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Aquatic Oligochaeta (Annelida) of Dam Lakes Çatören and Kunduzlar (Turkey)

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Abstract

Çatören and Kunduzlar Dam Lakes, located on Seydi River, represent the main irrigation water resources of the Seyitgazi District (Eskişehir Province), in west-central Turkey. The river and the reservoirs are both under the threat of pollution primarily originating from several domestic point source discharges and land-based runoff. The numerical and proportional distributions of oligochaetes in Çatören and Kunduzlar Dam Lakes were surveyed seasonally in 2010 and 2011 at two stations on each lake. According to the results of this study, the benthic invertebrate fauna of Çatören Dam Lake consisted of Oligochaeta (40.2 %), Chironomidae larvae (32.2 %) and the varia (27.6 %); the benthic invertebrate fauna of Kunduzlar Dam Lake consisted of Oligochaeta (56.7 %), Chironomidae larvae (18.2 %) and the varia (25.1%). By evaluating the data via a Shannon-Wiener index it was found that the Çatören Dam Lake had an index of 2.32; while Kunduzlar Dam Lake had an index of 3.27. Several physicochemical water quality parameters were also analyzed during this study. The relationships between the dynamics of organisms and environmental parameters were supported by Pearson correlation index. It was determined that Çatören and Kunduzlar Dam Lakes waters were polluted and slightly polluted, respectively. The dominance and abundance of oligochaete species and low species richness showed that similar studies should be carried out periodically in Çatören and Kunduzlar Dam Lakes for the future monitoring of the dam lakes.

Key words: Oligochaeta, Çatören and Kunduzlar Dam Lakes, Turkey

Introduction

Benthic macroinvertebrate assemblages are very important for aquatic system food chains and may serve as biological indicators of various environmental stresses on aquatic ecosystems (Richardson and Kiffney 2000). Invertebrate communities are also trustworthy indicators of water and ecosystem conditions (Chao et al. 1996). Oligochaetes have a worldwide distribution, with species adapted to every kind of body of water, such as brackish water, fresh water or salt water. In addition, certain species of Oligochaeta are abundant in organically polluted waters because of lack of competition and an abundant food supply coupled with a tolerance to reduced oxygen condition (Brinkhurst and Jamieson 1971) and they are considered an interesting indicator of water quality because of their ubiquity and abundance in aquatic ecosystems (Sæther 1979; Pinder 1986). However, there have been few studies on the invertebrate fauna and water quality of Çatören and Kunduzlar Dam Lakes (CDL and KDL, respectively) (Altındağ and Özkurt 1998; Özkurt 2000) and, to date, there have been no studies related to their oligochaete faunas and environmental parameters. This study is aimed at investigating the qualitative and quantitative characteristics of the oligochaete faunas in the CDL and KDL. In this study, scales of distribution of oligochaete species and relationships with environmental variables were examined. Data have also been used to identify correlative relationships between physicochemical features and the dynamics of oligochaete fauna.

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Materials and methods

Study Area

Çatören and Kunduzlar dam lakes are located in the Kırka basin of Eskişehir (Figure 1) and have been used for irrigation, erosion control and energy supply since 1984 and 1986, respectively. The surface areas and maximum depths of the dam lakes are 2.64 km^2 and 4.04 km^2, and 28 m and 38 m, respectively. Kümbet and Akin are the main streams that carry water to CDL and KDL, respectively (Figure 1).

