

Preference of Zebra Mussel, *Dreissena polymorpha* in the Diet and Effect on Growth of Gobiids: A Comparative Study Between Two Different Ecosystems

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Abstract

We investigated presence of zebra mussel, *Dreissena polymorpha*, which is considered as harmful for two freshwater ecosystems (Ömerli Reservoir and Lake Sapanca), in the food preferences of several gobiid species namely; *Neogobius melanostomus*, *Neogobius gymnotrachelus*, and *Neogobius fluviatilis*. In Lake Sapanca, zebra mussel was the dominant food component in the diet of gobiids. However, in Ömerli Reservoir, plant with macrophytes and algae were the dominant food sources both studied gobiids. Intraspecific diet overlap indices showed that gobiid species from the same lake preferred similar food types ($S \geq 0.8$). However, when we compared the lakes, the diet overlap index between *N. fluviatilis* (Lake Sapanca) and *N. gymnotrachelus* (Ömerli Reservoir) was not significant ($S = 0.5$) which indicates different food choices. The relationships between total length and weight, which had slope values >3 in all but one case, differed significantly between species. One exception was between *N. fluviatilis* (Lake Sapanca) and *N. melanostomus* (Ömerli Reservoir). In generally, slopes of the relationships in fish species from Lake Sapanca were bigger than those of Ömerli Reservoir. This result suggests that gobiids fed with mostly zebra mussel had better weight gain compared to gobiids fed with mostly plant-based food. This study showed that gobiid fishes are an important consumer of zebra mussel and their predation would affect the mussel populations, especially in the ecosystems where zebra mussel is abundant.

Keywords: Diet, *Dreissena polymorpha*, gobiid fishes, growth.

Kaya Balıklarının Besin Tercihlerinde Zebra Midyesi, *Dreissena polymorpha*'nın Tercihi ve Bunun Kaya Balıklarının Büyümesine Üzerine Etkisi: İki Farklı Ekosistem Arasında Karşılaştırmalı Bir Çalışma

Özet

Ömerli Rezervuarı ve Sapanca Gölü için zararlı olarak kabul edilen zebra midyesi, *Dreissena polymorpha*'nın bazı kaya balığı türlerinin, (*Neogobius melanostomus*, *Neogobius gymnotrachelus* ve *Neogobius fluviatilis*) besin tercihlerindeki varlığını araştırdık. Sapanca Gölü'nde zebra midyesi kaya balıklarının baskın besin maddesi iken, Ömerli Rezervuarında makrofitler ve algler en çok rastlanan besindi. Türler arası beslenme indeksi aynı gölde yaşayan kayabalıklarının benzer besin tiplerini seçtiklerini ($S \geq 0,8$) gösterdi. Ancak, her iki gölü karşılaştırdığımızda, *N. fluviatilis* (Sapanca Gölü) ve *N. gymnotrachelus* (Ömerli Rezervuarı) arasındaki besin indeksi, farklı besinleri tercih ettiklerini gösterecek şekilde önemsiz olarak çıkmıştır ($S = 0,5$). Boy ile ağırlık arasındaki ilişkinin eğimi, bir istisna dışında bütün karşılaştırılan türler arasında önemli derecede farklı çıktı. Sadece, *N. fluviatilis* (Sapanca Gölü) ve *N. melanostomus* (Ömerli Rezervuarı)'nın boy ağırlık ilişkilerinin eğimleri arasındaki fark önemsiz çıkmıştır. Genel olarak Sapanca Gölü'ndeki balıkların boy ağırlık ilişkilerindeki eğim Ömerli Baraj Gölü'ndekilere göre daha yüksek çıkmıştır. Bu sonuç, çoğunlukla zebra midyesi ile beslenen kaya balıklarındaki ağırlık artışının, genelde bitkisel materyalle beslenen kaya balıklarına göre daha iyi olduğu hipotezini desteklemiştir. Bu çalışma, kaya balıklarının zebra midyesinin önemli bir tüketicisi olduğunu ve kaya balıklarının av baskılarının özellikle zebra midyesinin bol bulunduğu ekosistemlerde bu türün popülasyonları üzerinde önemli bir etkisi olabileceğini göstermiştir.

