in brackets)

| Size classes, cm/Seasons | Summer 2003 | Spring 2004 | Summer 2004 | Fall 2004 | Spring 2005 | Summer 2005 | All seasons |
|---|---|---|---|---|---|---|---|
| 0.01-0.99 | 71.4 (7) | 35.3 (17) | 9.1 (11) | 0.0 (1) | | | 33.3 (36) |
| 1.00-1.99 | 61.5 (26) | 22.2 (18) | | | 100.0 (1) | | 46.7 (45) |
| 2.00-2.99 | 62.5 (40) | 27.3 (11) | 0.0 (1) | 100.0 (1) | 100.0 (1) | | 55.6 (54) |
| 3.00-3.99 | 71.4 (56) | 0.0 (2) | 0.0 (1) | | | | 67.8 (59) |
| 4.00-4.99 | 66.7 (48) | | 7.7 (13) | | | 0.0 (1) | 53.2 (62) |
| 5.00-5.99 | 74.1 (27) | 0.0 (4) | 11.8 (34) | 61.5 (13) | 34.4 (32) | 57.1 (7) | 40.2 (117) |
| 6.00-6.99 | 60.0 (10) | 0.0 (3) | 28.6 (42) | 50.0 (22) | 50.0 (72) | 50 (8) | 43.9 (157) |
| 7.00-7.99 | 100.0 (1) | 0.0 (1) | 33.3 (15) | 40.0 (5) | 63.6 (33) | 72.7 (11) | 56.1 (66) |
| 8.00-8.99 | 0.0 (1) | | 100.0 (1) | 100.0 (1) | 25.0 (4) | 100.0 (2) | 55.6 (9) |
| All size classes | 67.3 (216) | 28.3 (56) | 20.0 (118) | 52.5 (43) | 49.6 (143) | 61.5 (29) | |

diet breadth indicated that this species was a specialist ($B_i$ = 1.78) in the reservoir of the Gelingüllü Dam. As shown in Table 3, the main prey of *P. parva* were cyanobacteria and insects. Cyanobacteria were encountered in high numbers and frequency in the gut contents. Members of the class Insecta were also found at high percentages of relative importance in the gut contents. Other diet organisms of *P. parva* members included photosynthetic algae, crustaceans, rotifers, worms, and fish remains. Crustaceans such as members of the Cladocera, Malacostraca, Copepoda were also notable (Table 3).

Diptera larvae (% IRI: 19.72I) and Chironomid larvae (% IRI: 0.94) were found at both high volume and frequency among the insects. Members of Hymenoptera (Carebara, Formicoidea), Collembola, Heleidae (Diptera), and Coleoptera (Hydrophilidae) were also included in the diet.

Among the members of the Cladocera, the genus *Bosmina* were the most common prey with a %IRI value of 1.3.The other species included in the diet from this order were *Alona* sp., *Bosmina* sp., *Chydorus* sp., *Ceriodaphnia* sp., *Daphnia* sp.

Rotifers were also identified in the diet, including *Asplanchna* sp., *Brachionus* sp., *Colurella* sp., *Kellicottia longispina, Keratella cochlearis, Keratella quadrata, Keratella* sp., *Keratella ticinensis, Lecane* sp., *Lapedella* sp., *Trichocerca brachyura,* and *Testudinella* sp. However, no significant differences in the percentages of IRI of these organisms were noted, although the frequencies of *K. quadrata* and *Asplanchna* sp. in the gut contents were slightly high. Many unidentified rotifers were also found in the gut contents. Cyanobacteria were commonly encountered in the gut contents. In particular, *Oscillatoria* sp. 2 (3.6×10 μ) was the dominant cyanobacterium among the members of the *Oscillatoria* genus. Other cyanobacteria encountered in the diet were *Gomphosphaeria* sp., *Merismopedia* sp. and *Spirulina* sp.

Among the members of the Chlorophyceae class, *Pediastrum* sp. was found to have the highest %IRI value in the gut contents. *Actinastrum* sp., *Cerasterias* sp., *Cosmarium* sp., *Eudorina* sp., *Gloeocystis* sp., *Planktosphaeria* sp., and *Scenedesmus* sp. with various sizes of filamentous algae were the other genera from the Chlorophyceae found in the diet.