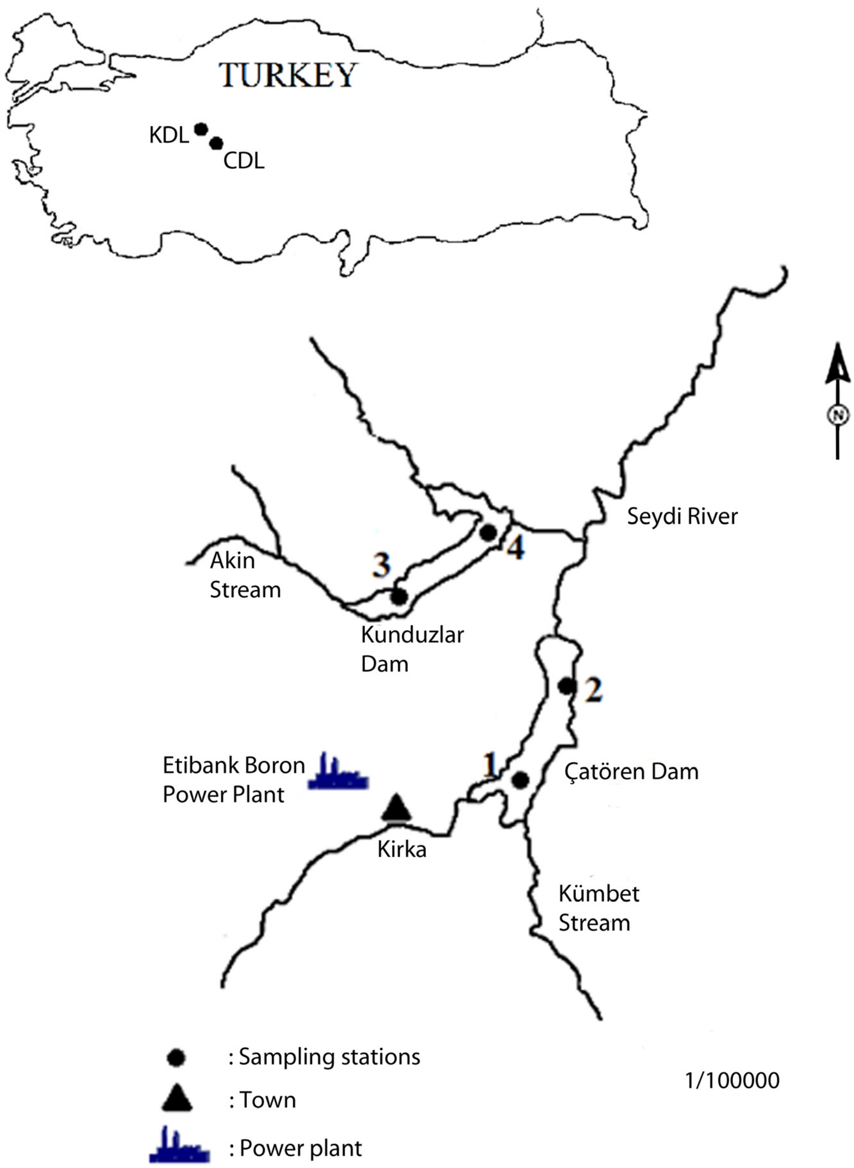

FIGURE 1: Location of sampling sites on the Çatören (CDL) and Kunduzlar (KDL) dam lakes, Seydi River (Seyitgazi District, Eskişehir Province) in west-central Turkey, where surveys for aquatic oligochaetes and other benthic macroinvertebrates were conducted during 2010 and 2011.

Sampling

This study was carried out between March 2010 and June 2011. Two replicate benthic samples were taken seasonally at four different stations (Figure 1) using an Ekman grab. Samples were washed in situ using a sieve of 200µm mesh size. The material was preserved in 4% formalin in the field, taken to the laboratory and sorted under a stereomicroscope. All samples were identified to family, order or class level and preserved in

70% alcohol. Taxa were grouped as Oligochaeta, Nematoda, Chironomidae larvae, Gastropoda and Bivalvia, plus low numbers of Hirudinea, Odonata, Ephemeroptera, Coleoptera and Hemiptera which were grouped as "Varia". Only oligochaete samples were identified to genera or species level. Oligochaete specimens were either studied as whole mounts in glycerine or mounted in polyvinyl lactophenol (for chaetal characters), and finally mounted as whole specimens in Canada balsam after dehydration. The identification of the oligochaete species was completed using the four identification keys (Brinkhurst and Jamieson 1971; Sperber 1950; Timm 1999; Timm and Veldhuijzen van Zanten 2002).

