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Changing of Mollusca Fauna In Comparison With Water Quality: Saricay Creek and Atikhisar Reservoir Models (Canakkale-Turkey)

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Abstract: Species composition, abundance and monthly distribution of the Mollusca fauna and the physicochemical variables of Saricay Creek and Atikhisar Reservoir have been investigated between September 2005-August 2006. Mollusca fauna in Saricay Creek and Atikhisar Reservoir was represented by 21 species of Gastropoda and 8 species of Bivalvia. Diversity, dominance and frequency were recorded monthly. By assessing the data via Shannon-Wiener index, Saricay Creek had an index of 2.58 richness at 8th station while, third station in Atikhisar Reservoir had the poorest with an index of 0.02. According to Bray-Curtis similarity index, the first and third stations were found to be very similar to each other, while 8th and 66 h stations were observed to be the most different from all of the other stations in terms of the dynamics of mollusca fauna. *Dreissena polmorpha* were the most dominant of 47.16% and frequent species of 48.96%, especially encountered in the Atikhisar Reservoir. The results of One-way Analysis of Similarity (ANOSIM) showed that mollusca compositions were significantly different between sampling sites ($p<0.05$). ANOSIM and Similarity Percentage analysis (SIMPER) revealed significant differences and a high degree of community dissimilarity within and between the sampling stations. The relationship between the dynamics of organisms and environmental parameters were analyzed using Canonical Correspondence Analysis. This study pointed out that water quality parameters especially COD, BOD, Anionic Detergent, salinity, TP, TN, temperature were effective on the abundance and distribution of Mollusca fauna.

Key words: Mollusca, saricay, atikhisar reservoir, biodiversity, CCA, anosim, simper

INTRODUCTION

Molluscs, consisting an important group in macrobenthic fauna, are distributed in marine, brackish, freshwater and terrestrial habitat thanks to their high resistance to environmental stressor factors.

They have ecological and economical importance because they are consumed mainly by fish, mammals, crustaceans, birds and are also served for human consumption. Some of mollusca have parasitological importance due to being hosts to parasitic organisms, which are agricultural pests (Yildirim, 1999). Besides, Mollusca have scientific importance as they are used in biomonitoring and risk assessment (Barbour *et al*., 1999; Salanki *et al*., 2003).

Statistical methods such as Canonical Correspondence Analysis (CCA), Cluster Analysis (CA) and Anosim and Simper analysis help us understand ecological status of studying area and help compare water quality and biological diversity to interpretate the data sets (Sharma, 1996; Kazanci and Dugel, 2000).

Recently, lots of malacological studies in West part of Turkey have been carried out (Ustaoglu *et al*., 2003; Cabuk *et al*., 2004; Yildirim *et al*., 2006; Kosal-Sahin and Yildirim, 2007; Arslan *et al*., 2007; Kokmen *et al*., 2007). The latest studies in this area pointed out that there were domestic and agricultural pollution resources in Saricay Creek (Ilgar and Sari, 2008; Kaya *et al*., 2009). Domestic and agricultural pollutants have been threatening Atikhisar reservoir and Saricay Creek providing drinking and irrigation water for Canakkale city and Atikhisar Basin (Akbulut *et al*., 2007).

Up to now, there has been no study about mollusca fauna and their relationships to environmental variables in the study area. This study is aimed to investigate quantitative charecteristics of Mollusca fanua in relation to water quality parameters. For this aim, CCA, CA, ANOSIM and Simper analysis were applied to data set.

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MATERIALS AND METHODS

Study area: Atikhisar Reservoir and Saricay Creek are located in the North-Western part of Turkey. The reservoir was built on Saricay Creek for drinking, irrigation and preventing floods. The reservoir has an average depth of 8.5 m and the maximum depth is 33 m with a surface area of 3.622 km^2. The reservoir is fed principally by Saricay Creek and its tributaries. Saricay Creek rises from Mount Ida, Canakkale. Its length is 40 km and it has a discharge of 15-1300 m^3/sn. It flows into Dardanelles at the Centrum of Canakkale city. Therefore, it is exposed to domestic waste and agricultural runoff.

In this study, 4 sampling sites (1-4th sites) from Atikhisar Reservoir and 4 sampling sites (5-8th sites) from Saricay Creek were chosen. Characteristic features of the sites were given in Table 1. Locations of the sampling sites are shown in Fig. 1.

