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Original Research

Effect of physicochemical parameters on zooplankton at a freshwater body of Euphrates Basin (Elazıg-Turkey)

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Abstract: In this study zooplankton was determined between June 2015-May 2016 in Keban Reservoir. Also some chemical and physical parameters as water temperature, pH, dissolved oxygen, electrical conductivity and Chlorophyll a were measured in situ, monthly. Total of 40 zooplankton species; 27 Rotifera, 11 Cladocera, 2 Copepoda species were identified in this study. The data of this study were evaluated number of individuals, species richness and species diversity. Maximum, minimum, SD and mean values of water quality parameters were calculated. As a result of Shannon Wiener index analysis of current study, species diversity was found highest in January (H'=2.03) and the least index value was found in May (H'=0.46). Margalef index value recorded in its highest value in January (D=1.07) in the 2nd station and the lowest value in February (D=0.11) in the 1st station.

Key words: Water quality parameters; Zooplankton; Species diversity; Species richness; Euphrates Basin.

Introduction

Changes in abiotic factors are reflected in the biochemical activity of both vertebrates and invertebrates. These factors determine the rate of metabolic transformations, the efficacy of immune systems, and reaction patterns of bodies to stressors (1,2). Assemblages of species in ecological communities reflect interactions between organisms and the abiotic environment as well as among organisms (3). Plankton species are valuable indicators of environmental conditions since they are ecological indicators of many physical, chemical and biological factors. Zooplankton plays a key role in aquatic environments maintaining clear water conditions at low predation pressure via grazing on phytoplankton; thus, they can be sensitive indicators of environmental disturbances (4; 5).

Zooplankters are often an important link in the transformation of energy from producers to consumers. Due to their large density, shorter life span, drifting nature, high group or species diversity and different tolerance to the stress, they are being used as an indicator organism for the physical, chemical and biological process in the aquatic ecosystems.

Zooplankton is an economically and ecologically important group of aquatic animals and their ecological processes influence fishery, oceanography and climate. Also zooplankton is one of the most important biotic elements that impact all functional aspects of aqueous ecosystems including food chains and trophic networks, energy flow, and the circulation of matter. They occupy a central position in pelagic zone food webs (6). The occurrence and distribution of plankton fauna depend on a number of factors such as climate change, habitat physicochemical properties, and biotic factors (7-11). Environmental factors are also important elements; for instance, water temperature impacts the growth and development of organisms and can influence their mortality (12).

Zooplankton community is cosmopolitan in nature and they inhabit all freshwater habitats of the world. Zooplankton diversity and density refers to variety within the community. Zooplankton plays an important role in aquatic ecosystem, as grazers that control algal and bacterial populations, as a food source for higher trophic levels and in the excretion of dissolved nutrients. The organization of biological communities in aquatic ecosystems is closely dependent on the variations of physical and chemical conditions linked to natural and anthropogenic factors (13).

The objective of the study was to determine whether physicochemical properties such as water temperature, pH, dissolved oxygen, electrical conductivity, total nitrogen, total phosphorus, chlorophyll-a significantly impacted zooplankton occurrence.

Materials and Methods

The Keban Reservoir is located on 45 kilometers north-west of Elazığ province and 65 kilometers north-east of Malatya province and constructed in Keban town which is situated on 10 kilometers south-west of the area where Karasu and Murat Rivers intersect. In Keban Reservoir, besides electricity production, fisheries and fish production are carried out.

Keban Reservoir, which was formed at the confluence of the rivers Munzur, Peri, Murat and Karasu, is among the most notable Reservoirs of the world with a storage

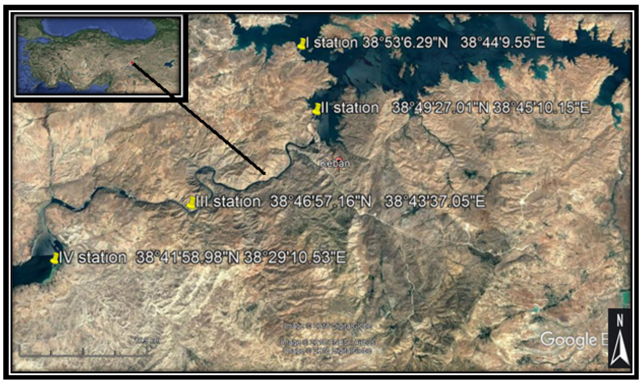

Figure 1. Sampling stations in the study area.

volume of about 30.6 billion cubic meters. The maximum water depth is 163 meters at the high supply level (14). The maximum operation level of the Reservoir is 845 meters above the sea level. The surface and drainage areas of the Reservoir are 675 km^2 and 64100 km^2 respectively (15). In the research, 2 stations were selected from the upper part of the reservoir body and the other 2 stations were located at the lower part of the reservoir body (Figure 1).

