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The Diel Changes in Feeding Activity, Microhabitat Preferences and Abundance of Two Freshwater Fish Species in Small Temperate Streams (Omerli, Istanbul)

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Abstract

We examined the abundance, food and microhabitat use of *Proterorhinus marmoratus* (Gobiidae) and *Cobitis vardarensis* (Cobitidae) during both day and night in two small temperate streams of the Black Sea region (North-West Turkey) between May and June 2005. Drift sampling catch per unit effort revealed significantly higher relative densities at night than during the day. Of the 110 fish captured during the seven sampling periods, 77 (88%) were *C. vardarensis* with the Bıçkı Stream having the most fish specimens both in frequency of occurrence and relative density. The main environmental variables that characterized the overall microhabitat use were velocity, light, depth, and proportions of cobbles. The fullness frequency of the gut contents was at their peak between 22:00 and 04:00 a.m and the most active feeding time was usually after midnight. Surface insects composed mainly of chirinomid larvae were the dominant food item for both species in the streams during the sampling period. Further studies are needed at multiple spatial scales to assess how habitat use and feeding habits varies with fluctuating population densities.

Keywords: Black Sea Region, chirinomid larvae, *Cobitis vardarensis*, feeding activity, *Proterorhinus marmoratus*, surface insects.

Ilıman Bölgelerdeki İki Küçük Derede (Ömerli, İstanbul) İki Tatlısu Balığının Bolluklarında, Mikrohabitat Seçimlerinde ve Beslenme Aktivitelerindeki Günlük Değişimler

Özet

2005 yılının ilkbahar ve yaz aylarında Karadeniz Bölgesi'nin (Kuzey-batı Türkiye) iki küçük ılıman deresinde gece ve gündüz süresince *Proterorhinus marmoratus* (Gobiidae) ve *Cobitis vardarensis* (Cobitidae) balıklarının habitat kullanımları, beslenmeleri ve bollukları incelendi. Sürüklenme örneklemesinin birim çaba başına düşen av miktarı, geceleri gündüze göre çok daha yüksek balık yoğunlukları olduğunu ortaya koydu. 7 örnekleme periyodunda yakalanan toplam 110 balıktan 77 tanesi (88%) *C. vardarensis*'ti ve bu tür Bıçkı deresinde hem ortaya çıkma frekansı hem de nispi yoğunluk açısından en çok birey sayısına sahipti. Mikrohabitat kullanımlarını tanımlayan en başlıca çevresel değişkenler akıntı hızı, ışık, derinlik ve büyük taşların oranı idi. Barsak içeriklerinin doluluk frekansları 22:00 ile 04:00 saatleri arasında en yüksekti ve en aktif beslenme zamanı çoğunlukla gece yarısından sonraydı. Başlıca chirinomid larvalarından oluşan yüzeyde bulunan böcekler örnekleme periyodu boyunca her iki tür için derelerdeki baskın besin maddesiydi. Çoklu uzamsal ölçeklerde yapılacak daha ileri çalışmalar bu balıkların değişen popülasyon yoğunluklarında beslenme alışkanlıklarının ve habitat kullanımlarının nasıl değiştiğini ortaya koymak için gereklidir.

Anahtar Kelimeler: Beslenme aktivitesi, chirinomid larvası, *Cobitis vardarensis*, Karadeniz Bölgesi, *Proterorhinus marmoratus*, yüzey böcekleri.

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INTRODUCTION

Distinct diel feeding patterns related to light periodicity are common among teleost fish, the food intake often being predominantly diurnal, nocturnal or crepuscular (Thorpe 1978). Such patterns are highly complicated and may include many factors such as predation risk (Metcalfe et al. 1999), prey availability (Glova et al. 1987), a range of environmental effects, (e.g., temperature, and day length: Fraser et al. 1995) potential for inter- or intraspecific competition (Keast and Welsh 1968) or capabilities of each fish species (e.g., dependence on

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vision for locating prey: Kreivi et al. 1999). Food and suitable physical habitat are among the most important limiting factors in stream fishes. Drift-feeding fish are often faced with predictable diel fluctuations in food availability in the form of drifting invertebrates (Elliott 1967). They are therefore faced with decisions about when is the optimal time to feed during each 24-h cycle (Metcalfe et al. 1999).