Anahtar Kelimeler: Beslenme, büyüme, *Dreissena polymorpha*, kaya balıkları.

INTRODUCTION

Paleontological records for zebra mussel, *Dreissena polymorpha* (Pallas, 1771) date back to the late Miocene (ca. 6-5 mya). Its paleogeography is broader and includes not only the region of the former Paratethys Sea, but also many river basins along the Northern Mediterranean Sea and in Eastern Europe (Babak 1983, Nuttall 1990, Starobogatov 1994). The zebra mussel appeared in Central Europe some 150 years ago. Since then it has gradually colonized most European fresh and brackish waters, creating a new food source for fish. The species spread across Central and Western Europe already in the 19th century (Kinzelbach 1992), and has just started its massive invasion in North America (MacIsaac 1996). Natural distribution range of zebra mussel is Black Sea, Caspian Sea and Aral Lake. Turkish waters are located in this range.

Zebra mussels have a significant and noticeable impact on human activities and on the environment by damming dams and industries, and by modifying the benthic communities of the colonized environments. The most significant problems are; pipe obstruction, pipe flow velocity reduction because of friction loss (turbulent flows), empty mollusc valve accumulation and waterway pollution from massive mortality, filter occlusion as well as increase in surface corrosion because of mussel infestation (Darrigran 2002).

In Turkey, negative effect of zebra mussels on the ecosystems has recently been recognized and the most notably effect of zebra mussels has been pipe obstruction in some reservoirs and lakes which is used as drinking water resource (Anonymous 2005). Because of their abundances these molluscs are important diet item for the fishes that have adapted to feed upon them. Zebra mussels contribute substantially to the diet of gobiid fishes (Gobiidae). They possess robust teeth that permit them to eat zebra mussels (Ghedotti et al. 1995) that can concentrate certain contaminants.

The gobies are indirectly consuming the toxicity load of the zebra mussels. When they do, the toxins stored into the water column are made available to the rest of the food chain, though this impact is likely less of a threat than its role as a bioaccumulator (Ghedotti et al. 1995).

In this paper, to elucidate predation effect of gobiids on zebra mussel, we examine the diet of

some gobiids captured in two ecosystems which has distinct morphometry, water quality and regime and trophic state. We also compared growth of these species in relation weight gain. Both lakes consist of zebra mussels, however, their abundances is different.

MATERIAL AND METHODS

The Study Areas

Lake Sapanca is located in the Marmara region of North-west Turkey (Fig. 1). Its surface area is 46.8 km² with a maximum depth of 55 m. It is 30 m above sea level. Annual average temperature is 17.23°C and it varies between 6.5°C and 29.5°C at the surface (Gürsoy 2001). The lake water is used as a source of drinking water by the city and district of Adapazarı and as a recreational area. Although Lake Sapanca water is enriched by water from trout farms, which are common in this region, with more than thirty in the vicinity of the lake, it has an oligotrophic character (Albay et al. 2003). The most common economically important fish species are roach *Rutilus rutilus* (L.), rudd *Scardinius erythrophthalmus* (L.), silver bream *Blicca bjoerkna* (L.), Baltic vimba *Vimba vimba* (L.), northern pike *Esox lucius* L., common carp *Cyprinus carpio* L. and European catfish *Silurus glanis* L.

Ömerli Reservoir is the biggest reservoir in İstanbul (northern part of the Marmara region) and is located in north-east (approximately 30 km) of the city (Fig. 1). The reservoir provides approximately 48% of the city's drinking water and average of 872000 m³ per day water is discharged from the reservoir. Morphometrically, the reservoir has a surface area of 23.5 km² and a volume of 2.2 x 10⁶ m³ and maximum depth is 62 m. Due to input of domestic and industrial wastewater, coming mainly via small streams, the whole water system is mesotrophic (Albay et al. 2003). At present, most abundant fish species commercially caught in the reservoir is as following order; gibel carp *Carassius gibelio* (Bloch, 1782), rudd, Baltic vimba and common carp.