The zooplankton distributions of the reservoir were determined between June 2015 - May 2016. The locations of the sampling stations are shown in Figure 1. Zooplankton samples were collected with a standard plankton net (Hydrobios Kiel, 25 cm diameter 55 µm mesh size) horizontal hauls. Vertical samples were taken with Nansen water bottle and were preserved in 4% formaldehyde solution in 250 ml plastic bottles.

Temperature, dissolved oxygen, pH, electrical conductivity and Chlorophyll a were measured in-situ with the YSI professional plus brand meter. Chlorophyll a was analyzed by using spectrophotometric method (16).

The species were identified according to Kolisko (17), Segers (18), Flössner (19), Negrea (20) Einsle (21).

Species diversity indexes are calculated with the following formulas (Jorgensen et al. 2005).

Shannon Wiever: $H' = -\sum p_i \ln(p_i)$

Margalef indeks: M= (S-1) ln N

The Shannon-Wiever (H') species diversity index also takes into account the proportional participation rates of each species. The index value is high when the species is rich and there is an equal share in terms of quantity between the species.

Margalef species richness index (M) refers to the abundance of species diversity and richness of the environment. The index value increases depending on the species richness (22).

For the calculation of $Q_{\text{Brachionus/Trichocerca}}$ index the following formula has been used (23).

Q=number of species from Brachionus/number of species from Trichocerca.

Results

A total of 40 zooplankton species were identified during the sampling period, representing 27 species belonging to Rotifera, 11 species to Cladocera, and 2 species to Copepoda (Table 1). *Asplanchna priodonta, Keratella cochlearis, Polyarthra dolichoptera* from Rotifera; *Bosmina longirostris, Daphnia cucullata* from Cladocera*; Acanthiodiaptomus denticornis, Cyclops vicinus* from Copepoda were identified in all of stations. Eleven species were only reported one station: *Asplanchna sieboldi*, *Brachionus urceolaris, Cephalodella catellina, C.delicata, C.forficula, Colurella colurus, Filinia*

Table 1. Distribution of zooplankton according to stations in the Keban Reservoir.

	Stations			
Species	**1**	**2**	**3**	**4**
Rotifera				
Ascomorpha ecuadis Petry, 1850	+	+	+	-
Asplanchna priodonta Gosse, 1850	+	+	+	+
Asplanchna sieboldi (Leydig, 1854)	-	-	+	-
Brachionus urceolaris Müller, 1773	-	-	-	+
Cephalodella catellina (Müller, 1786)	-	-	-	+
C. delicata Wulfert, 1937	-	-	+	-
C.forficula (Ehrenberg, 1830)	+	-	-	-
C.gibba (Ehrenberg, 1830)	-	+	+	-
C.colurus (Ehrenberg, 1830)	-	+	-	-
Euchlanis dilatata Ehrenberg, 1832	+	+	+	-
Filinia terminalis (Plate, 1886)	-	-	-	+
Keratella cochlearis (Gosse, 1851)	+	+	+	+
K. quadrata (Müller, 1786)	+	-	+	-
K.tecta (Gosse, 1851)	-	+	+	-
Lecane luna (Müller, 1776)	+	-	+	-
L. ungulata (Gosse, 1887)	-	+	-	-
Lepadella ovalis (Müller, 1786)	-	-	+	-
Lindia torulosa Dujardin, 1841	+	-	-	-
Notholca squamula (Müller, 1786)	+	+	+	-
Polyarthra dolichoptera Idelson,1925	+	+	+	+
P. remata Skorikov, 1896	-	+	+	-
P. vulgaris Carlin, 1943	+	-	+	-
Synchaeta pectinata Ehrenberg, 1832	-	+	+	-
S. oblonga Ehrenberg, 1832	+	+	+	-
Testudinella patina (Hermann, 1783)	+	-	-	-
Trichocerca capucina (Wierzejski & Zacharias, 1893)	+	+	+	-
Trichocerca similis (Wierzeski, 1893)	+	-	-	+
Cladocera				
Alona rectangula Sars, 1862	-	+	-	+
Bosmina longirostris (Müller, 1785)	+	+	+	+
Ceriodaphnia reticulata (Jurine, 1820)	+	+	-	-
Chydorus sphaericus (Müller, 1776)	+	-	-	+
Daphnia cucullata Sars, 1862	+	+	+	+
Daphnia longispina Müller, 1875	+	+	-	-
Daphnia magna (Straus, 1820)	+	+	+	-
Diaphonosoma birgei Korinek, 1981	+	-	-	-
Leydigia leydigi (Schoedler, 1863)	+	-	-	-
Leptodora kindtii (Focke, 1844)	-	-	-	+
Sida crystallina (Müller, 1776)	+	-	-	+
Copepoda				
Acanthopdiaptomus denticornis	+	+	+	+
Cyclops vicinus Ulyanin, 1875	+	+	+	+
Total number of species	26	22	23	15