The characteristics of stream fish assemblages are also determined by several abiotic factors operating at multiple spatial and temporal scales (Matthews 1998). This would be the case for especially small streams in the Mediterranean climates such as Turkey, which suffer unpredictable seasonal drought events of greatly variable intensity from year to year (Tarkan 2010). The harsh conditions of the Mediterranean streams caused by summer droughts may act as a critical filter for their inhabitance by freshwater fish species (Magalhaaes et al. 2002). Furthermore, the streams in the Mediterranean climate have long suffered intense alterations due to the high water demand in densely populated areas (Hamdy et al. 1995). In addition, many rivers and streams in Turkey are now negatively affected by urbanization or other land uses and consequently heavily polluted (Tarkan 2010). Impoundment is also a widespread phenomenon in Turkey, and most large- and medium-sized watercourses are fragmented by large dams (Özuluğ et al. 2005). This structural, physical, and chemical deterioration of fluvial ecosystems is one of the main threats to Turkish freshwater fish fauna (Özuluğ et al. 2005), commonly acting synergistically with introduced species (Gaygusuz et al. 2007a).

Members of the Gobiidae and Cobitidae form an important component of the native freshwater fish fauna in Turkish and Europe streams (i.e. Geldiay and Balık 1996, Kottelat and Freyhof 2007), and yet diel feeding patterns are unknown for most species. The Tubenose goby, *P. marmoratus* is one the best studied species in this respect. This fish species has recently attracted scientific interest mostly due to its invading character in both North America and Europe (Danube section) with its potential impacts on native species and ecosystem function (Copp et al. 2005). It is believed that the activity of this species is greater at night (Eros et al. 2005), but, its diel feeding pattern is unknown. In addition, in its native distribution area (Black Sea Region), its ecology has been poorly studied (i.e. Tarkan et al. 2006, Gaygusuz et al. 2007b). Studies of diel feeding rhythms and habitat requirements in natural populations are laborious and, to our knowledge, no previous field studies of feeding periodicity of tubenose goby and Vardar spined loach *C. vardarensis* have been performed in their native lotic populations. Thus, the primary objective of this study was to examine the diel changes in feeding pattern, habitat preferences and abundance of these species, which are found dominantly in small streams of the Marmara Region of Turkey. Our specific objectives were to: (i) determine the relative densities and composition of these two species in two small streams which flow into Ömerli Reservoir during day and night; (ii) determine their diel feeding activity; and (iii) identify the principal environmental variables associated with these species-specific habitat use.

MATERIAL AND METHODS

Bıçkı and Eski Riva streams are relatively small and not heavily polluted. These streams are covered by dense plant cover and have a substratum dominated by gravel and sand. In their connection points with the Ömerli Reservoir, and the substratum is usually muddy due to silt, sand and organic particular. Both streams have a high variable flow which is fast in the winter and spring months, however, seasonal droughts were observed (Tarkan et al. 2009). The Ömerli Reservoir was established in 1972 to provide drinking water for city of Istanbul. The reservoir currently is the biggest drinking water reservoir in İstanbul (area= 23.5 km^2; maximum depth= 62 m; volume= 2.4 x 10^6 m^3; Latitude 41° 02' N, Longitude 29° 2' E). The reservoir provides nearby Istanbul with nearly 48% (mean= 872000 m^3 per day) of its drinking water, but the reservoir has been suffering from increased eutrophication over the last few decades due to the input of domestic and industrial waste water, which enter mainly via streams (Albay et al. 2003).

Sampling was undertaken on seven occasions between May and July 2005. Samples were collected using a net with an opening 0.24 m^2 (0.8 m width by 0.3 m depth) and a mesh size of 500 μm at 2-h intervals for 24 h. Relative density, i.e. catch per unit effort (CPUE), of both species was calculated for each sampling point and hour. On each occasion, a suitable stretch of the streams consisting of different

microhabitats was randomly chosen and divided into shorter stretches, each to be sampled once in that day. Immediately after capture, the fish were fixed in 4% formaldehyde and transported to the laboratory. In the laboratory, each individual was weighed with an accuracy to 0.01 g, and its total length was measured with accuracy to 1 mm. The fish were dissected and the alimentary canal was removed for further analysis of gut content. Gut content was weighed (to 0.0001 g accuracy) and placed in a gridded Petri dish to examine under a stereomicroscope. Each prey was identified at lowest possible taxonomic level (Rose and Tregouboff 1957, Mozdukhay 1969). Proportion of items in each gut was calculated by dividing the number of grids occupied by each food type by the total number of grids the contents covered. From the individual gut contents, we calculated the average proportion of different items consumed for each species.