Samplings of Mollusca and water quality parameters: Water samples were collected monthly between November 2005 and October 2006 from stations 1-4 of Atikhisar reservoir and stations 5-8 from Saricay Creek to analyze Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Chlorophyll-a, Total Phosphate (TP) and Total Nitrate (TN) and Anionic Detergent (AD) in water. One and two litter polyethylene bottles were used to determine the chemical properties of the water. The bottles were kept at 4°C and were analyzed within 24 h. All samples were collected, preserved and stored for analysis as outlined in the Standard Methods for the examinations of Water and Wastewater (APHA, 1992). Other physicochemical parameters such as temperature, salinity, pH, dissolved oxygen, oxygen saturation and electrical conductivity were measured in situ using the YSI 100 multiparameter probe.

Mollusca fauna were sampled in duplicate at the same dates in the water samples. Van Veen Grab, which has got 0.1 m^2 area were used for sampling of sediments in sites 1-4 and 8. Quatrate (Hess Sampler), which has a 30×30 cm sampling area, were used for sampling of sediment in sites 5, 6 and 7 in Saricay Creek due to shallow water. The benthic samples were sieved in screen mesh size of 0.5 mm. Mollusc samples were preserved in alcohol of

Table 1: Details of the sampling stations in Saricay and Atikhisar Reservoir

Station	Coordinate	Depth (cm)	Bottom structure	Agricultural area around it	Settlement area around it
1	40°04'56.65"N 26°31'32.69"E	200-250	Muddy, Detritus	Present	Absent
2	40°06'05.01"N 26°31' 50.53" E	150-200	Sandy, Stony, gravel	Present	Absent
3	40°06'32.42"N 26°31'19.95"E	800-900	Muddy, Detritus	Present	Present (Atikhisar village)
4	40°07'16.83"N 26°31'30.09"E	600-700	Detritus, Stony	Present	Absent
5	40°07'39.02"N 26°31'30.77"E	30-40	Detritus, sandy, Gravel, stony	Absent	Absent
6	40°08'22.29"N 26°28'17.91"E	50-60	Macrophytes, Sandy	Present	Present (Saraycik village)
7	40°08'41.05"N 26°25'08.85"E	40-50	Macrophytes, Sandy, black muddy	Absent	Present (Canakkale)
8	40°08'34.96"N 26°24'00.48"E	120-130	Black Muddy	Absent	Present (Canakkale)

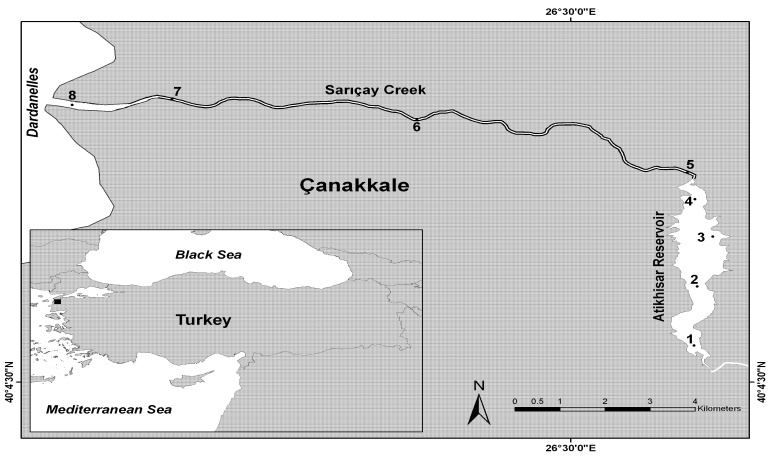

Fig. 1: Map of the study area and sampling stations in the Atikhisar Reservoir and Sariçay Creek, Canakkale

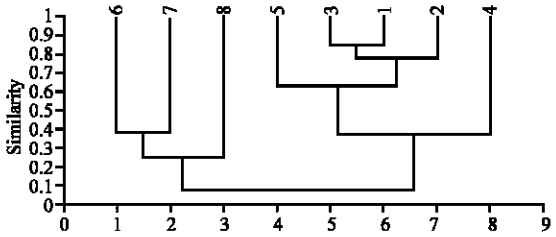

Fig. 2: The dendogram of similarity of stations in respect to Mollusca fauna (UPGMA algoritm, Bray-Curtis measurement)

70% in glass vials. Species identifications of mollusks were carried out according to Zhadin (1952) and Gloer (2002) by using binocular microscope (Fig. 2).

Data analysis: Abundance data of mollusca were transformed into square root for analysing. CCA were applied for determination of effets of environmental parameters on abundance, distribution diversity of mollusca fauna. CA implemented for revealing similarity and dissimilarity of sites in terms of common and rare mollusca species abundance. One way-ANOSIM (Analysis of Similarity) analyses were carried out to determine significance of similarity of sites. SIMPER (Similarity of Percentage) were also employed for determining percent contribution of species between significant sites. PAST 1.75 software programmes was used in all analyses (Richard and Wichern, 1992; Sharma, 1996; Tabanchnick and Fidell, 2001; Magurran, 2005).