Table 2. Maximum, minimum, SD and mean values of water quality parameters in the 1.Station

Parameters	Max	Min	Mean±SD
T	27.80	8.70	15.2±7.5
pH	8.90	7.64	8.15±0.3
DO	9.90	5.39	7.64±1.59
E.C	420	354	379±18.5
Chl-a	0.80	0.10	0.30±0.21

T=Temperature; DO=dissolved oxygen; EC = electrical conductivity; Chl-a = chlorophyll a µg/L.

Table 3. Maximum, minimum, SD and mean values of water quality parameters in the 2.Station.

Parameters	Max	Min	Mean±SD
T	28.80	8.80	15.6±7.8
pH	8.50	8.02	8.23±0.11
DO	9.70	5.92	8.60±1.18
E.C	456	348	378±28.1
Chl-a	0.91	0.10	0.29±0.26

T=Temperature; DO = dissolved oxygen; EC = electrical conductivity; Chl-a = chlorophyll a µg/L

Table 4. Maximum, minimum, SD and mean values of water quality parameters in the 3.Station.

Parameters	Max	Min	Mean±SD
T	29.70	9.70	18.3±7.1
pH	8.70	8.00	8.44±0.2
DO	13.04	6.90	9.50±2.05
E.C	465	324	372±34.83
Chl-a	1.95	0.10	0.63±0.53

T=Temperature; DO=dissolved oxygen; EC = electrical conductivity; Chl-a = chlorophyll a µg/L.

Table 5. Maximum, minimum, SD and mean values of water quality parameters in the 4.Station.

Parameters	Max	Min	Mean±SD
T	30.30	9.60	18.82±7.4
pH	8.73	8.30	8.44±0.13
DO	12.7	6.90	9.39±1.76
E.C	535	343	391±54.60
Chl-a	4.21	0.30	1.31±1.20

T=Temperature; DO=dissolved oxygen; EC = electrical conductivity; Chl-a = chlorophyll a µg/L.

terminalis, Lecane ungulata, Lepadella ovalis, Lindia torulosa, Testudinella patina.

In the first station 26 species were recorded. The least number of species have been identified in 4th station with 15 zooplankton species.

In the reservoir, temperature ranged from 8.70 °C to 30.30 °C. The highest WT (water temperature) values were measured at Station 4, whereas the lowest values were observed at Station 1. The pH values varied from 7.64 to 8.73. The highest DO value was measured at 4th station with 13.04mg/L the lowest at 2nd station with 5.39 mg/L. EC values varied from 343 to 465 µS/cm**.** The highest Chl-a values were measured at Station 4 with 4.2 (table 2-5).

It was determined that the species diversity in study area was at its highest at the 2nd station in January (H'= 2.03) and was at its lowest in may (H'= 0.46) in the 4th station. Margalef index value recorded in its highest value in January (D=1.07) in the 2nd station and the lowest value in February (D=0.11) in the 1st station(Table 6-7).

Table 6. Monthly D (Margalef index) values of station of study field.