At each discrete sampling point and hour, 14 microhabitat environmental variables were recorded, distance from bank (DiB), water depth (Dep), distance to nearest cover (DNC), bottom substratum type as a percentage of the point sample area (silt (%Si): <0.06 cm, sand (%Sa): 0.06-0.2 cm, gravel (%Gr): >0.2-4.0 cm, pebbles (%Pe): >4.0-6.4 cm, cobbles (%Co): >6.4 cm), percentage of submerged vegetation (Sve), percentage of roots or other ligneous matter (Lig), and percentage of overhanging cover. Water velocity (Vel) was determined semi-quantitatively according to Carter et al. (2004), using a dip-net pole; upon immersion of the pole, (1) absent: no ripple effect around the pole was noted as zero water velocity; (2) weak: a gentle ripple effect (broken water) around the pole (>0 but <5cm s^{-1}); (3) moderate: an elevated ripple effect around the pole (5-10 cm s^{-1}). Light intensity (lx) was measured to the nearest 1 lx using a Lutron LX 10^3 digital light meter and categorized as low (<5 lx), moderate (5-200) and high (>200). Temperature, dissolved oxygen, conductivity, total dissolved solids, and pH were measured *in situ* using a multi-parameter probe (Radiometer, Pioneer 65).

Electivity indices were calculated to determine preference or avoidance of fishes for environmental variables in the streams. Negative values approaching -0.5 indicate avoidance, and positive values approaching +0.5 indicate preference (Copp 1992). Deviations from expected occurrence of fishes and microhabitat categories were tested using the Fisher Exact test as were co-occurrences between fish species and size classes. Temporal differences in physical parameters were determined by Variance of Analysis (ANOVA). The CPUE data for day and night were compared using the Mann-Whitney U-test (Quinn and Keough 2002).

RESULTS

Physical Features and Sample Size

Some physical variables such as temperature, dissolved oxygen, conductivity, total dissolved solids and pH were not considered for statistical analyses as they were not significantly different between sampling stations and dates (ANOVA, $P>0.05$) only difference in the measured physical features revealed in the light intensity between evening (20:00) and night sampling (06:00) ($P<0.01$) (Table 1). The species, minimum, maximum, and averages of total length (cm) and weight (g) are given in Table 2. Of the 110 fishes captured during seven sampling periods, 77 (88%) were *C. vardarensis* with the Bıçkı stream having most fish specimens both in frequency of occurrence and relative density (i.e. CPUE data).

Diel Changes in Feeding Activity

Both species studied were found more frequently in night than in day samples. Similarly, the relative density of all individuals studied was significantly higher (Mann-Whitney U-test) at night than during the day (Fig. 1), both during spring ($P<0.01$) and summer ($P<0.001$). Initial analysis between fish and habitat relationships revealed basically similar patterns for night and day. Because of the small number of fish captured during the day than at night, further analysis of fish-habitat relationship was restricted to data collected at night (Fig. 2).

The fullness frequency of the gut contents peaked between 22:00 and 04:00 a.m. Before 22:00 and after 04:00 a.m., both studied species did not prefer to forage as their guts were almost empty. The most active feeding time was usually after midnight. This pattern was very similar for *C. vardarensis* in the two studied streams (Table 3-4).

In the Bıçkı Stream, detritus was the dominant food item in May (%62) and in June (%41) while surface insects dominated the diet of *C. vardarensis* in July. However, surface insects (mainly chirinomids) became the most abundant food in May (%80) and July (%40) and detritus (51.4%) in June for this fish

Table 1. Minimum, maximum and mean values of physical variables of Eski Riva and Bıçkı Streams between May and June 2005.