Various members of the Bacillariophyceae were found in the gut contents of *P. parva* at the reservoir of the Gelingüllü Dam. *Cymbella* sp. and *Nitzschia* sp. (400 μ) were the most abundant and frequently encountered organisms. *Amphora* sp., *Cocconeis* sp., *Caloneis* sp., *Cyclotella* sp., *Cymatopleura* sp., *Diploneis* sp., *Fragilaria* sp., *Gomphonema* sp., *Gyrosigma* sp., *Navicula* sp.1 (80 μ), *Navicula* sp. 2 (50 μ), *Navicula* sp. 3 (100 μ), *Nitzschia* sp. 1 (50 μ), *Nitzschia* sp. 2 (100 μ), *Nitzschia* sp. 3 (150 μ), *Nitzschia* sp. 4 (200 μ), *Stauroneis* sp., *Surirella* sp., and *Synedra* sp., were the other species found in the gut contents.

**Size Classes and Gut Contents**

A total of 89 different prey organisms were found in all examined specimens. However, only 20 prey organisms with a %IRI value greater than 1% are listed in Table 4. Diptera larva and *Oscillatoria* sp. 2 (3.6×10 μ) were found in all size classes. The percentage of IRI values of various size classes of *P. parva* were statistically different ($H$ = 111.05; df = 8; P<0.001). The species richness was the highest in the 7.0–8.0 cm size class and the lowest in the largest size class. With the exception of the members of the class 8.0–9.0 cm, the smaller individuals were found to have low species richness values compared to the larger individuals. Moreover, the smaller individuals were found to have fed on organisms with high single-species-dominance and high evenness values. However, it can be stated that the members of even the smallest group are generalists, as judged by the breadth of their diet ($B_i$ = 3). As shown in Table 4, instead of *Oscillatoria* sp. 2, which was the most abundant prey in the gut contents of other size classes of *P. parva*, *Cymbella* sp. and diptera larva were the main prey components in the smallest size class of *P. parva*.

Table 5 indicates the absence of dietary overlap between the members of the group with the smallest lengths and the other groups. The same results were

**Table 3.** Percentage distributions of prey organisms in the diet of *P. parva* in the reservoir of the Gelingüllü Dam

| Prey groups | %V | %F | %N | %IRI |
|---|---|---|---|---|
| Cyanobacteria | 9.014 | 30.449 | 99.622 | 74.174 |
| Insecta | 72.939 | 22.436 | 0.001> | 20.753 |
| Cladocera | 6.274 | 72.115 | 0.012 | 2.962 |
| Platyhelminthes | 4.480 | 2.885 | 0.001> | 1.346 |
| Malacostraca | 5.851 | 1.282 | 0.001> | 0.254 |
| Copepoda | 0.058 | 28.526 | 0.003 | 0.173 |
| Nematoda | 0.343 | 3.205 | 0.001> | 0.114 |
| Bacillariophyceae | 0.755 | 36.538 | 0.312 | 0.190 |
| Oligochaeta | 0.028 | 8.013 | 0.001> | 0.024 |
| Rotifera | 0.168 | 20.833 | 0.003 | 0.010 |
| Chlorophyceae | 0.085 | 23.077 | 0.040 | 0.008 |
| Dynophyceae | 0.001> | 6.731 | 0.006 | 0.001 |
| Ostracoda | 0.005 | 0.641 | 0.001> | 0.001> |
| Tardigrada | 0.001> | 1.603 | 0.001> | 0.001> |
| Euglenophyta | 0.001> | 0.962 | 0.001> | 0.001> |
| Fish vertebrae | 0.001> | 0.321 | 0.001> | 0.001> |
| Fish egg | 0.001> | 0.962 | 0.001> | 0.001> |