The Prey

D. polymorpha is a sessile mussel, attaching itself to different substrata. It is less than 0.5 mm in length when it switches to sessile lifestyle. Its life expectancy is 4-5 years, and it attains a maximum size about 30 mm in length and 11-14 mm in height. *Dreissena* often forms large and structurally complicated colonies consisting of several layers

(floors) built up by successive generations.

Zebra mussels are relatively large, shelled prey that must be handled individually by predatory fish. Each mussel must be pulled from substratum and crushed by the teeth.

The Predators

Fish samples for diet analysis were taken in 19 March 2003 and 16 April 2005. They were caught with gillnets (10 and 22 mm), seine and electrofishing (Elektracatch, WFC911). They were preserved in %4 formalin solution. From Ömerli Reservoir, *Neogobius melanostomus* (Pallas, 1814) and *Neogobius gymnotrachelus* (Kessler, 1857), while from Lake Sapanca, *Neogobius melanostomus* (Pallas, 1814) and *Neogobius fluviatilis* (Pallas, 1814) were caught.

Each individual was weighted with accuracy to 0.01 g, and its total length was measured with accuracy to 1 mm. The fish were dissected and alimentary canal was removed for further analysis of gut content. Gut content was weighted (to 0.0001 g accuracy) and placed on a gridded Petri dish to examine under a stereomicroscope.

Statistical Analysis

We calculated the proportion of items in each gut 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 average proportion of different items consumed for each species. The number of empty stomachs was very low. The proportion of plant, *D. polymorpha* and detritus were recorded.

Diet overlaps between fish species were estimated according to Schoener's similarity index (Schoener 1970):

$$S = 1 - 0.5 \left(\sum_{i=1}^n |p_{xi} - p_{yi}| \right)$$

Where p_{xi} = proportion of food category i in the diet of species x

p_{yi} = proportion of food category i in the diet of species y

n = number of food categories

According to Davis and Todd (1996) Schoener's diet overlap index values above 0.6 were considered significant.

The length-weight relationship was described by the equation: $WT = aTL^b$, where a and b are constants (Le Cren 1951). Regressions on log-transformed data were tested for differences in slopes between lakes (Zar 1999).

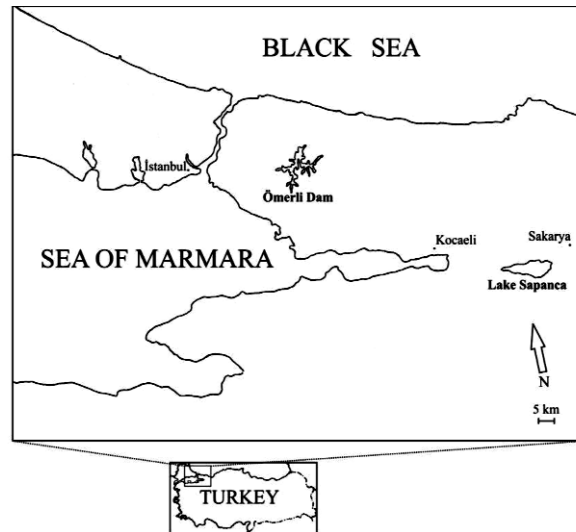


Fig. 1. The study areas.

RESULTS

The species, minimum, maximum and averages of total length (cm) and weight (g) are given in Table 1. In Lake Sapanca, zebra mussel was the dominant component of diet in *N. melanostomus* by 78% and *N. fluviatilis* by 38%. However, In Ömerli Reservoir, plant with macropytes and algae was the dominant food source both *N. melanostomus* and *N. gymnotrachelus* by 87% and 69%, respectively (Fig. 2).

Intraspecific diet overlap indices for *N. fluviatilis* and *N. melanostomus* in Lake Sapanca and *N. gymnotrachelus* and *N. melanostomus* in Ömerli Reservoir were 0.8 and 0.9, respectively. However, the diet overlap index between *N. fluviatilis* (Lake Sapanca) and *N. gymnotrachelus* (Ömerli Reservoir) was 0.5.