Ten physico-chemical variables were measured at each of the four stations (Table 2). Water temperature, hydrogen ion concentration (as pH), dissolved oxygen (mg/L) and conductivity (mSiemens) were measured in the field. Two replicates of water samples from each station were stored in polyethylene bottles (1000 ml). The chemical and biological oxygen demand (BOD and COD), SO_4, NO_3N, NO_2N were all determined in accordance with the standard method procedures (APHA 1992). The water samples were kept in a refrigerator at a temperature below 4 °C and were analyzed within 24 hours. The highest and lowest values of the measured physico-chemical parameters of four sampling sites of CDL and KDL during the study period are given in Table 2.

Statistical Analysis

Shannon index was based on PAST 1.75b (Hammer, Harper and Ryan 2001). Bellan-Santini's (1969) quantitative dominance index (Bellan-Santini 1969) of each species was estimated by; $D_i = N_i/N_t$x 100, where N_i = number of individuals of species *i*; and N_t = total number of macrobenthic specimens. Also, relationships between the distribution of the oligochaete species and environmental variables were determined using Spearman correlation in SPSS 9.0 for Windows.

RESULTS and DISCUSSION

During this study, 24 invertebrate taxa were recorded, collectively, from the Çatören and Kunduzlar dam lakes; however, since the scope of this study focused on the aquatic oligochaete fauna in these lakes, only the oligochaetes were identified to the genus or species level (Table 1). A total of 2524 individuals were counted, comprising 15 species of Oligochaeta and nine taxa representing Gastropoda, Chironomidae, Bivalvia, Nematoda and varia. A taxonomic list of the oligochaete species and other benthic invertebrates determined in the CDL and KDL during the study, with their individual numbers and dominance (D %) values were given in Table 1.We found that the CDL and KDL's zoobenthos was dominated by oligochaetes and Chironomidae larvae. Oligochaeta was composed of a high value of dominance (40.2% and 56.7% for CDL and KDL, respectively); the second taxon was Chironomidae (32.2 % and 18.2 %).

Oligochaete species richness varied between 10 and 15 in the study area (Table 1). The highest Oligochaeta species number was found in KDL (15 species) while the lowest oligochaete species (10 species) were found in CDL. *Psammoryctides albicola* was found to have the highest dominance value (8.3 %D) and it was followed by *Potamothrix hammoniensis* (7.8 %D) and *Limnodrilus hoffmeisteri* (6.6 %D) and *Limnodrilus claparedianus* (5.9 %D) in KDL; while in CDL, *Stylaria lacustris* was found to have the highest dominance value (8.2 %D) and it was followed by *Pristina jenkinae* (5.1 %D), *Nais elinguis*(5.5 %D) and *Potamothrix hammoniensis* (4.7 %D). In addition, *Potamothrix bavaricus, Psammoryctides barbatus, Psammoryctides albicola, Uncinais uncinata,*and *Paranais frici* were found in only KDL. According to Shannon index, the species diversity in KDL was found as 3.27 while in CDL 2.32 (Table 2). It is clearly shown that the number of species (N), taxa number and Shannon (H) are higher in KDL than in the CDL.

Pearson's correlation coefficients between abundance of selected oligochaete species (which were shown common distribution or high abundance) and examined environmental parameters of CDL and KDL water were examined. In KDL especially tubificine species, *P. albicola, P. hammoniensis, L. hoffmeisteri* and *L. udekemianus* showed significant positive correlations to the BOD ($p<0.01$); *Potamothrix hammoniensis* and *L. hoffmeisteri* showed positive correlations to the SO_4 and NO_2-N respectively ($p<0.05$). In CDL, it was found that the abundance of naidid species *Nais elinguis* and *Aulophorus furcatus* showed a negative correlation to the DO level of the water ($p<0.05$) while *P. jenkinae* showed a positive correlation ($p<0.05$).