	Min.	Max.	Mean
(Bıçkı S.)	t/pH/D.O/TDS/Cond./l.	t/pH/D.O/TDS/Cond./l.	t/pH/D.O/TDS/Cond./l.
20.05.2005	17.50/9.10/15.8/132/265/<1	18.50/9.70/17.9/158/299/134	17.925/9.34/16.4/146/278/35.8
08.06.2005	19.00/8.70/10.8/94/189/<1	20.20/9.30/13.2/121/205/221	19.650/8.91/11.9/109/194/71.7
23.06.2005	17.90/7.20/13.2/109/249/<1	19.30/8.10/14.8/132/275/615	18.550/7.67/13.7/121/265/159.5
14.07.2005	22.30/7.70/11.2/145/312/<1	23.10/8.50/12.4/170/341/2120	22.725/8.00/12.1/158/326/394
(E.Riva S.)			
16.05.2005	15.10/7.79/15.1/140/321/<1	17.00/8.21/18.4/165/352/690	15.680/8.06/16.2/150/338/118.8
06.06.2005	17.40/8.68/10.4/275/308/<1	18.20/9.01/11.8/296/342/890	17.600/8.81/109/283/321/288.3
23.07.2005	20.50/8.94/8.4/231/409/<1	22.30/9.21/9.1/255/438/1580	21.360/9.09/8.7/247/424/414.8

t: Temperature (OC), pH: Power of Hydrogen, D.O: Dissolved Oxygen (mg/L), TDS: Total Dissolved Solid (mg/L), Cond.: Conductivity (μSm/cm), l.: lux.

Table 2. Minimum, maximum and mean values with standard errors and deviation of total length (cm) and weight (g) of fishes caught in Eski Riva and Bıckı Streams.

Habitat/Species		Min.	Max.	Mean	s.e.	s.d.	n
Bıçkı Stream *C. vardarensis*	TL (mm)	55	102	78.5	0.143	1.228	64
	W (g)	1.1081	7.0064	3.5678	0.171	1.473	64
E. Riva Stream *C. vardarensis*	TL (mm)	63	96	75.4	0.244	1.093	13
	W (g)	1.8275	6.6593	3.2425	0,32	1.432	13
E. Riva Stream *P. marmoratus*	TL (mm)	47	70	59.4	0.24	0.759	33
	W (g)	1.1782	4.2517	2.849	0.307	0.972	33