RESULTS AND DISCUSSION

Water quality parameters: In this study, water quality data obtained monthly from 8 sites were given in Table 1 with minimum, maksimum, average and water quality classes according to Turkish Inland Water Standarts. Annual average of COD, BOD_5, pH, temperature and total phostate in all stations were determined first class by comparing them to water quality standarts in Turkey. Annual average of dissolved oxygen and oxygen saturation in all stations were showed as the second class.

The head content of the river water reflect the instantaneous balance among inputs, storage and outputs. Temperatures of stream and river vary in relation to air temperature.

The oxygen content with small turbulent streams in approximately at or somewhat above saturation. Concentrations decline during summer months as a equilibrium solubility decline increasing tempretures. However, like lake Ecosystem the oxygen content of running water is modified markedly by chemical and biological processes.

Measure source of nitrogen income to streams and lakes is from influences, both from surface land, drenage and from groundwater sources. Inputs of nitrogen loading in many streams and lakes, especially inregions rich in limestone (Whetzel, 2001).

Dissolved inorganic phosphorus averages about 10 $\mu g\ L^{-1}$ are accepted worldwide among unpolluted river. Total dissolved phosphorus in these waters about averages about 25 $\mu g\ L^{-1}$. In the present study, TP was measured 3-27 $\mu g\ L^{-1}$ in all stations. Therefore Atikhisar Reservoir can be accepted as unpolluted water. According to Whetzel (2001), Trophic level of the reservoir was oligo mesotrophic. According to inland water quality criteria of Turkey, the reservoir and Saricay Creek were the second class in terms of TP (Table 2).

Diversity and abundance of mollusca fauna: Bivalvia and gastropoda sampled in this study were quantitatively investigated in Saricay and Atikhisar Reservoir monthly. Result of this study indicated total 29 mollusca taxa belonging to Gastropoda Classis, Planorbidae Family (3 taxa), Hydrobidae Family (2 taxa), Valvatidae Family (3 taxa), Lymnneidae Family (4 taxa), Thridaridae Family (1 taxon), Bivalvia Classis, Unioidae Family (2 taxa), Sphaeridae (3 taxa), Dreissenidae, Mytilidae, Cardiidae and Solenidae Families (1 taxon). Distribution, abundance, frequence and dominance, biotic indices of the taxa were given in Table 3. According to Table 3, the highest frequent and dominant taxon was *Dreissena polymorpha* with 47.16% D and 48.96% F in Bivalvia Classis. In this way, the highest frequent and dominant taxon in the Gastropoda Classis was *Physella acuta* with 11.76% D, 15.63% F.

According to Table 3, *Dreissena polymorpha* were encountered at the highest frequency at the site 5 located in upper of Saricay Creek, while *Pysella acuta* were observed in site 7 located near the rivermouth of Saricay.

It can be speculated that the reason of encountering the highest dominance and frequency in site 5 was that this station is located at the outlet of the reservoir and is exposed to the drifting effects on the taxa. In the following stations (6 and 7), zebra mussel density and abundace were reduced. This situation supported our idea of drifting effects.

As *Dreissena polymorpha*, zebra mussel, is an invasive species, it reproduces very highly. Thus, it consumes a lot of phytoplankton constituting the primer producer of the food web. This situation affects the

Table 2: Water parameters of the stations showing min., max., annual average and water quality class in terms of Turkish Inland Standarts

