

## Aquatic oligochaetes (Annelida: Clitellata) of seven lakes in the Ceyhan River basin (Turkey)

Özlem FINDIK<sup>1</sup> & Seval ARAS<sup>2</sup>

<sup>1</sup>*Neusehir Hacı Bektaş Veli University, Faculty of Arts and Sciences, Neusehir, Turkey; e-mail: ofindik74@yahoo.com*

<sup>2</sup>*Neusehir Hacı Bektaş Veli University, Faculty of Engineering and Architecture, Department of Environmental Engineering, Neusehir, Turkey; e-mail: sevalkokmen@gmail.com*

**Abstract:** Oligochaeta samples were collected from seven lakes (2 natural and 5 non-natural) of Ceyhan River basin during the summer and autumn seasons of 2014. The Ceyhan River basin is located in the south-eastern Anatolia region in Turkey. Lakes Gölbaşı and Azaplı are located in a protected area. Some physico-chemical parameters of surface water were measured in situ. Sampling for oligochaetes was conducted by using both hand-nets and an Ekman Birge grab sampler, with samples obtained from different depths. Oligochaetes represented the dominant group of the total benthic macroinvertebrates in samples, with the exception of samples collected from Ayvalı Dam lake. A total of 11,293 oligochaete specimens were sorted from samples collected from these lakes, from which 14 species belonging to 2 subfamilies (Naidinae and Tubificinae) were identified. *Potamothrix hammoniensis* (90.24%) and *Limnodrilus hoffmeisteri* (7%) were the most abundant oligochaetes in the samples.

**Key words:** Oligochaeta; Ceyhan River basin; Turkey; lakes

### Introduction

In Turkey, there are approximately 120 natural lakes and 706 reservoirs, each with different structural and ecological features (DSİ 2015). The number of reservoirs has been steadily increasing in Turkey, as it has elsewhere in the World. Turkey has been recognized as one of the most important countries in the Palearctic Region in terms of its aquatic ecosystems, water sources, important bird areas, and wetlands because of its geomorphological structure (Magnin & Yarar 1997). The Ceyhan River basin is located in the south-eastern Anatolia region in Turkey (Fig. 1). The area is considered to be an important breeding area for avifauna. Gölbaşı and Azaplı are tectonic karstic lakes. The other lakes (Ayvalı, Kartalkaya, Kilavuzlu, Aslantaş and Hakkıbeyli) are reservoirs. The area within and surrounding the Ceyhan River basin area is important for agricultural and industrial activities, receiving extensive discharges, and surface and subsurface contributions of pollutants from these activities.

It is widely accepted that assessment of the benthic macroinvertebrate communities is an important part of the evaluation of environmental quality of aquatic ecosystems (Stewart et al. 2000). The lake profundal benthic community is composed mainly of chironomid larvae and oligochaetes. These two groups of common

benthic organisms are very important as a food resource for a large number of predators, such as benthic-feeding fish and some insects, and as significant material exchangers across the sediment-water interface. Aquatic oligochaetes that permanently live at the bottom are broadly distributed world-wide and frequently are the most abundant group in many freshwater ecosystems. Certain species show certain specific adaptation in ecosystems at different trophic levels to extreme environmental situations related to high temperature, hydrogen ion concentration (as pH), organic matter content in the sediment, and low dissolved oxygen in the water sediment interface (Armitage et al. 1995).

The objective of this study was to determine the species composition and distribution of aquatic oligochaetes, and their relationship with environmental variables in the seven lakes (2 natural lakes and 5 reservoirs) within the Ceyhan River basin.

### Material and methods

Samples of benthic macroinvertebrates were collected from seven lakes in the Ceyhan River basin during the summer (9–15 July) and autumn (13–16 November) of 2014. Two types of sampling devices were used to collect aquatic oligochaetes: hand net samplers in shallow regions where the substrate was mostly clay and macrophytes, and Ekman-Birge grab samplers for deeper areas.

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Fig. 1. Location of the Ceyhan River basin and the lakes under study.

Oligochaetes and other macroinvertebrates were separated from substrate materials in samples using a 500  $\mu\text{m}$  sieve, and using thin long-nosed tweezers; sieved specimens were then fixed in 4% formalin. The samples brought to the laboratory were divided into groups and then preserved in 70% ethyl alcohol (Welch 1948). Samples were sorted, identified and enumerated in the laboratory using both dissecting and compound microscopes. With the exception of immature and damaged/incomplete specimens, all oligochaetes sorted from benthic samples were identified to the lowest possible taxonomic level, usually to genus or species. Oligochaete specimens were identified using the keys and diagnoses presented in the following publications: Brinkhurst (1971a, b), Kathman & Brinkhurst (1998), Timm (1999) and Pinder (2010). Classification and nomenclature follow that presented in the above references, and also in Erséus et al. (2008) and Reynolds & Wetzel (2015).