**Table 4.** The %IRI values of prey items (only more than 1%) in terms of size classes (cm) of *P. parva*

| | %IRI | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Diets | 0.01-0.99 | 1.00-1.99 | 2.00-2.99 | 3.00-3.99 | 4.00-4.99 | 5.00-5.99 | 6.00-6.99 | 7.00-7.99 | 8.00-8.99 |
| Platyhelminthes | 0.0 | 5.3 | 4.0 | 0.6 | 0.0 | 1.1 | 1.5 | <0.01 | 49.2 |
| Unidentified Malacostraca | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.6 | 0.0 |
| Amphipoda | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.2 | 0.3 | 2.0 | 0.0 |
| Adult Insecta | 0.1 | 2.4 | 0.2 | <0.01 | 0.0 | 0.1 | <0.01 | <0.01 | 0.1 |
| Diptera larvae | 28.8 | 17.1 | 26.5 | 18.4 | 1.1 | 2.4 | 30.0 | 39.3 | 0.0 |
| *Chironomus* sp. | 0.0 | 0.0 | 0.0 | 0.3 | 18.5 | 1.1 | 0.8 | 2.9 | 0.0 |
| Copepoda | 6.0 | 3.1 | 0.1 | <0.01 | <0.01 | 0.5 | <0.01 | <0.01 | <0.01 |
| *Alona* sp. | 2.5 | 0.1 | <0.01 | <0.01 | 0.0 | 0.3 | <0.01 | <0.01 | 0.0 |
| *Bosmina* sp. | 2.1 | 6.9 | 0.2 | 0.8 | 1.3 | 2.8 | <0.01 | <0.01 | 0.1 |
| *Chydorus* sp. | <0.01 | 0.0 | 0.0 | 0.0 | <0.01 | 0.2 | <0.01 | <0.01 | 1.3 |
| *Daphnia* sp. | 0.1 | 1.4 | <0.01 | <0.01 | 4.9 | 9.0 | <0.01 | <0.01 | 0.0 |
| Unidentified Cladocera | 1.9 | 2.3 | 0.4 | <0.01 | <0.01 | 1.0 | <0.01 | <0.01 | 0.2 |
| *Lecane* sp. | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | <0.01 | <0.01 | <0.01 | 0.0 |
| Unidentified Rotifera | 2.3 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.0 |
| *Cymbella sp.* | 50.5 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.1 | 0.1 | <0.01 |
| *Oscillatoria* sp.2 (3.6×10 μ) | 0.0 | 60.2 | 68.5 | 77.6 | 73.8 | 75.6 | 66.9 | 51.5 | 29.0 |
| *Oscillatoria* sp. 4 (2.5×20 μ) | 0.0 | 0.0 | <0.01 | 2.1 | 0.0 | <0.01 | 0.1 | 0.8 | 0.0 |
| *Oscillatoria* sp. 3. (12.5×4 μ) | 0.0 | 1.2 | <0.01 | 0.1 | 0.4 | <0.01 | <0.01 | 0.4 | 0.0 |
| Filamentous algae (12.5x50 μ) | 0.0 | 0.0 | 0.0 | 0.0 | <0.01 | 0.0 | <0.01 | <0.01 | 4.7 |
| Filamentous algae (30×150 μ) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 13.7 |
| H | 1.49 | 1.36 | 0.80 | 0.69 | 0.82 | 1.08 | 0.79 | 1.09 | 1.30 |
| S | 37 | 26 | 28 | 33 | 34 | 52 | 61 | 87 | 17 |
| E | 0.41 | 0.42 | 0.24 | 0.20 | 0.23 | 0.27 | 0.19 | 0.24 | 0.46 |
| $B_i$ | 3 | 2.49 | 1.85 | 1.57 | 1.72 | 1.72 | 1.86 | 2.37 | 2.88 |
| Numbers of *P. parva* | 25 | 24 | 24 | 19 | 29 | 70 | 88 | 29 | 4 |

**Table 5.** The $P_{xy}$ values (> 0.50 are indicated in bold) among the various size classes of *P. parva*

| Size class, cm | 1.00-1.99 | 2.00-2.99 | 3.00-3.99 | 4.00-4.99 | 5.00-5.99 | 6.00-6.99 | 7.00-7.99 | 8.00-8.99 |
|---|---|---|---|---|---|---|---|---|
| 0.01-0.99 | 0.24 | 0.27 | 0.19 | 0.03 | 0.07 | 0.29 | 0.31 | 0.00 |
| 1.00-1.99 | | 0.82 | 0.79 | 0.64 | 0.70 | 0.79 | 0.69 | 0.35 |
| 2.00-2.99 | | | 0.88 | 0.70 | 0.73 | 0.95 | 0.78 | 0.33 |
| 3.00-3.99 | | | | 0.76 | 0.80 | 0.86 | 0.71 | 0.30 |
| 4.00-4.99 | | | | | 0.82 | 0.69 | 0.56 | 0.29 |
| 5.00-5.99 | | | | | | 0.72 | 0.57 | 0.31 |
| 6.00-6.99 | | | | | | | 0.83 | 0.31 |
| 7.00-7.99 | | | | | | | | 0.29 |

also obtained for the group with the largest lengths.