Station	1	2	3	4	5	6	7	8
Temperature (°C)	5.6-27.7	5.9-27.5	7.3-27.6	6.3-27.3	5.1-21.3	7.7-23.7	6.6- 25.6	6.3-25.5
	(17.175)-I	(17.27)-I	(17.42)-I	(17.51)-I	(13.5)-I	(15.91)-I	(16.74)-I	(17.06)-I
Conductivity (Umhos/cm)	186.8-375	180.3-347.8	183.9-350.1	184.2-363.9	184.5-436.1	206.6-568	170.1- 689	200.3-335.3
	(299.86)	(302.3)	(292.06)	(289.1)	(301.8)	(340.93)	(348.08)	(265.66)
Dis.Oxygen (mg L^{-1})	6.04-8.95	6.02-9.8	6.1-9.2	6.1-8.63	4.83-9.9	5.11-8.7	5.4-9.19	4.86-9.73
	(7.9)-II	(7.89)-II	(7.51)-II	(7.43)-II	(7.75)-II	(6.83)-II	(7.53)-II	(7.26)-II
Saturation (%)	73.9-95.8	71.1-98.4	70-93.5	69-94.1	64.9-92.5	62-91.5	75.4-105	64.2-93.2
	(69.89)-II	(86.73)-II	(84.18)-II	(81.18)-II	(79.87)-II	(77.41)-II	(85.77)-II	(82.67)-II
COD (mg L^{-1})	1-15	1-11	1-8	1-13	2-9	1-29	1-29	2-7
	(4.16)-I	(5.16)-I	(4.42)-I	(4.17)-I	(3.75)-I	(6.33)-I	(7.5)-I	(3.5)-I
BOD (mg L^{-1})	0.1-0.5	0.1-0.6	0.1-0.5	0.1-0.7	0-0.9	0.1-50	0.1-15	0.1-17
	(0.23)-I	(0.23)-I	(0.24)-I	(0.23)-I	(0.39)-I	(4.63)-I	(4.35)-I	(1.84)-I
Detergent (mg L^{-1})	0.0026-0.16	0.004-0.176	0.0026-0.3	0.0026-0.23	0.0025-0.22	0.0079-0.3	0.0079-0.49	0.01-0.51
	(0.077)	(0.06)	(0.115)	(0.08)	(0.07)	(0.07)	(0.1)	(0.17)
T P (µg L^{-1})	3.10-10.18	7.43-12.2	8.17-27.15	7.21-19.80	5.048-10.95	7.02-14.55	8.31-12.41	8.61-14.57
	(8.62)-II	(9.56) -II	(10.68)-II	(9.88)-II	(8.86)-II	(9.91)-II	(9.8)-II	(10.03)-II
T N (µg L^{-1})	7.50-22.84	0.96-27.41	7.08-25.38	2.84-21.16	5.35-25.02	9.44-24.86	9.12-30.41	8.94-76.43
	(13.04)	(12.27)	(15.12)	(12.48)	(14.67)	(15.22)	(15.8)	(21.13)
Salinity (ppt)	0.1-0.2	0.1-0.2	0.1-0.2	0.1-0.2	0.1-0.2	0.1-0.3	0.2-3.5	9.5-17.6
	(0.17)-I	(0.175)-I	(0.167)-I	(0.18)-I	(0.18)-I	(0.21)-I	(1.05)-I	(12.99)-IV
pH (pH Unit)	7.48-9.16	7.46-9.11	7.57-8.58	7.51-8.95	6.82-7.98	7.12-8.69	7.49-8.8	7.65-8.76
	(8.03)-I	(8.03)-I	(7.95)-I	(7.98)-I	(7.54)-I	(7.62)-I	(7.99)-I	(8.13)-I
Chlorofil-a (mg L^{-1})	0.39-37.14	0.45-15.76	1.99 -17.54	1.23-14.86	2.12-12.73	0.34-13.33	0.19-18.47	0.031-18.88
	(11.83)	(7.016)	(9.21)	(7.42)	(8.46)	(7.5)	(9.24)	(7.48)
TSS (mg L^{-1})	0.004-0.036	0.001-0.023	0.0012-0.035	0.0007-0.05	0.003-0.045	0.0018-0.03	0.0062-0.31	0.0116-0.04
	(0.013)	(0.0083)	0.0088	(0.01)	(0.01)	(0.01)	(0.05)	(0.02)

Table 3: Taxa belonging to Mollusca determined in Atikhisar Reservoir and Saricay Creek, percentage of dominance and frequency and biotic indices (Shannon Wiener, Raman-Margalef and Evennes indices)