During the sampling periods, surface water quality parameters – temperature, hydrogen ion concentration (as pH), and dissolved oxygen (DO) – were measured in situ with Hache-Lange (HQ40D). Values for other water quality parameters – biological oxygen demand (BOD), chemical oxygen demand (COD), ammonia ( $\text{NO}_4\text{-N}$ ), nitrite nitrogen ( $\text{NO}_2\text{-N}$ ), nitrate nitrogen ( $\text{NO}_3\text{-N}$ ), and total phosphorus (Total-P) – were obtained from water samples collected from sampling sites and analyzed in the laboratory following Standard Methods (APHA 1998).

Multivariate analysis was performed with CANOCO 5. Principle Component Analysis (PCA), (as provided in CANOCO; ter Braak & Smilauer 2012) was carried out as a linear method to establish associations between oligochaetes and environment variables.

## Results and discussion

This study was carried out to determine the fauna of aquatic oligochaetes of Ceyhan River basin's lakes. A

list of the 16 species of aquatic oligochaetes collected from the study areas (7 lakes) is given in Table 1. Some undeterminable juvenile forms have been ranked to genera or families.

Oligochaete species richness varied between 1 and 9. The highest diversity of oligochaetes (9 species) was recorded from samples collected in Lake Gölbaşı (a natural lake) while the lowest diversity (1 species) was recorded in Ayvalı Dam lake (an impoundment).

Distributions of physicochemical parameters by lakes are displayed in Table 2. It is important in water management to monitor the concentrations of the various natural and anthropogenic constituents in water, especially in lakes and reservoirs that are used as domestic water supplies (Kökmen 2007). The seasonal mean of the lowest measured nitrate concentration was in Lake Gölbaşı ( $0.05 \text{ mg L}^{-1}$ ). The highest measured nitrate concentration was in Lake Aslantaş ( $0.32 \text{ mg L}^{-1}$ ). The highest measured dissolved oxygen was  $9.41 \text{ mg L}^{-1}$  in Hakkıbeyli Dam lake and the lowest value was detected in Ayvalı Dam lake ( $7.920 \text{ mg L}^{-1}$ ).

Distribution of abundance oligochaetes in summer and autumn is shown in Fig. 2. Sampling could not be completed in Lake Azaplı during the summer months when the lake became very eutrophic and was covered by aquatic and semi-aquatic macrophytes. During the autumn months, 64 samples were collected from the lakes. The most frequently collected species were *Tubifex tubifex* (35 individuals), and *Potamothrix hammoniensis* and *Nais variabilis* (both with 9 individuals). Lakes Azaplı and Gölbaşı are connected by a channel. The dominant taxa included *Psammoryctides* sp. (81 individuals), *Limnodrilus hoffmeisteri* (64 individuals),

Table 1. Oligochaeta taxa identified from seven lakes located in the Ceyhan River basin, Turkey.

	Lake						
	Azaplı	Ayvalı	Gölbaşı	Kartalkaya	Aslantaş	Kılavuzlu	Hakkıbeyli
Tubificinae					+		
<i>Stylaria lacustris</i> (L., 1767)	+		+				
<i>Nais</i> sp.			+				
<i>Nais variabilis</i> (Piquet, 1906)	+			+			
<i>Nais simplex</i> (Piquet, 1906)				+			
<i>Nais communis</i> (Piquet, 1906)			+		+		
<i>Dero digitata</i> (Mueller, 1773)	+			+			
<i>Dero dorsalis</i> (Ferroniere, 1899)			+				
<i>Tubifex tubifex</i> (Müller, 1774)	+		+				
<i>Putamontrix hammoniensis</i> (Michaelsen, 1901)	+		+				
<i>Limnodrilus hoffmeisteri</i> (Claparède, 1862)		+	+	+	+	+	+
<i>Psammoryctides barbatus</i> (Grube, 1861)			+				
<i>Aulophorus furcatus</i> (Müller, 1773)			+				
<i>Pristina aequisetata</i> (Bourne, 1891)							+
<i>Pristina rosea</i> (Michaelsen, 1909)							+
Enchytraeidae							+

+ denotes presence

Table 2. Physico-chemical parameters in seven lakes located in the Ceyhan River basin, Turkey.