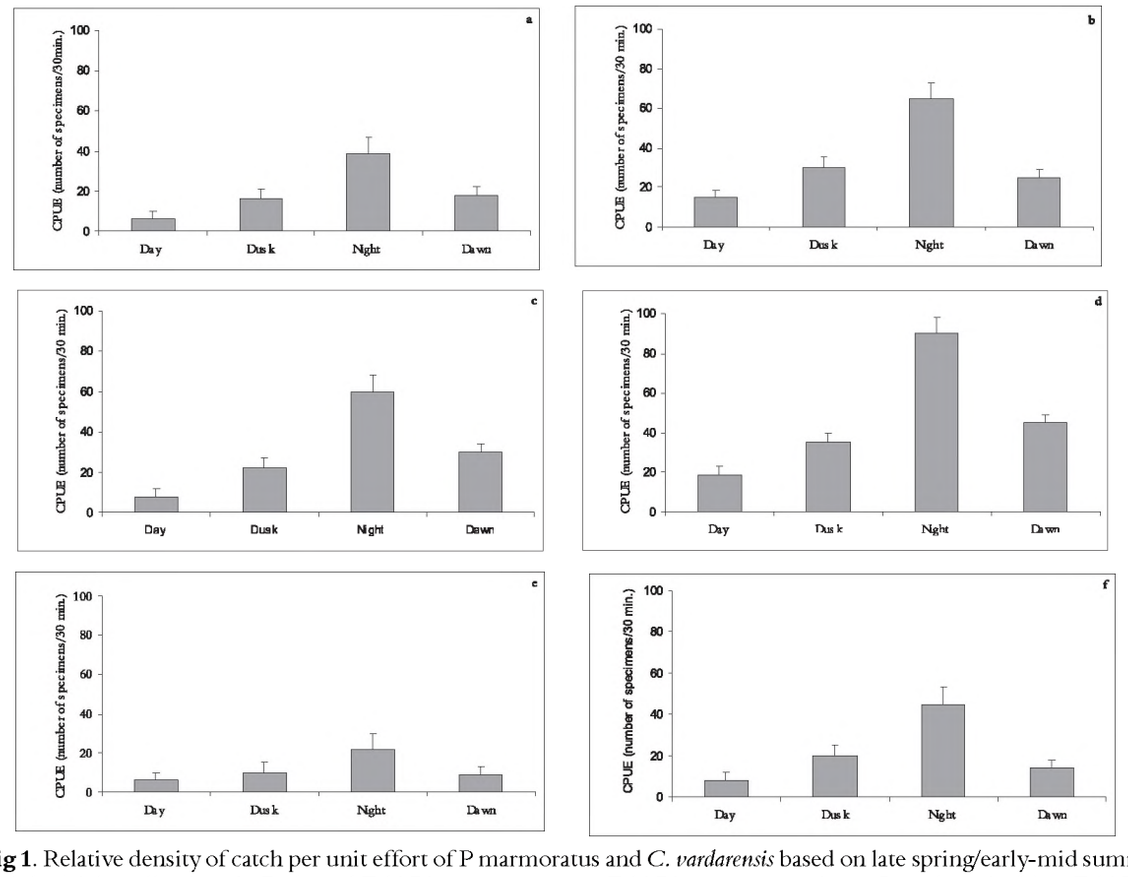

Fig 1. Relative density of catch per unit effort of P marmoratus and *C. vardarensis* based on late spring/early-mid summer and day/night collections in Bıçkı and Eski Riva streams. (a) = Eski Rivastream - spring - *C. vardarensis*; (b) = Eski Riva stream - summer - *C. vardarensis*, (c) = Bıçkı stream - spring - *C. vardarensis*, (d) = Bıçkı stream - summer - *C. vardarensis*, (e) = Eski Riva stream - spring - *P. marmoratus*; (f) = Eski Riva stream - summer - *P. marmoratus*.