In Turkey, surface water quality is classified according to: a) physical and inorganic-chemical parameters, b) organic parameters, c) inorganic parameters, and d) bacteriological parameters. In addition, each group contain four water quality classes; surface water quality classes are defined as: class I: high quality waters, class II: slightly contaminated waters, class III: contaminated waters, and class IV: severely polluted waters (SSKY 2008). According to SSKY (2008), the values of *p*H, conductivity, and temperature were found at normal levels during the course of this present study (Table 2). When the water quality was evaluated for nutrients, the values of SO_4 and NO_2N were found at third and second quality level, respectively, in CDL; while the values of SO_4 and NO_2N were found at first and second quality level, respectively, in KDL. According to the Turkish water quality classes (SKKY 2008) CDL sampling sites during the 4 sampling months in 2010–2011 (Table 2) were categorized as Class III (in terms of physical and inorganic-chemical parameters) and Class II (in terms of organic parameters) while KDL sampling sites were categorized as Class II and Class I respectively. According to SSKY (2008), Class II waters are used for: (a) drinking purposes (after advanced treatment), (b) recreational purposes, (c) fish farming (except trout), (d) irrigation, and (e) other purposes not covered by Class I; Class III waters can be used for industrial purposes (except food and textile industries).

TABLE 1: Taxonomic list of the oligochaete species and other benthic invertebrates determined in the Çatören (CDL) and Kunduzlar (KDL) dam lakes, Seydi River (Seyitgazi District, Eskişehir Province) in west-central Turkey, during the present study, with their individual numbers and dominance (D %) values.

		CDL			KDL		
		1st	2nd	D	3rd	4th	D
	OLIGOCHAETA						
1	*Limnodrilus claparedianus* Ratzel, 1869	25	0	3.5	63	39	5,6
2	*Limnodrilus hoffmeisteri* Claparéde, 1862	15	15	4.2	78	42	6,6
3	*Tubifex tubifex* (Müller, 1774)	12	0	1.7	27	2	1,6
4	*Potamothrix hammoniensis* (Michaelsen, 1901)	15	18	4.7	63	78	7,8
5	*Potamothrix bavaricus* (Oschmann, 1913)	0	0	0.0	48	0	2,6
6	*Psammoryctides barbatus* (Grube, 1861)	0	0	0.0	42	18	3,3
7	*Psammoryctides albicola* (Michaelsen,1901)	0	0	0.0	72	78	8,3
8	*Nais elinguis* Müller, 1773	24	15	5.5	42	33	4,1
9	*Nais variabilis* Piguet, 1906	6	9	2.1	48	9	3,1
10	*Aulophorus furcatus* (Müller, 1774)	15	6	3.0	51	30	4,5
11	*Dero digitata* (Müller, 1773)	6	9	2.1	15	18	1,8
12	*Uncinais uncinata* (Orsted, 1842)	0	0	0.0	6	12	1,0
13	*Stylaria lacustris* (Linnaeus, 1767)	25	33	8.2	9	57	3,6
14	*Paranais frici* Hrabě, 1941	0	0	0.0	15	0	0,8
15	*Pristina jenkinae* (Stephenson, 1931)	15	21	5.1	36	0	2,0
	Number of oligochaete taxa at the stations	10	8	-	15	12	-
16	Gastropoda	45	66	15.7	48	24	4,0
17	Bivalvia	0	6	0.8	21	33	3,0
18	Nematoda	3	18	3.0	36	27	3,5
19	Chironomidae	159	69	32.2	210	120	18,2
	VARIA						
20	Coleoptera	24	9	4.7	21	15	2,0
21	Hemiptera	0	0	0.0	15	24	2,1
22	Odonata	6	12	2.5	42	63	5,8
23	Ephemeroptera	0	6	0.8	42	24	3,6
24	Hirudinea	0	0	0.0	6	15	1,2
	Shannon H'	2.32			3.27		

TABLE 2: Some parameters of the water in Çatören (CDL) and Kunduzlar (KDL) dam lakes, Seydi River (Seyitgazi District, Eskişehir Province) in west-central Turkey by season (W: winter, December 2010, Sp: Sring, April 2011, Su: Summer, July 2011, Au: Autumn, October, 2011).