Taxa stations	1	2	3	4	5	6	7	8	D (%)	F (%)
Gastropoda										
Galba truncatula (Muller, 1774)	-	-	-	-	-	-	121	40	1.32	4.17
Stagnicola palustris (Muller, 1774)	-	-	-	-	-	-	11		0.09	1.04
Radix auricularia (Linnaeus, 1758)	-	-	-	-	-	-	207	140	2.93	11.46
Radix peregra (Muller, 1774)	-	-	-	-	-	121	283	80	3.79	12.5
Physa fontinalis (Linnaeus, 1758)	-	-	-	-	-	-	-	50	0.41	2.08
Physella acuta (Draparnaud, 1805)	-	-	-	-	-	22	1078	310	11.76	15.63
Planorbis planorbis (Linnaeus, 1758)	-	-	-	30	-	66	-	30	1.03	4.17
Planorbis carinatus (Muller, 1774)	-	-	-	10	-	-	-	-	0.08	1.04
Gyraulus crista (Linnaeus, 1758)	-	-	-	-	-	-	-	150	1.23	4.17
Rissoa sp.	-	-	-	-	-	-	-	140	0.82	6.25
Potamopyrgus antipodarum (Gray, 1843)	-	-	-	-	-	-	22	100	1.16	7.29
Belgrandiella sp.	20	-	-	-	-	-	-	-	0.16	1.04
Melanoides tuberculatus (Tres, 1774)	-	-	-	-	-	22	-	-	0.26	2.08
Melanopsis sp.	-	10	-	-	-	-	-	-	0.08	1.04
Valvata pulchella (Studer, 1789)	-	-	-	620	-	-	-	-	5.07	1.04
Valvata cristata (Tres, 1774)	-	-	-	10	-	-	-	-	0.08	1.04
Valvata piscinalis (Tres, 1774)	20	-	-	60	-	-	-	10	0.73	3.13
Monodonta sp. (Lamarck, 1799)	-	-	-	-	-	-	-	40	0.33	3.13
Calliostoma zizyphinum (Linnaeus, 1758)	-	-	-	-	-	-	-	2450	4.50	7.29
Bittium reticulatum (Da Costa, 1778)									3.11	5.21
Bivalvia										
Mytilus galloprovincialis (Lamarck, 1819)	-	-	-	-	-	-	-	239	1.96	4.17
Anadonta cygnea (Linnaeus, 1758)	-	-	-	-	-	11	11	-	0.09	1.04
Cardium sp.	-	-	-	-	-	-	-	220	3.44	4.17
Pisidium casertanum (Poli, 1791)	10	-	-	40	-	55	187	-	0.09	1.04
Sphaerium nitidum (Westerlund, 1876)	-	-	-	-	-	11	-	-	0.09	1.04
Sphaerium nucleus (Studer, 1820)	-	-	-	-	-	11	11	-	0.09	1.04
Abra alba (Lamarck, 1818)	-	-	-	-	-	-	-	170	1.88	6.25
Ensis sp.	-	-	-	-	-	-	-	20	0.16	2.08
Dreissena polymorpha (Van Beneden,1835)	650	1050	600	300	3128	33	-	-	47.16	48.96
Taxa number	4	2	1	7	1	9	9	16	-	-
Individual Number	700	1060	600	1070	3128	352	1931	4189	-	-
Shannon-Wiener Index	0.68	0.29	0.02	1.70	0.02	2.19	1.95	2.58	-	-
Evenness_e^H/S index	0.66	0.67	0.98	0.78	0.98	0.99	0.78	0.82	-	-
Raman-Margalef index	0.58	0.28	0	1.48	0	2.07	1.74	2.86	-	-

growth and reproduction of the upper component of the food web such as zooplankton and fish. It is also, a limiting factor on growth, reproduction and habitat replacing (Karatayev *et al*., 1997). Also, Zebra mussel invasion is a common problem that covers inside pipes and outlet canals in reservoirs. Additional costs for cleaning pipes and canals are needed (Bobat *et al*., 2004). In this study, the invasive species were encountered in all stations in the Atikhisar Resevoir during the year. But, it was encountered in site 5 located outlet of the Reservoir in Saricay Creek at the highest ratio (47.16% D, 48.96% F). Zebra mussel has negative effects on the dissolved oxygen and Chloropyll-a level in water (Sullivan and Endris, 1998). In this study, according to CCA analysis, it was seen that the main factors affecting the abundance and distribution of Dreissena polymorpha in terms of sites and time are dissolved oxygen and Chloropyll-a in Atikhisar Reservoir and Saricay Creek, (Dp = *Dreissena polymorpha*; Gt = *Galba truncatula*; Sp = *Stagnicola palustris*; Ra = *Radix auricularia*; Rp = *Radix peregra*; Pf = *Physa fontinalis*; Pa = *Physella acuta*; Pp = *Planorbis planorbis*; Pca = *Planorbis carinatus*; Gc = *Gyraulus crista*; Rs = *Rissoa* sp.; Pan = *Potamopyrgus antipodarum*; Bs = *Belgrandiella* sp.; Mt = *Melanoides tuberculatus*; Ms = *Melanopsis* sp.; Vc = *Valvata cristata*; Vpi = *Valvata piscinalis*; Ms = *Monodonta* sp.; Cz = *Calliostoma zizyphinum*; Br = *Bittium reticulatum*; Mg = *Mytilus galloprovincialis*; Ac = *Anadonta cygnea*; Cs = *Cardium* sp.; Pca = *Pisidium casertanum*; Sn = *Sphaerium nitidum*; Snu = *Sphaerium nucleus*; Aa = *Abra alba*; Es = *Ensis* sp.) (Fig. 3).