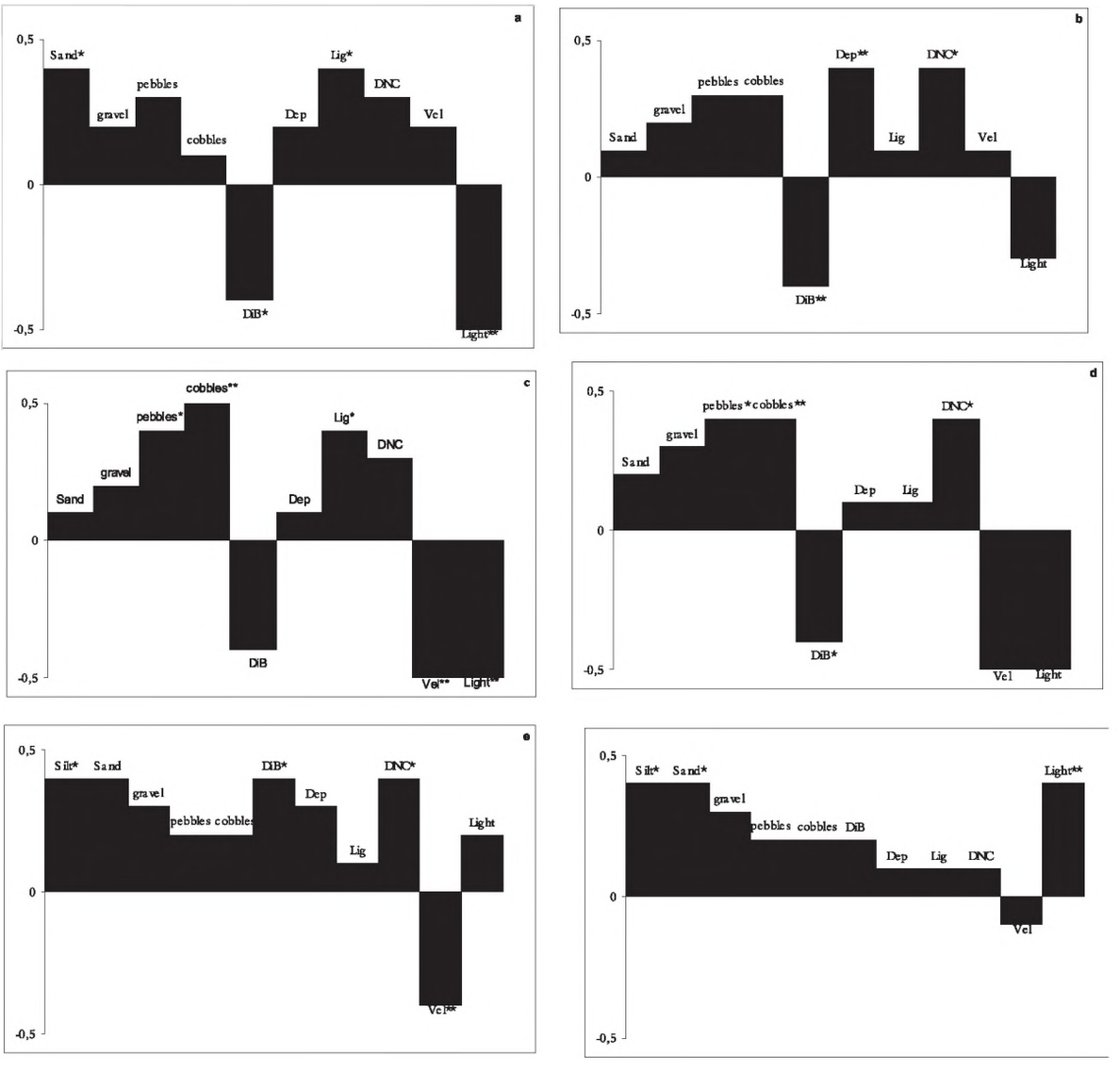

Fig 2. Microhabitat electivity profiles (values approaching + 0.5= preference; values approaching -0.5= avoidance) of *P. marmoratus* and *C. vardarensis* in Bıçkı and Eski Riva Streams between May and July 2005. See Material and Method for microhabitat variables and Fig. 1 for letter explanations. Significant deviations from expected (Fisher Exact) are indicated as * (P< 0.05) and ** (P< 0.01).

species in the Eski Riva stream. The *P. marmoratus* gut content was dominated by surface insects in May however this dominancy was shared with chirinomid larvae in June (Fig. 3).

Microhabitat Preferences and Abundance

The main environmental variables that characterized the overall microhabitat use of small fishes in the Bıçkı and Eski Riva streams (in order of decreasing importance) was velocity, light, depth, and proportions of cobbles. Distance from the nearest bank, however, was the variable for which the highest number of species demonstrated significant (P<0.05) electivities (Fig. 2). Both *C. vardarensis* and *P. marmoratus* showed many microhabitat variables, and these were mainly strong (P<0.01) and exclusively in the summer season.

The most distinctive microhabitat use was observed in *C. vardarensis* which preferred microhabitats characterized by distance from the nearest bank, light and velocity. This was consistent with *P. marmoratus*, which demonstrated mostly slightly weaker electivities, with distance from the nearest bank and light but showed strong electivities with bottom type % sand and silt being the most

Table 3. Diel variation in gut fullness of *C. vardarensis* at different localities and sampling occasions in Bıçkı and Eski Riva Streams.

	20:00/20:30	22:00/22:30	24:00/24:30	02:00/02:30	04:00/04:30	06:00/06:30
C. vardarensis (Bıçkı) - 20.05.2005	22.23	41.67	33.33	36.00	20.00	5.12
C. vardarensis (Bıçkı) - 08.06.2005	12.25	57.10	39.00	54.40	20.00	2.30
C. vardarensis (Bıçkı) - 23.06.2005	2.26	10.00	100.00	50.00	30.00	20.12
C. vardarensis (Bıçkı) - 14.07.2005	6.30	15.00	38.00	75.10	25.00	2.00
C. vardarensis (Eski Riva) - 16.05.2005	3.46	18.73	15.21	14.08	9.90	4.56
C. vardarensis (Eski Riva) - 06.06.2005	5.56	20.00	10.00	10.00	2.80	1.23
C. vardarensis (Eski Riva) - 23.07.2005	22.56	90.00	10.00	65.00	13.56	3.65

Table 4. Diel variation in gut fullness of *P. marmoratus* at sampling occasions in Eski Riva Stream.

	20:00/20:30	22:00/22:30	24:00/24:30	02:00/02:30	04:00/04:30	06:00/06:30
P. marmoratus (Eski Riva) -20.05.2005	13.39	80.00	55.00	25.00	21.10	5.62
P. marmoratus (Eski Riva) -06.06.2005	15.00	25.00	42.36	29.25	10.00	6.32