	CDL					KDL				
Parameters/Sampling	W. 2010	Sp. 2011	Su. 2011	Au. 2011	Average ± SD	W. 2010	Sp. 2011	Su. 2011	Au. 2011	Average ±SD
Physical inorganic-chemical parameters										
Temperature (°C)	7.8	12.4	17.3	19.7	14.3 ± 5.2	9.2	13.3	18.6	18.2	14.8 ± 4.4
pH	7.9	8.1	7.8	8.6	8.1 ± 0.31	8.2	8.4	8.1	8.3	8.2 ± 0.1
DO (mg L^{-1})	7.6	6.8	4.3	5.4	5.7 ± 1.3	8.3	8.1	6.2	6.8	7.3 ± 1
SO_4^{-2} (mg L^{-1})	285	210	225	315	258.7 ± 49.5	86	55	105	110	89 ± 24.9
NO_3N (mg L^{-1})	2.63	2.45	3.38	4.16	3.1 ± 0.7	0.75	1.19	0.41	0.58	0.7 ± 0.3
NO_2N (mg L^{-1})	0.026	0.0071	0.0058	0.029	0.01 ± 0.01	0.011	0.014	0.023	0.026	0.01 ± 0.01
Water Quality Class			**III**					**II**		
Organic parameters										
BOI (mg L^{-1})	3.6	7.2	3.2	3.1	4.2 ± 1.80	2.8	3.1	4.4	4.6	3.72 ± 0.9
KOI (mg L^{-1})	10.9	15.6	18.5	19.4	16.1 ± 3.83	9.9	14.2	17.5	18.4	15 ± 3.8
Water Quality Clasis			**II**					**I**		
Other										
Total hardness (mg L^{-1} $CaCO_3$)	196	208	226	218	212 ± 12.9	267	270	274	284	273.7 ± 7.4
Conductivity (μmhos cm^{-1})	325	368	412	395	375 ± 37.9	416	397	401	408	405.5 ± 8.3
					Water Quality Clases (SKKY, 2008)					
	I	II	III	IV		I	II	III	IV	
DO (mg L^{-1})	8	6	3	< 3		8	6	3	< 3	
SO_4 (mg L^{-1})	200	200	400	> 400		200	200	400	> 400	
NO_3N (mg L^{-1})	5	10	20	> 20		5	10	20	> 20	
NO_2N (mg L^{-1})	0.002	0.01	0.05	> 0.05		0.002	0.01	0.05	> 0.05	
BOI (mg L^{-1})	4	8	20	> 20		4	8	20	> 20	
KOI (mg L^{-1})	25	50	70	> 70		25	50	70	> 70	