Months	I.station	II.station	III.station	IV.station
June	0.61	0.38	0.13	0.13
July	0.73	0.24	0.62	0.51
August	0.37	0.50	0.75	0.47
September	0.48	0.65	0.61	0.58
October	0.32	0.27	1.02	0.72
November	0.50	0.40	1.05	0.89
December	0.51	0.66	0.62	0.85
January	0.32	1.07	0.45	0.48
February	0.11	0.12	0.12	0.14
March	0.69	0.53	0.22	0.33
April	0.40	0.45	0.68	0.13
May	0.39	0.49	0.88	0.41

Table 7. Monthly H' (Shannon - Wiever index) values of station of study field.

Months	I.station	II.station	III.station	IV.station
June	1.34	1.33	0.63	0.63
July	1.82	0.86	1.53	1.56
August	1.24	1.11	1.80	1.42
September	1.38	1.06	1.03	1.21
October	1.07	1.09	1.34	1.07
November	1.42	1.27	1.77	1.76
December	0.73	1.37	1.43	1.81
January	0.68	2.03	0.99	1.49
February	0.67	0.50	0.67	0.69
March	1.01	1.40	0.64	0.72
April	0.79	1.44	1.31	0.56
May	0.92	1.40	0.71	0.46

The $Q_{Brachionus/Trichocerca}$ index was calculated as the ratio of *Brachionus* to *Trichocerca*. If the ratio is equal to or under 1, the lake is oligotrophic; if it is between 1-2, the lake is mesotrophic; and if it is greater than 2, the lake is eutrophic (23).

$Q_{B/T}$ trophy index was calculated as $Q_{B/T}$= 0.5 This value means that Keban Reservoir has got oligotrophic character.

In the 1st and 3rd stations the most individual number of total zooplankton recorded in December. In the 2nd station in September and in the last station in October the most numbers of individuals were recorded (Figure 2.).

Discussion

Zooplankton fauna of this Reservoir was composed mainly of Rotifera group (67.5 % of the total). In addition, Cladocera and Copepoda constituted 27.5 % and 5 % of total zooplankton, respectively.

Number of identified rotifers in dam lakes and reservoir of Turkey ranged between 6 and 54. (24). Keban Reservoir is in the middle range with 27 Rotifer species.

In Beyhan, Kalecik, Cip, Boztepe Reservoirs rotifers have taken the first place as frequency of occurrence and species richness. (25-28). In Keban Dam lake that was built on Eupharete River *Polyarthra vulgaris* from Rotifera recorded in each sampling (29). In this study this species was recorded in two stations. In Gülüşkür

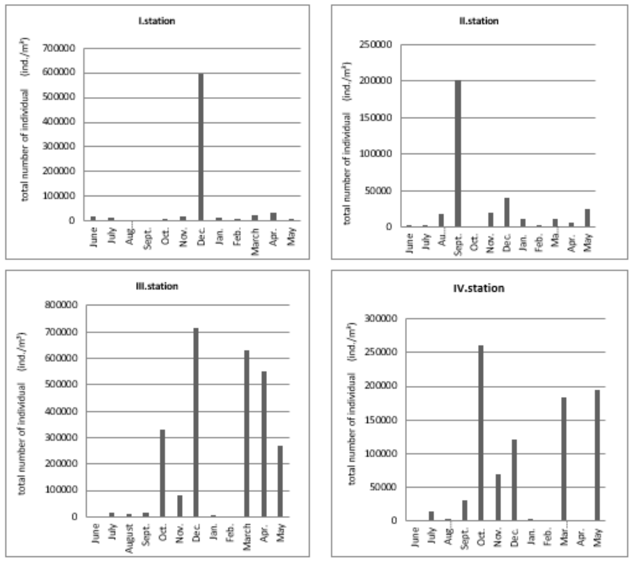

Figure 2. The monthly total zooplankton individual numbers (ind/ m^3) in the stations.

bay of Eupharete River *Keratella cochlearis* and *P. vulgaris* were most dominant species (30). *K cochlearis* was observed in every station in this study.

Sychaeta oblonga, Keretalla cochlearis and *Polyarthra vulgaris* were suggested as predominant representative organisms of oligotrophic lakes in temperate climate areas (17). These three species were recorded in high numbers in this Reservoir.

Murat River is one of the most important attributes of Euphrate River. In Murat river *K cochlearis, P. dolichoptera, S. pectinate* from Rotifera and *Cyclops vicinus* from Copepoda were recorded in high numbers as in Keban Reservoir (31).