Gastropoda feed on algae, detrital particles and bacteria of the periphyton on submersed substrata. Physidae members feed on mainly detritus and periphyton (Brown, 2008). *Pysella acuta* was dominant mostly in site 7 at Saricay Creek. That this site has huge mass vegetation and detritus explains that the reason of this taxa dominant in site 7. In site 7, the other striking gastropod taxa are *Radix peregra* and *Radix auricularia*. Radix family members are generally located on stone bitopes (Rieradevall and Bonada, 1999). In this study, *R. peregra* and *R. auricularia* were encountered in the mass vegetation area of the site 7. That two taxa encountering in a mass vegetation area can be interpretated as these two taxa adapting into vegetation biotope. While, *P. acuta*, *R. peregra* and *R. auricularia* were highly frequent in site 7., *P. acuta*, *R. peregra* were encountered less in site 6. According to CCA analysis, it can be said that electrical conducticity of water mostly affects the distribution and abundance of *R. peregra* and BOD and COD level of water are influential on the distribution of *R. auricularia*, *P. acuta*.

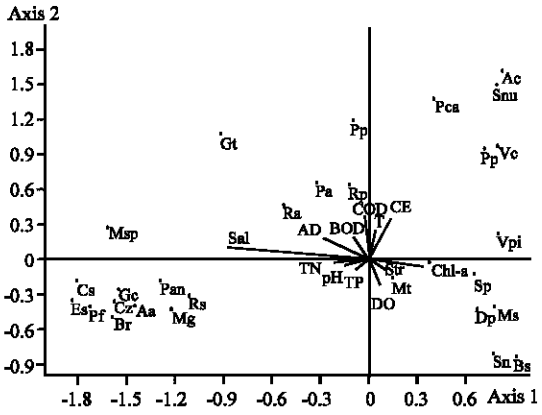

Fig. 3: CCA (Canonical correspondence analysis) of water parameters withcay Creek

Drifting organisms is very common in rivers and streams. Due to drifting, organisms located in upper streams can be encountered at downstream or at the mouthriver (Allan, 1995). Site 8 in Saricay Creek is a river mouth area flowing into Dardanelles. Freshwater species encountered in upper stream of Saricay such as *R. auricularia*, *G. truncatula*, *R. peregra*, *P. fontinalis*, *P. acuta*, *P. planorbis*, *V. piscinalis* and *G. Crista* were obserbed less in site 8 in the feature brackish water. We estimate that these seven freshwater molluscs came in to site 8 by drifting from upper areas of the Creek.

Potamopyrgus antipodarum is a species living in fresh and brackish water and rapidly spreading in sediment. The efficieny of assimilation (epressed as percentage of ingested organic carbon that is assimilated) of the stream snale, *Potamopyrgus* varied from 3.7-9.0% depending on the type of sediment used as food (Heywood and Edwards, 1962). As *P. antipodarum* distributed less quantity in freshwater site 7 at Saricay Creek and more in brackish water in site 8 of Saricay, it can be seen that habitat features of sites affects the distribution of this taxa.

According to CCA analysis diagram, it was seen that the most efficient factor in distribution of organisms was salinity. During the study, species such as *Rissoa* sp., *Calliostoma zizyphinum*, *Bittium reticulatum*, bivalviadan *Mytilus galloprovincialis*, *Cardium* sp., *Abra alba*, *Ensis* sp. were sampled in site 8, which has got brackish water feature not found in any of the other stations. This can be interprated that salinity highly affects distribution of these gastropoda and bivalvia taxa.

Pisidium casertanum, prefering mud biotopes is a small freshwater bivalvia having a length between 4-6 cm, living in lakes and rivers (Thorp and Covich, 2001). In this study, we sampled both Atikhisar reservoir (site 4) and

Saricay Creek (site 7). These taxa were much encountered at the site 4 located near dam set at height 8-10 m and site 7 in Saricay. The amount of inorganic and detritus particules rises depending on the depth of the lakes and reservoirs. At the depth of 18-20 m, the surface can be classified as the soft bottom biotope. This biotope structure explained the distribution and abundance of organisms living in soft bottom such as Pisidium. In a study carried out in Lake Redo, it was reported that abundance of Pisidium casertanum depended on the depth. The reason for this was that the taxon preferred the richer sediment structure and more depth (Lindegaard, 1992).

Site 4 is the deepest station of the Atikhisar Reservoir and it is near the dam set. *P. casertanum* was encountered here, more than the other sites in Reservoir. It was thought that the reason was the density of inorganic and organic particles and sediment quality in site 4. By the same token, *P. casertanum* was encountered much in site 7, which has highly mass vegetation covered large area. According to CCA analysis, water quality parameters affect the distribution of these taxa highly (Fig. 3). Besides, considering biomass and preferring biotope of *P. casertanum*, the features of the sediment affected the distribution.