Conclusions

It was found that the zoobenthos of Dam Lakes were dominated by two groups of invertebrates, Oligochaeta and Chironomidae, which is typical of many freshwater systems. Dam lakes oligochaete fauna consist mainly of taxa with wide ecological tolerances and extensive geographical ranges. The oligochaetes in KDL were mainly represented by three species, *P. hammoniensis*, *P. albicola,* and *Limnodrilus hoffmeisteri*, each of which was present throughout the year. The naidine species, *Stylaria lacustris* and *N. elinguis*, were the dominant species present in CDL. *Limnodrilus hoffmeisteri* and *L. claparedianus* are commonly collected in organically enriched waters. In addition, these tubificine species are often found in large numbers in highly polluted waters (Brinkhurst and Jamieson 1971; Mason 1996) and *Potamothrix hammoniensis* is a reliable indicator of eutrophy or local organic enrichment when occurring in considerable densities (Milbrink 1980). In the study area, these tubificine species were the most abundant. The pollution of the dam lake KDL could be characterized by the species *T. tubifex, L. hoffmeisteri, L. claparedianus* and *P. hammoniensis.* The most common oligochaete species in KDL were *Stylaria lacustris, Nais elinguis, Pristina jenkinae* and *Aulophorus furcatus.* These naidine species, common inhabitants of sewage filter beds, ponds, lakes and streams, have also been found in brackish water (Davis 1982). In addition, *Pristinella jenkinae* has been collected from a wide range of current velocities and within a wide temperature range by Pascar-Gluzman and Dimentman (1984) who reported euryoic and eurythermal species. These four species are reported to be tolerant of severe pollution and have been found in a stream degraded by industrial effluents (Maciorowski et al. 1977; Harman 1979). *Stylaria lacustris*, *Nais elinguis, Pristina jenkinae* and *Aulophorus furcatus* were reported to occur in abundance in stony bottomed, muddy substratum, organically enriched streams and lakes in Turkey (Çamur-Elipek et al. 2006; Arslan and Şahin 2006; Akbulut et al. 2009).This fact can be explained by the euryoeic character of four naidine species, as reported by Pascar-Gluzman and Dimentman (1984) and Davis (1982).

The distribution, species composition, and development of aquatic oligochaetes depends on many factors such as water temperature, chemical and physical properties of the water (Grigelis et al. 1981), sediments, bottom microflora, and vegetation cover. In the present study, there were no significant differences from the point of view of the dam lakes substrate type. However, the main and important differences between the dam lakes stations were the vegetation. High naidine species abundance in the CDL may be partly due to their rich littoral vegetation.

The relationship between the number of tubificine taxa and BOD was directly proportional ($p<0.01$), while the relationship between the number of some naidine taxa (*Nais elinguis* and *Aulophorus furcatus*) and DO was inversely proportional ($p<0.05$).

The dominant oligochaete species collected during this study, *P. hammoniensis*, *P. albicola*, and *L. hoffmeisteri,* are commonly collected from eutrophic lakes (Brinkhurst and Jamieson 1971; Milbrink 1980). Most of the naidine taxa recorded during this study were found in CDL stations, which contain a high density of aquatic vegetation. The subfamily Naidinae contains species with a wide variety of environmental preferences. In both dam lakes, oligochaete diversity was low, but abundance was high. Generally, tubificine members were widespread in all year during the study period. Several authors (Milbrink 1980; Pascar-Gluzman and Dimentman 1984; Särkkä 1994; Mason 1996) indicated that some species of tubificine and naidine were an indicator of organic loading in lakes. All of our results during this present study support these findings.

As we mentioned above, according to physical and inorganic-chemical and organic parameters, it was determined that CDL and KDL waters were polluted and slightly polluted respectively (Table 2). Emiroğlu et al. (2010) investigated boron concentration of Seydi Stream water, its sediment, and different organisms from surrounding Kırka county. They examined inflow and outflow waters of CDL and KDL dam lakes. They found that boron levels in water flowing into CDL was 3.45 mg L^{-1}, but lower (2.51 mg L^{-1}) in water flowing into KDL.Their results showed that boron concentrations of the Seydi Stream water is higher than the Turkish Environmental Guidelines standard (>1 mg L^{-1}). In comparison, mean values of boron in surface waters throughout Europe are typically below 0.6 mg L^{-1}.

According to the boron concentrations found in their study, Emiroğlu et al. (2010) concluded that water of Seydi Stream was included to the class IV (>1 mg L^{-1}) heavily polluted water that should not be used at all (for drinking, recreational, fish farming and irrigation purposes).

Consequently, irrigation, sewage system, variable flow rate and temperature affect the quality of waters in CDL and KDL. The structure of benthic invertebrate fauna in the CDL and KDL changes with effects of environmental variables. The dominance by, and abundance of, oligochaete species showed that similar monitoring studies should be carried out periodically in CDL and KDL for the future of the dam lakes.

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