C. vicinus was the most observed species of Copepoda in this Reservoir. This species is the most recorded Copepoda species in the Reservoirs of Göksu (32), Keban (33), Gelingüllü (34).

In the down stream of Euphrate River Bozkurt and Genç (35) identified 41 zooplankton species (19 species from Rotifera, 12 species from Cladocera and 10 species from Copepoda). *A. priodonta, C. gibba, C. colurus, E. dilatata, K. cochlearis, L. luna, L. ovalis, P. dolichoptera, T. capucina* from Rotifera; *B. longirostris, C. sphaericus, D. cucuylata, D. longispina, D. birgei* from Cladocera, *C. vicinus* from Copepoda are the same identified species in this study. And also in the same study *K. cochlearis*, *P. dolichoptera*, *B. longirostris* and *C. vicinus* were recorded in each station as in this study.

In Hancağız Dam Lake 34 species from Rotifera, 11 from Cladocera, 7 from Copepoda, In Tahtalı dam lake 37 species from Rotifera, 20 from Cladocera, 8 from Copepoda, Dicle Dam Lake 37 species from Rotifera, 9 from Cladocera, 4 from Copepoda were recorded (36 - 38). As can be seen, the Rotifera group is the first in terms of both species and relative density followed by Cladocera and Copepoda in the studies carried out in many Reservoirs in the region.

When we look at the seasonal abundance of zooplanktonic organisms, the highest numbers of organisms were found in spring and at least in winter. Generally, fresh water habitats start to warm up in the spring and increase in phytoplanktonic organisms with increasing nutrients. This increase is followed by zooplankton species diversity and number increases. Temperature is the limiting factor in the presence and distribution of zooplanktonic organisms (39). In Keban Reservoir, this increase in the number of zooplanktonic organisms is expected due to the warm weather and increasing amount of nutrients in spring.

Life cycles of zooplankters are related to the environmental factors (*e.g.* water temperature, conductivity, pH, dissolved oxygen). Water temperature and dissolved oxygen values are the most important factors affecting the zooplankton. Water temperature is one of the most important parameter, which manages chemical and biological activity of organisms in aquatic life (40).

The alkaline limit of pH level, which is important for the life of zooplankton, is 8.5 (41). In this study, the alkali limit was not recorded above the value of 8.5.

Dissolved oxygen amounts differ based on the photosynthesis rate of the plants and trophic level of the lakes in addition to the temperature (42). Most of the Rotifera species have high oxygen tolerance Koste and Devol stated that waters with low oxygen content affected zooplankton distribution, reproduction and development, and dissolved oxygen levels below 5 mgL^{-1} in freshwater prevents zooplankton development (43, 44). In Keban reservoir dissolved oxygen level was determined over 5mg/L in every sampling. So this habitat is convenient for zooplankton life according to dissolved oxygen level.

Conductivity values ranged from 343µS/cm to 465 µS/cm in all sampled water bodies and salinity can be predicted using conductivity: bodies of water with conductivity lower than 1000 µS /cm are freshwater, and those that range from 1000 to 6000 µS/cm are subhaline (45). Keban Reservoir showed freshwater characteristics.

According to Ataguba et al (46), Shannon-Wiener and Margalef Indexes will not rank communities in the same manner but will increase as richness increases. Especially Shannon-Wiener indicates the productivity and species richness of an aquatic habitat. In the study area the highest value *H'* determined as 2.03. The index value in the productive waters should be over 2.5. The productivity level of Keban Reservoir is known as low. This data supports the idea that the lake is poor in terms of species richness. $Q_{B/T}$ trophy index was calculated as $Q_{B/T}$= 0.5 This value means that Keban Reservoir has got oligotrophic character.

In the study, chlorophyll a value was changes between 0.10- 4.21µg/L. According to the Management on Surface Water Quality regulations, the chlorophyll a value between 3.5 – 9 µg/L is considered to be a mesotrophic lake in the limited values of trophic classification system in lakes, ponds and dam lakes (47).

The continuity of the ecological balance of natural fish stocks, zooplankton and other aquatic life forms must be monitored periodically continuously in order to avoid contamination of the reservoir and to preserve the water quality in order not to adversely affect human health.

Interest conflict

The author have proclaimed that no competing interests present.

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