**Seasonal Variation in the Gut Contents of *P. parva***

The diet of *P. parva* showed seasonal variation (Table 6). In spring 2004, plant organisms were absent from the diet. The %IRI values of *P. parva* diet showed a statistically significant seasonal variation ($H$=43.7; P<0.001). The Shannon diversity index was the highest in summer 2004, with high species richness, high evenness, and high diet breadth values. The fall season had the lowest diversity and highest dominancy in terms of the gut contents. Diptera larva was the most important food item in the diet during the fall.

## Discussion

Feeding intensity is negatively related to the percentage of empty stomachs (Bowman and Bowman, 1980). The high %VI value of 48.6% indicates that feeding intensity was low throughout the sampling period. Male individuals with lower %VI (37%) had higher feeding intensity than females (53%), at least for the specimens 0.01-2.0 cm in length in summer 2003 and spring 2004. The feeding intensity of the immature specimens was high in summer 2004. This is in accordance with the understanding that a higher feeding intensity is more commonly observed among smaller individuals (Grove and Crawford, 1980; Pallaoro *et al*., 2004). Seasonal variation was observed in feeding intensity. Several authors (Tyler, 1971; Jardas *et al*., 2004) pointed out that as a general trend the feeding intensity of fish declines with decreasing water temperature. However, this view was not consistent with the findings of this study, except for the summer of 2004. The high vacuity index values of the specimens in the summers of 2003 and 2005 could be explained by a high digestion ratio caused by the high temperature. The low feeding intensity probably resulted from the low mean temperature of 9.7°C during the nesting season in spring 2005.

*P. parva* is known to be carnivorous (Billard, 1997; Declerck *et al*., 2002) and is also known as a phytoplankton feeder (Hliwa *et al*., 2002). In their native habitats it was reported that juveniles of *P. parva* feed mainly on zoo-and phytoplankton as well as on other small crustaceans, diatoms and algae while adults feed on both planktonic and benthic organisms (Mukhatcheva, 1950 in Banarescu, 1999). Although there is limited information about the feeding of the introduced populations, isopods, plecoptera and trichoptera larvae as well as sponges and detritus were found among the stomach contents and it was concluded that *P. parva* is omnivorous hence eats any food at its disposal.

In this study, the members of Cyanobacteria

**Table 6.** The %IRI values of prey items (only more than 1%) in terms of season

| Diets | %IRI | | | | | |
|---|---|---|---|---|---|---|
| | Summer 2003 | Spring 2004 | Summer 2004 | Fall 2004 | Spring 2005 | Summer 2005 |
| | N = 71 | N = 44 | N = 94 | N = 20 | N= 72 | N = 11 |
| Platyhelminthes | 3.47 | | | 5.33 | 1.03 | |
| Nematoda | | 0.07 | 0.13 | 0.71 | 2.52 | |
| Unidentified Malacostraca | | | 0.36 | | | |
| Amphipoda | 0.16 | | 1.43 | | | |
| Oligochaeta | <0.00 | | 0.01 | <0.00 | 1.01 | |
| Adult Insecta | <0.00 | 2.37 | 0.09 | 0.04 | 0.19 | |
| Coleoptera-Hydrophilidae | | 0.40 | <0.00 | | | |
| Diptera larva | 11.59 | 60.27 | 9.62 | 91.55 | 25.00 | |
| *Chironomus* sp. | | 5.72 | 10.33 | | | |
| Copepoda | 0.01 | 4.14 | 0.44 | <0.00 | 0.03 | 1.26 |
| *Alona* sp. | 0.03 | | 0.27 | 0.03 | 0.13 | 5.03 |
| *Bosmina* sp. | 0.59 | 6.20 | 1.47 | 0.70 | 1.07 | 1.68 |
| *Chydorus* sp. | | | 0.02 | <0.00 | 0.47 | 2.52 |
| *Daphnia* sp. | <0.00 | 1.52 | 8.76 | 0.51 | 0.09 | |
| Unidentified Cladocera | <0.00 | 19.25 | 0.16 | 0.02 | 0.39 | 26.38 |
| *Cymbella* sp. | | | 1.97 | 0.46 | 0.01 | 0.07 |
| *Nitzschia* sp. 1 (50 μ) | <0.00 | | 0.02 | <0.00 | 0.21 | |
| *Nitzschia* sp. 2 (100 μ) | <0.00 | | 0.10 | 0.08 | 0.15 | <0.00 |
| *Nitzschia* sp. 5 (400 μ) | <0.00 | | 2.33 | <0.00 | 0.46 | 0.02 |
| *Oscillatoria* sp. 1 (5 × 5 μ) | 0.02 | | 6.45 | 0.01 | <0.00 | 61.76 |
| *Oscillatoria* sp.2 (3.6 × 10 μ) | 83.83 | | 55.57 | | 67.13 | |
| *Oscillatoria* sp. 4 (2.5 × 20 μ) | 0.15 | | 0.04 | 0.43 | | |
| *Oscillatoria* sp. 3. (12.5 × 4 μ) | 0.12 | | <0.00 | 0.06 | | |
| Filamentous algae (6 × 50 μ) | <0.00 | | | | | 1.28 |
| H | 0.58 | 1.27 | 1.6 | 0.41 | 0.98 | 1.08 |
| S | 19 | 11 | 47 | 21 | 30 | 14 |
| E | 0.20 | 0.63 | 0.42 | 0.13 | 0.29 | 0.41 |
| $B_i$ | 1.39 | 2.44 | 2.92 | 1.19 | 1.94 | 2.20 |
| Numbers of *P. parva* specimens | 71 | 44 | 94 | 20 | 72 | 11 |