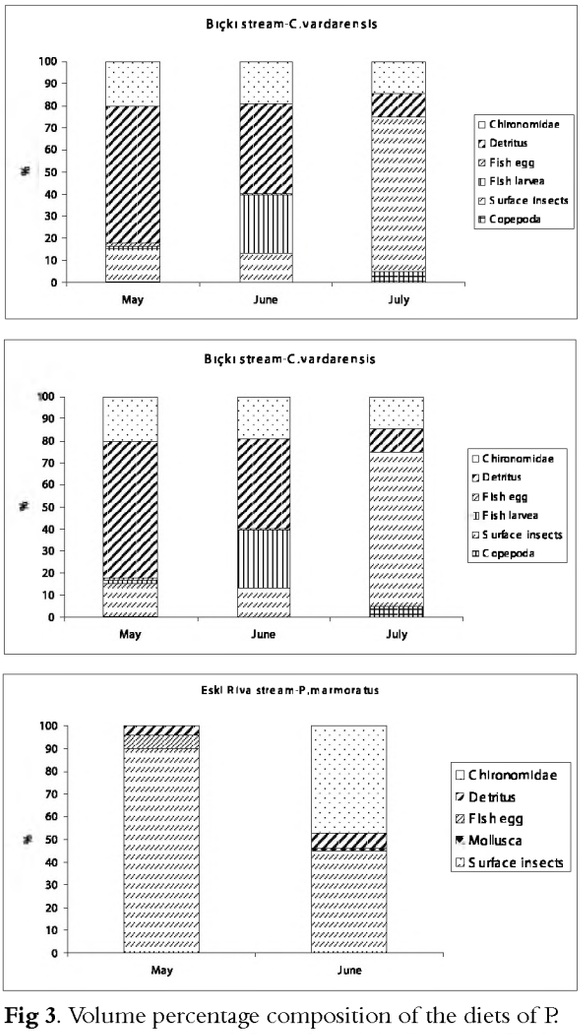

Fig 3. Volume percentage composition of the diets of P. marmoratus and *C. vardarensis* in Bıçkı and Eski Riva streams.

notable (Fig 2).

DISCUSSION

Our results suggested that both studied freshwater fishes were active at night. Previous studies also pointed out substantial differences between night and day catches of fish assemblages from very variable aquatic ecosystems (e.g. Copp and Jurajda 1993, Wolter and Freyhof 2004). Commonly, increase in biomass and numbers of fishes were the most distinguished differences at and after dusk. This patterns lead to change in species composition and relative abundance (i.e. assemblage composition) of fishes. Reasons for these differences may depend on many factors which are mainly related to the behavioral traits of the fishes. The most probable reason would be predator avoidance of fish by decreasing their catchability, given that active fishes may be more effectively caught those taking refuge. Because, the fish especially in their early life could be much more capable of perceive and escape from the predators at night. Another important effect for night time preference of fishes would be resource use which may change between day and night and cause daily movements between habitats (Wolter and Freyhof 2004). Activation of fishes is strongly influenced by fish size during the night, which is an important aspect of the diel variations in the fish assemblage structure of the river littoral (Copp and Jurajda 1999). To our knowledge, diel activities of *P. marmoratus* and *C. vardarensis* have not been studied in their native range. However, in the Hungarian Danube Region, where *P. marmoratus* is considered a non-native fish species, was reported to have no significant diel density differences (Eros et al. 2005).

Our CPUE estimates of *P. marmoratus* density in the Eski Riva stream (Fig. 1) appear to be quite low relative to those obtained elsewhere using successive removal and electro-fishing methods (e.g. Eros et al.

2005). These differences are probably more related to the differences in sampling method than differences in gobiid density between the Regions. Contrary to wading-based sampling methods (e.g. backpack electrofishing surveys, and successive removal), which are not normally feasible in large regulated rivers, the sampling protocol we used was designed for the microhabitat level fish assemblage studies of small streams. Consequently, *C. vardarensis* and *P. marmoratus* were found to occur throughout the small streams in the Black Sea Region, and they occupy most of the available habitats.

Our passive sampling method was very suitable to see night time preferences of fishes as the drift nets were constant during the whole sampling season. Increase in velocity and decrease in light intensity towards darkness was correlated to the increase in the activity of fishes. Both studied species in the present study showed strong microhabitat electivities which may suggest their special microhabitat preferences in the streams of the Ömerli Reservoir. Gobies generally are considered to be nocturnally active (Jude et al. 1995, Grabowska and Grabowski 2005) and they are susceptible to hide in and around the large rocks and boulders. Indeed, gobies are also known to be abundant in shallow water along gravel beaches where the amount of refuge was relatively low (see also Grabowska and Grabowski 2005). This habitat use differences in day and night probably depend on the diel differences in goby density which was also supported by our results in the present study. These diel differences were highly linked to light intensity, velocity, and bottom type of the streams which all are peculiar to the night. Strong preferences of both *C. vardarensis* and *P. marmoratus* to the distance from the bank in both day and night can be attributed to their hiding behavior from predators which are very well known particularly in gobies. Inshore movement of gobies may also be restricted to very short distances (i.e. from meters to tens of meters) owing to the sedentary life style of these fishes (Jude et al. 1995). In the case of *P. marmoratus*, this pattern would not appear to be corroborated by the relatively weak microhabitat electivities of this species in the River Danube (Eros et al. 2005). This is probably due to the non-native status of *P. marmoratus* in the Danube Region which is usually assumed to be needed for any alien species' successful invasion to new environments (e.g. Beyer et al. 2007).