Cabuk *et al.* (2004) reported that *R. peregra*, *G. truncatula* and *P. acuta* preferred the NO_3-rich habitats. Barbour *et al.* (1999) declared that taxa tolerance value of *P. acuta* was high and can be accepted as indicator species. This study pointed out that BOD, COD, AD parameters in site 7 and 8 affected the distribution and abundance of *R. auricularia, R. peregra*, *P. acuta* and *G. truncatula* as regards CCA.

Cluster analysis: According to cluster analysis, sites were classified into 4 groups in terms of Mollusca fauna. 1st. Group: 1, 2, 3 and 5th. sites; 2nd group: 4th site; 3rd Group: 6 and 7th Sites; 4th Group: 8th. site.

First group; 1, 2 and 3rd site in Atikhisar Reservoir have got muddy detritus, sandy detritus and muddy detritus, respectively. Their dephts are between 200-900 cm and similarity of the three sites changed between 75-85%. Site 5 was located at the starting point of Saricay Creek after Reservoir resembles three stations by 60% similarity. As bottom structure of site 5 is muddy, sandy, stonely and with vegetations, it has got rich biotopes. No pollution was found in the station.

Second group 4th site, which has a 900 cm depth, is in front of the dam set. It has muddy, detritus and richness in terms of organic material. So, it is different from the other sites in the reservoir.

The 6 and 7th sites in the 3rd group in Saricay Creek has been threatened under domestic and agricultural pollution. Similarity ratios of the two sites are about 40%. This could be becasue similarity ratio was low, as their bottom and vegetation cover was different.

Because, the 4th group 8th site was located at the rivermouth of Saricay Creek, water quality parameters has been fluctuating every day. Domestic, agricultural and industrial pollutants have been extremely threatening to site 8. In this area, there are stinking black muddy layers in the bottom. At some area, which has been affected by sea waves and currents, bottom structures are sandy and vegetations are plentiful. So, mollusca diversity, bottom structure and water quality parameters are different from the other sites.

Canocical Correspondence Analysis (CCA): CCA revealed the impact of physico-chemical parameters of water on the abundance and distributions of Mollusca fauna. Salinity, pH, TP and TN have affected the distribution and abundance of *Monodonta* sp., *Cardium* sp., *P. fontinalis*, *E. ensis*, *C. zizyphinum*, *A. alba*, *P. antipodarum*, *Rissoa* sp. *M. galloprovincialis*, *B. reticulatum* in site 8, *G. truncatula*, *P. acut* and *R.auricularia* 1.,4, 6 and 7th stations. Conductivity and temperature affected *R. peregra*, *P. planorbis*, *M. tuberculatus*, *S. palustris*, *V. piscinalis*, *P.casertanum*, *A. cygnea*, *S. Nucleus* by anionic detergent, salinity and BOD in site 7 and 8. In site 1 and 2, dissolved oxygen, oxygen saturation and Chl-a impressed the distribution of *D. polymorpha, Belgrandiella* sp., *Melanopsis* sp. and *S. nitidium*.

Anosim and simper analyses: In the ANOSIM analyses carried out, statistical differences among the stations (Global R = 0.3059 and $p<0.001$) were revealed (Table 4).

According to Table 3, while, differences between the sites 2 and 4 at Atikhisar Reservoir were significant ($p = 0.0249$), the other stations at the reservoir had no significant differences ($p<0.0001$). SIMPER analysis showed that taxa constituting dissimilarities between the sites 2 and 4 were *Dreissena polymorpha* (contribution% = 52.51) and *Valvata pulchella* (contribution% = 3.22). This was because bottom of the station 2 was mostly hard substratum and zebra mussel covered all the stones and the other hard materials. The differences might be due to the substratum structure (Table 5).

Besides, it was determined that all sites (the sites 1, 2, 3 and 4) in Atikhisar Reservoir were significantly different from all sites (the sites 5, 6, 7 and 8) in Saricay Creek. It was evaluated seperately due to their different ecosystems (lentic and lotic).