Lake	pH	Temperature (°C)	DO (mg L <sup>-1</sup> )	BOD (mg L <sup>-1</sup> )	COD (mg L <sup>-1</sup> )	Ammonia (mg L <sup>-1</sup> )	NO <sub>2</sub> (mg L <sup>-1</sup> )	NO <sub>3</sub> (mg L <sup>-1</sup> )	Total-P (mg L <sup>-1</sup> )
Azaplı	8.830	15.10	8.600	5.500	20.000	0.684	0.002	0.100	0.360
Ayvalı	8.350	21.15	7.920	15.000	64.865	0.152	0.010	0.145	0.460
Gölbaşı	8.765	22.00	7.995	6.125	35.915	0.256	0.015	0.050	1.050
Kartalkaya	8.900	20.65	8.115	18.300	67.055	0.359	0.016	0.310	0.680
Aslantaş	8.765	25.65	9.385	12.875	46.740	0.050	0.006	0.320	0.243
Kılavuzlu	8.180	17.40	7.950	11.375	48.770	0.275	0.007	0.230	0.625
Hakkıbeyli	8.565	23.65	9.410	17.600	73.142	0.330	0.141	0.200	0.540

*P. hammoniensis* (52 individuals), *Aulophorus furcatus* (21 individuals), and *T. tubifex* (17 individuals). Four oligochaeta taxa were present only in Lake Gölbaşı: *Dero dorsalis*, *Nais communis*, *Nais* sp. and *Stylaria lacustris*.

The only oligochaete species collected in Ayvalı reservoir, *L. hoffmeisteri*, was represented by only four individuals, present in autumn. No oligochaetes were present in samples collected during the summer period, likely because water fluctuations during the summer months are very high. The most frequently collected oligochaete species in Kartalkaya Dam lake (which is used for irrigation and as a domestic water supply) were *L. hoffmeisteri* (18 individuals), *Nais simplex* (10 individuals), and *N. variabilis* (1 individual).

The oligochaete fauna of Lake Kılavuzlu had the highest population density (10,298 individuals) in comparison to all other studied lakes. The dominant species were *P. hammoniensis*, with 10,000 individuals, and *L. hoffmeisteri*, with 298 individuals, likely influenced by fish cage systems in the lake, and in response to domestic and agricultural dumping and other anthropogenic effects.

Species composition of oligochaetes was diverse, with four species collected in Lake Hakkıbeyli. The dominant species were *L. hoffmeisteri*, with 372 individuals, *Pristina aequisetata*, with 113 individuals, *Pristina*

*rosea*, with 123 individuals, and unidentifiable Enchytraeidae, with one individual.

With the exception of Ayvalı reservoir, the oligochaeta composition of Lake Aslantaş was less diverse in comparison to the other lakes studied, with a low average density of 30 individuals. In autumn, no oligochaeta were found because of sampling that was done in the rocky littoral region. A total of 30 individuals belonging to the Naididae family were identified: *N. communis* (Naidinae), with 1 individual; unidentified Tubificinae, with 25 individuals; and *L. hoffmeisteri*, with 4 individuals.

According to the results of PCA, the first canonical axis (Axis 1) explained 41.40% of the total variability in the species data and the following axes decreased gradually (29.36% for axis 2, 16.63% for axis 3) (Fig. 3). Cumulative percentage variances of species-environment relation were 41.40, 70.76, 87.39 and 96.41, respectively. PCA revealed that *L. hoffmeisteri* and *P. hammoniensis* were related to Total-P, while *Pristina aequisetata* and *P. rosea* were related to dissolved oxygen concentration, BOD, COD, temperature, nitrite and nitrate. Brinkhurst (1974) reported that the organic matter contents of sediments and the dissolved oxygen concentration near the bottom are the most important factors determining the abundance of oligochaetes in lakes. According to Newrkla & Wijegoonawardana