Even though there have not been any studies on diel activity of *P. marmoratus* and *C. vardarensis* to date, some close relatives of *P. marmoratus* from the gobiid family (*Neogobius gymnotrachelus* Kessler 1857) is known to meet their energetic requirements by nocturnal feeding. Our preliminary data collected supports these observations given that both *P. marmoratus* and *C. vardarensis* were rarely sighted by day. Gut content of both collected species fluctuated considerably with peak values at night or in the early morning. Accordingly, the feeding rates were the highest during the night and lowest during the day time for all three months. Thus, *C. vardarensis* and *P. marmoratus* appear to be primarily nocturnal feeders.

Variations in the light intensity in the streams should influence the diel feeding patterns of the both species. During most of the study period, there was a full moon and no periods of complete darkness. Therefore, there should be sufficient light for visual feeding even near midnight, which may explain the high food intake of both species during the night although there are some distinct diel variations in light intensity. However, in some sampling days, several hours of complete darkness occurred at night, but nevertheless, both species also had their highest food intake at night in these days. Especially in summer months both species consumed >%60 of their total diet food intake during the 6-h period of darkness from 22:00 to 04:00 hours. These facts suggested that both studied fish are obviously capable of feeding in darkness and having a predominantly nocturnal food intake.

The nocturnal feeding pattern for both fish species may be related to availability of prey and predator avoidance. The latter seems to be irrelevant since potential fish and avian predators were very rare in the studied streams. Therefore, diel variations in prey availability may be more important. Drifting invertebrates in flowing water is usually greater by night than by day, often by an order of magnitude (Müller 1965, Allan 1995). As previously noted in both field and laboratory studies, high nocturnal activity among the aquatic invertebrates on the bottom may be reflected by increased nocturnal drift (Elliott 1967, Allan 1995). This situation was apparent with observed increase in invertebrate density in our drift samples also.

Consequently, the nocturnal feeding of both species in the present study may be a response to exposure and higher activity of benthic invertebrates at night.

Surface insects composing mainly of chirinomid larvae were the dominant food item for both species in the streams throughout the sampling period. This finding has also management implications, because some non-native freshwater species such as *Gambusia holbrooki* and *G. affinis* were introduced with the aim of controlling insects, especially mosquitoes (İnnal and Erk'akan 2006). These fish species were then distributed to all suitable water bodies in Turkey (Geldiay and Balık 1996). However, there are no any studies on their effect on mosquitoes in Turkey and earlier field and experimental studies in some European countries showed that these fish species were not successful in preventing a mosquito increase in wetlands as they preferred usually microinvertebrates (copepods, cladoceran, ostracods and rotifers) (Garcia-Berthou 1999), with scarce predation on insect larvae (Rodriguez 1989). Also some other studies reported that benthic animals (e.g. chironomids) are a small fraction of the mosquitofish diet (Stober et al. 1998). As the results of the present study indicated potential high effect on the insects by native fishes (*P. marmoratus* and *C. vardarensis*), should be considered instead of non-native fish introductions for future management implications in mosquito control.

In conclusion, *P. marmoratus* and *C. vardarensis* showed high night time activation, nocturnal feeding with dominant food as surface insects, and a strong microhabitat use mainly for velocity, light, and bottom type. These characteristics describe a very selective species which have weak plasticity in their life history traits. Although *P. marmoratus* has remarkably increased in number in the Danube Delta and North America lakes (Eros et al. 2005) as a non-native species after it was introduced in those Regions, it represents an important component of native freshwater fauna in most of the freshwater bodies in the Black Sea Region. Because of temperature fluctuations and habitat destructions (i.e. droughts, river regulations for damming) in recent years, most of the habitats for these species have become unsuitable in their native range.

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