The relationships between TL and WT, which had slope values >3 in all but one case, differed significantly between species. One exception was between *N. fluviatilis* (Lake Sapanca) and *N. melanostomus* (Ömerli Reservoir) which had not significant differences in slopes of the relationship (ANCOVA, $F_{calculated} = 3.50 < F_{critical\ point} = 4.00$, $df = 63$, $p > 0.05$). In generally, slopes of the relationships in fish species from Lake Sapanca were bigger than those of Ömerli Reservoir (Table 2).

DISCUSSION

Our analysis of the gobiid's stomach contents in Lake Sapanca showed that the most preferred food item was *D. polymorpha*. However, in Ömerli Reservoir it was mostly macrophytes and algae. Food overlaps suggested that diet preferences did not differ between the species within lakes, but

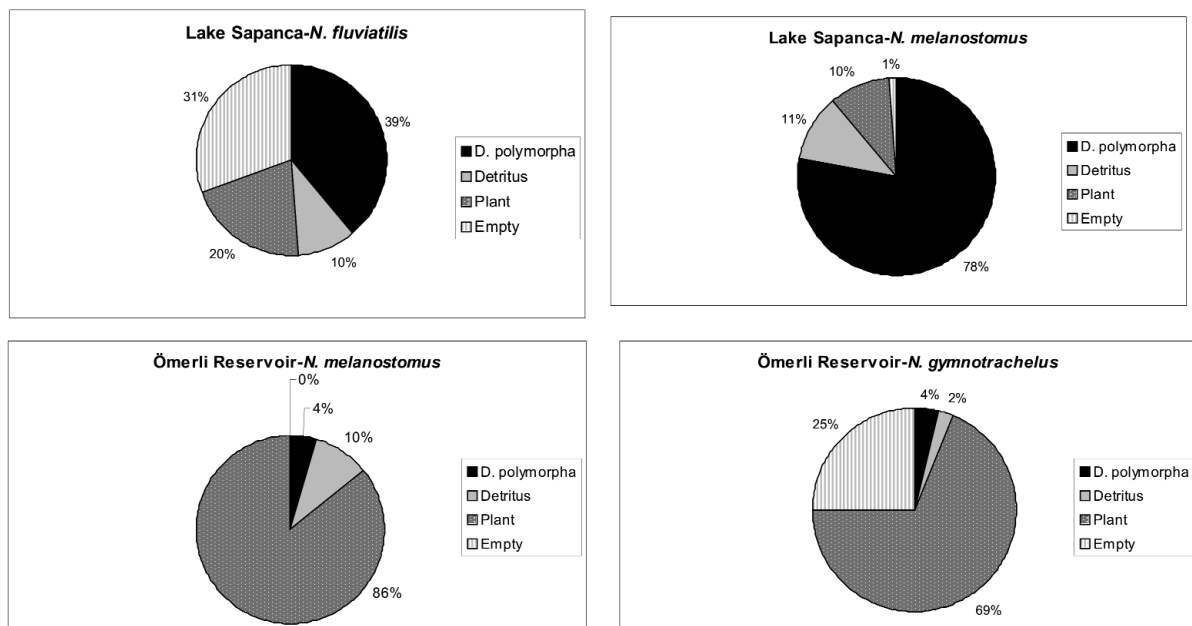


Fig. 2. Percentages of food items in the diet of gobiid fishes from Lake Sapanca and Ömerli Reservoir.

Table 1. Maximum, minimum and average values with standard errors of total length (cm) and weight (g) of fishes caught in Ömerli Reservoir and Lake Sapanca.

	Total length (TL)			Total Weight (WT)		
	Minimum	Maximum	Average $\pm$ S.D.	Minimum	Maximum	Average $\pm$ S.D.
Lake Sapanca						
<i>N. melanostomus</i> (n=20)	7.1	14.9	8.2 $\pm$ 2.4	5.0	55.1	10.6 $\pm$ 15.7
<i>N. fluviatilis</i> (n=22)	6.8	12	7.7 $\pm$ 1.5	3.2	22.3	6.3 $\pm$ 5.4
Ömerli Reservoir						
<i>N. melanostomus</i> (n=45)	6.7	15.6	7.6 $\pm$ 1.4	4.5	63.6	7.2 $\pm$ 8.8
<i>N. gymnotrachelus</i> (n=28)	6.5	12.1	7.3 $\pm$ 1.1	4.2	21	5.5 $\pm$ 3.3