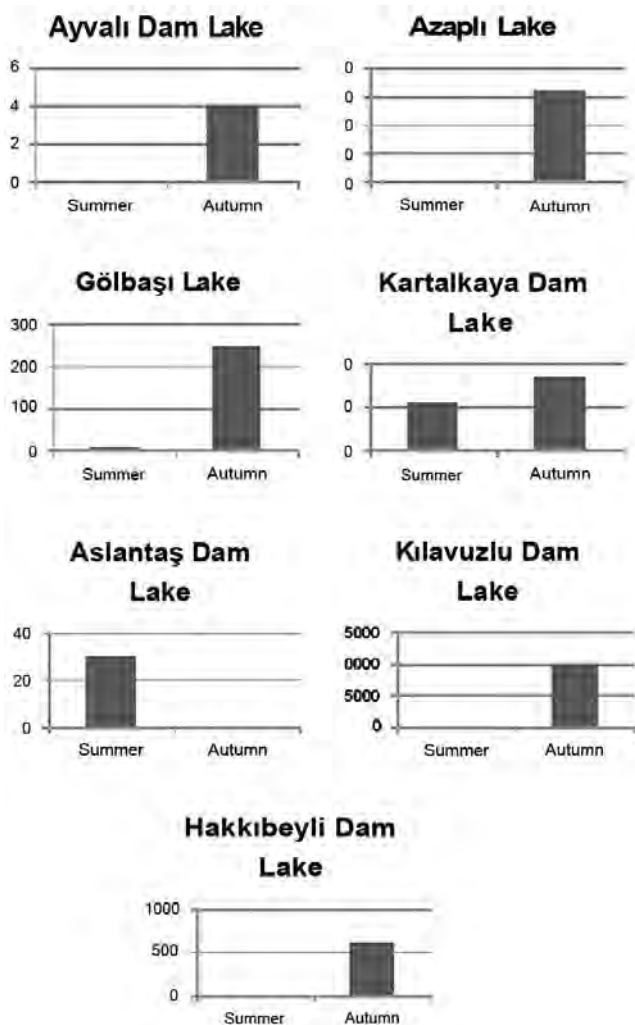


Fig. 2. Abundance of aquatic oligochaetes in samples collected from seven lakes located in the Ceyhan River basin (Turkey) during summer (July) and autumn (November) of 2014. Y-axes: numbers of individuals.

(1987), oligochaetes are able to increase in number with increasing sediment organic matter content.

*Limnodrilus hoffmeisteri* (in 6 lakes) and *P. hammoniensis* (in 3 lakes) were the most commonly observed species. *Limnodrilus hoffmeisteri* is considered a biological indicator of organic pollution and eutrophication (Brinkhurst 1969), and this species clearly prefers warmer habitats (Timm et al. 2001). The Ceyhan River basin belongs to the Mediterranean climatic zone.

*Nais communis* and *P. hammoniensis* are widely distributed in Turkey and across Europe occurring in eutrophic lakes with a wide range of nutrient concentrations (Van Duinen et al. 2006; Yıldız et al. 2008). According to their ecological valence, Tubificinae and several of its genera (e.g., *Tubifex* and *Limnodrilus*) are considered cosmopolitan taxa. They have clearly adapted to a wide range of environmental conditions and their abundance can reach immense sizes in aquatic systems with high trophic levels. Oligochaete taxa in the subfamily Tubificinae (*Limnodrilus* spp. and *Potamothrix* spp.) and the subfamily Naidinae (*Dero* spp.

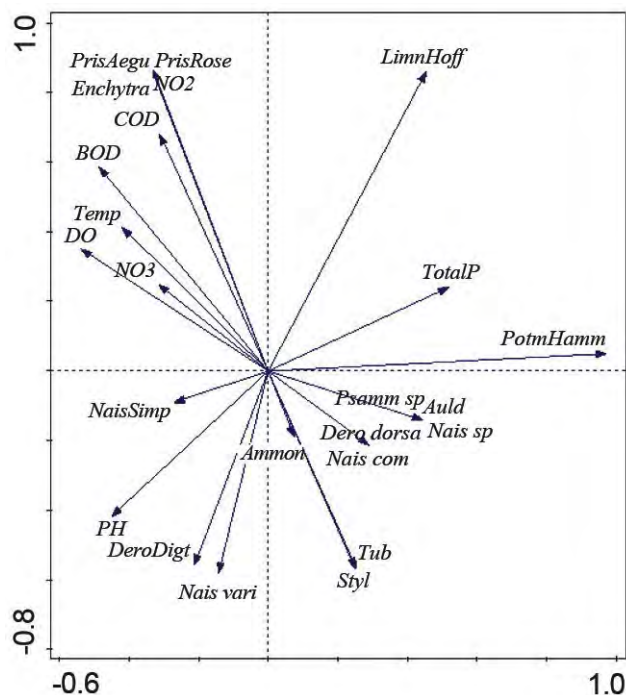


Fig. 3. Species-environment diagram from Principal Component Analysis (PCA). *PrisAequ*: *Pristina aequisetata*; *PrisRose*: *Pristina rosea*; *Enchytra*: Enchytraeidae; *LimnHoff*: *Limnodrilus hoffmeisteri*; *PotmHamm*: *Potamothrix hammoniensis*; *NaisSimp*: *Nais simplex*; *Nais vari*: *Nais variabilis*; *DeroDigt*: *Dero digitata*; *Nais com*: *Nais communis*; *Dero dorsa*: *Dero dorsalis*; *Tub*: *Tubifex tubifex*; *Auld*: *Aulophorus furcatus*; *Styl*: *Stylaria lacustris*; *Psamm sp*: *Psammoryctides barbatus*; *Tub*: Tubificinae.

and *Nais* spp.) are highly tolerant of low oxygen levels in water.

In conclusion, among all the lakes investigated during this project, species-poor Lake Ayvalı differs from the six other species-rich lakes. Oligochaetes of seven lakes were dominated by species characteristic of nutrient rich waters, including *L. hoffmeisteri* and *P. hammoniensis*.

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