Table 4: ANOSIM analysis results (R = 0.3059, p<0.0001)

Global R/p	Ist1	Ist2	Ist3	Ist4	Ist5	Ist6	Ist7	Ist8
Ist1	0	0.6324	0.3801	0.1485	0.1543	0.0001	0	0
Ist2	-0.02052	0	0.0947	0.0249	0.2255	0	0	0
Ist3	-0.00163	0.06645	0	0.5969	0.2786	0.0045	0	0
Ist4	0.05708	0.1766	-0.02625	0	0.1209	0.0481	0.0012	0
Ist5	0.04998	0.0302	0.02499	0.05314	0	0.0008	0	0
Ist6	0.3751	0.5866	0.2476	0.09449	0.3331	0	0.0734	0
Ist7	0.5576	0.75	0.4527	0.3278	0.5335	0.0837	0	0.0002
Ist8	0.7497	0.8939	0.6843	0.6474	0.7652	0.4382	0.2856	0

Table 5: The result of simper analysis

Stations	Overall average dissimilarity (%)	Taxon	Contribution (%)	Cumulative (%)
1-6	96.76	*Dreissena polymorpha*	54.250	56.07
		Pisidium casertanum	8.762	65.12
1-7	99.72	*Dreissena polymorpha*	39.400	39.51
		Physella acuta	17.930	57.49
1-8	99.49	*Dreissena polymorpha*	19.480	19.58
		Calliostoma zizyphinum	12.900	32.55
2-4	61.51	*Dreissena polymorpha*	52.510	84
		Valvata pulchella	3.225	89.16
2-6	97.21	*Dreissena polymorpha*	67.880	69.82
		Pisidium casertanum	6.717	76.73
2-7	100.00	*Dreissena polymorpha*	50.710	50.71
		Physella acuta	16.680	67.38
2-8	98.88	*Dreissena polymorpha*	27.190	27.5
		Calliostoma zizyphinum	12.170	39.8
3-6	97.69	*Dreissena polymorpha*	42.010	43.01
		Radix peregra	12.230	55.53
3-7	100.00	*Dreissena polymorpha*	32.480	32.48
		Physella acuta	20.120	52.6
1-6	96.76	*Dreissena polymorpha*	54.250	56.07
		Pisidium casertanum	8.762	65.12
3-8	99.09	*Dreissena polymorpha*	14.120	14.25
		Calliostoma zizyphinum	13.980	28.35
4-6	97.51	*Dreissena polymorpha*	31.770	32.58
		Radix peregra	12.700	45.6
4-7	97.71	*Dreissena polymorpha*	24.200	24.27
		Physella acuta	19.640	43.97
4-8	99.81	*Calliostoma zizyphinum*	13.660	13.68
		Dreissena polymorpha	11.210	24.92
5-6	97.94	*Dreissena polymorpha*	57.490	58.7
		Radix peregra	11.090	70.03
5-7	100.00	*Dreissena polymorpha*	47.230	47.23
		Physella acuta	18.500	65.73
5-8	100.00	*Dreissena polymorpha*	26.870	26.87
		Calliostoma zizyphinum	12.420	39.29
6-8	95.17	*Calliostoma zizyphinum*	13.790	14.49
		Physella acuta	9.074	24.02

The Site 5 located at the upstream of Saricay Creek after the Reservoir were significantly different from the sites 6, 7 and 8 ($p<0.01$). According to SIMPER analysis, taxa forming dissimilarities between the sites 5 and 6 are *Dreissena polymorpha* (contribution% = 57.49), *Radix peregra* (contribution% = 11.09); between site 5 and 7 were *Dreissena polymorpha* (contribution% = 47.23), *Physella acuta* (contribution% = 18.5); between site 5 and 8 were *Dreissena polymorpha* (contribution% = 26.87), *Calliostoma zizyphinum* (contribution% = 12.42).

There were no significant differences between the sites 6 and 7 ($p = 0.0734$). The Site 8 was significantly different from the other stations ($p = 0.01$). The site 5 was significantly different from the other sites due to lack of pollution sources, drifting, rich biotope and lack of settlement areas and agricultural areas. It was also, determined that The site 8 was significantly different from the other sites due to the rivermouth area, domestic pollutants from the settlement area and chemical pollutants from the painting and repairing docks of fishing vessels.

CONCLUSION

In this study, a total of 29 mollusca taxa were determined, 20 belonging to Gastropoda and 9 to Bivalvia. That the diversity of mollusca was high can be explained by lentic, lotic and eustarine habitat and different substratum existing in the study area.

The Mollusca taxa found in this study formed the first records for the Atikhisar Reservoir and Saricay Creek.

CCA revealed that water quality parameters especially COD, BOD, Anionic Detergent, salinity, TP, TN and temperature were effective on the abundance and distribution of Mollusca fauna. Besides it was assumed that biotope structure of the sites was also influential.

Dreissena polymorpha, invasive species in Atikhisar Reservoir was found extremely abundant (D = 11%, F = 51.04%). It was evaluated that the situation was a ecological disaster for Atikhisar Reservoir providing drinking and irrigation water for Canakkale and Atikhisar Basin. So, the authorities should take preventive measures against an invasion of zebra mussels in the basin.

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