Table 2. Length-weight parameters a and b, the standard error of the slope and the correlation coefficient (r^2) for fishes caught in Lake Sapanca and Ömerli Reservoir.

	a	b	SE(b)	r^2
Lake Sapanca				
<i>N. melanostomus</i> (n=20)	0.0082	3.2575	0.0651	0.9949
<i>N. fluviatilis</i> (n=22)	0.0110	3.0042	0.1714	0.9096
Ömerli Reservoir				
<i>N. melanostomus</i> (n=45)	0.0142	3.0054	0.0733	0.9474
<i>N. gymnotrachelus</i> (n=28)	0.0327	2.5591	0.1177	0.9569

differed between lakes. This phenomenon supported that gobiids appears to display great plasticity and opportunism in its feeding habits, taking a variety of prey types and usually choosing the most abundant food organisms. For many prey types one can expect selection by the predator of the largest and consequently the most profitable prey available. For example, an increase in the size of planktonic prey ingested involves little or no increment in the coat of ingestion (Werner and Hall 1974, Gardner 1981, Myszkowski 1986).

The differentiation of diet preferences between

the lakes could be attributed to high abundance of *D. polymorpha* in Lake Sapanca. Zebra mussel is one of the most abundant benthic organisms in Lake Sapanca (Koşal 2002). Our observations also showed that when using gillnets in the lake, we captured large numbers of zebra mussels that were unattached to substrate, but had still formed druses by attaching to each other, or had strung themselves together on long strands.

In Ömerli Reservoir, the zebra mussel is not too abundant as the reservoir has very variable environment. Since the reservoir is used as a source of drinking water for the İstanbul metropolitan area, an average of 872000 m³ per day water is discharged from the reservoir which leads very unstable water level stabilization, and this certainly can affect the population dynamics of zebra mussel which is well known to attach to most hard substrates and even macrophytes (Leach 1992, Kilgour and Mckie 1992, Martel et al. 1994). This factor could reduce zebra mussel population in Ömerli Reservoir. This finding was supported as many dead zebra mussel attached on roots and rocks were seen in especially summer when water level is low in the reservoir.

Our results indicated that gobiid fishes prefer zebra mussel especially when zebra mussel is sufficiently high. The analysis of the gobiid's diet in its natural range consistent with our finding that reported the main diet component were Mollusca (mainly *Dreissena*), polychaete, chironomidae

larvae, amphipod and small fish (Pinchuk et al. 2003, Kostrzewa and Grabowski 2003).

Length-weight relationships are very important life history and morphological comparisons of populations from different locations (Tarkan et al. 2006). The exponent *b* of the relationship typically has a value close to three, but varies between two and four. A value of three indicates that fish growth symmetrically or isometrically; values other than three indicate allometric growth (Tesch 1971). In Lake Sapanca, the *b* values showed that growth of gobiids was faster in weight than in length. However, in Ömerli Reservoir *b* values are lower than those in Lake Sapanca. A comparison of *b* values between the lakes studied in the present study indicated that gobiids in Lake Sapanca show better growth in terms of weight gain. We suggest that this could be result from quality of food in the diet of gobiids. It is well known that the assimilation efficiency of plant and algal material is less than those of animal food in fishes (Persson 1983).

On the basis of our results, we may conclude that gobiid fishes are important consumers of the zebra mussel and their predation may affect the dynamics of the mussel populations, especially in the ecosystems where zebra mussel is abundant. This can be very crucial for the management of zebra mussel to control their populations when they become pest. In this respect, gobiid species must not be considered as harmful or discard species and must be protected as other natural species. However, it should be noted that as many negative impacts of introduced gobiid species on the ecosystems are known (e.g., Crossman et al. 1992, Jude and DeBoe 1996, Naseka et al. 2005) introduction or stocking of these species should generally be restricted to the minimum or completely avoided.

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