The bold values indicate the dominant prey items were found to be rather important. The proportion of cyanobacteria cells was higher than the other components of the diet. If it is assumed that insect larvae and cladocerans live in mats of filamentous algae, *P. parva* may ingest these algae unwillingly. There is an interesting relationship between the relative importance of dominant food items, diptera larvae, and dominant cyanobacteria in terms of the seasonal composition of prey organisms. The %IRI of cyanobacteria was the highest in seasons with less numbers of diptera larvae. This feeding pattern could explain why *P. parva* members consume cyanobacteria as the dominant food item. Under conditions with a scarcity of main prey organisms, *P. parva* could ingest high amounts of cyanobacteria to indirectly consume more diptera larva. However, more data for the characterization of the feeding habitats of *P. parva* are needed to support this hypothesis. Another reason for the major uptake of cyanobacteria might be the availability of this organism. Plant materials tend to be identified more frequently than invertebrates in the gut contents of this species (Xie *et al*., 2000). The results of this study indicate that *P. parva* found in the reservoir of the Gelingüllü Dam is an omnivorous fish.

According to the data obtained in this study, if plant materials were not taken into consideration, the main prey organisms were insects, particularly diptera larvae, members of *Chironomus* genus. Planktonic Cladocera such as *Bosmina* sp., *Daphnia* sp., and other unidentified Cladocera were the secondary prey. Other prey groups, such as Rotifera, Copepoda, Malacostraca, Oligochaeta, Ostracoda, Tardigrada, fish, and fish eggs were of minor importance. The member of these taxa can be accepted as occasional prey. The previous data on the feeding habits of *P. parva* in Belgium, France, and China are in agreement with these findings (Billard, 1997; Declerck *et al*., 2002; Xie *et al*., 2000).

The magnitude of H (0.88) is lower than the usually recorded values [between 1.5 and 3.5 and rarely greater than 4.5 (Margalef, 1972)]. This indicates that only a few prey groups are relevant in the diet of *P. parva* in the reservoir of the Gelingüllü Dam. Smaller individuals feed on various prey organisms, particularly zooplankton such as copepods, cladocerans, and rotifers. Wolfram–Wais *et al*. (1999) indicated that *P. parva* members with lengths greater than 32 mm mainly fed on chironomid larvae and especially epiphytic species. Similarly, in our study, chironomids were not encountered in the gut contents of *P. parva* individuals smaller than 30 mm.

There was no dietary overlap between the smallest size class and the other classes. Diet overlap among the size classes was the lowest in the smallest size class. This low degree of overlap could be explained by early morphological differentiation (which occurs before the individuals reach a length of 25 mm) of *P. parva* (Zahorska *et al*., 2009). Smaller individuals may use alternative resources based on their morphology and are capable of eliminating the negative effects of intra-specific competition (Svanback and Bolnick, 2007). However, the high degree of overlap among the other size groups indicates that there might be an intra-specific competition among the consecutive size classes of *P. parva* when resources are limited. The diet of *P. parva* showed seasonal variations, as indicated by other studies (Wolfram–Wais *et al*., 1999; Xie *et al*., 2000). This variability could be a result of variable food availability in different seasons. The feeding plasticity of *P. parva* may have an important influence on the adaptive ability on establishing successful populations. Therefore, forementioned feeding traits of this invasive fish may have an influence on the establishment of a successful population in Gelingüllü reservoir.

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