Zooplankton Fauna of Demrek Dam Lake (Kırıkhan, Hatay)

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**ABSTRACT**

The annual average of Secchi disk depth (100.42 ±38.99 cm), water temperature (21.06±5.96 °C), dissolved oxygen (8.33±0.99 mg/l), nitrate (0.43±0.19 mg/l), nitrite (0.02±0.01), hardness (172±17.27 mg/l), silica (1.17±0.28 mg/l), phosphate (0.14±0.03 mg/l), organic phosphate (1.09 ±0.56 mg/l) and chlorophyll-a (0.05±0.03 mg /l) were detected and according to these values, it was determined that the reservoir water has eutrophic and hyperneurophic character. Rotifera had the highest proportion with 45 taxa, followed by Cladocera with 11 species and Copepoda with 7 species. Asplanchna priodonta, Keratella cochlearis, Polyarthra dolichoptera, Sychaeta stylo mata, Bosmina longirostris, Diaphanosoma biregi, and Disparalona rostrata were present throughout the whole study period. The most abundant species from Rotifera was Sychaeta stylo mata (26034±56482.24 ind./m³) followed by Polyarthra dolichoptera (15356±9593.48 ind./m³) and Keratella cochlearis (11850±15441.51 ind./m³). In the study, the most common species belonging to Cladocera was Ceriodaphnia pulchella (7042±6759.93 ind./m³) and the most abundant copepod species was Cyclops vicinus (2553±1596.48 ind./m³).

**Keywords:** Demrek Dam Lake, water quality, zooplankton

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**Introduction**

The zooplanktonic organisms living in the lake ecosystem not only form the nutrients of planktivorous fish but also become a source of food for all insects, fish larvae, invertebrates, and other aquatic animals in the ecosystem. Besides, zooplankton are potential indicators for the water properties, pollution, and eutrophic status of the waters in which they are found (Hecky and Kilham 1973; Bërziën and Pejler 1987; Mikschi 1989).

Various studies have reported that there is a close relationship between the efficiency of the aquatic environment and zooplanktonic organisms; since pollution has negative effects on zooplankton. In lake ecosystems, there is a balance between the living and inanimate factors of the lake.

Since the damages caused by people to nature disrupt the balance of the ecosystem, a considerable part of the living organisms in the lakes are destroyed due to pollution. The most important factor that...
disrupts the balance in the ecosystem is the unconscious exploitation of the environment to meet the luxurious living needs of the growing population. Studies on zooplanktonic organisms, which constitute the nutrients of many fish species in their younger periods and that transform the plant foods into animal proteins in the aquatic environment, have also been accelerated (Güher 1999).

As a result of the increase in industrial, domestic, and agricultural waste disposal into water systems, there is an accumulation of highly nutritious elements leading to eutrophication. Since excessive phytoplankton growth and biological pollution are involved in eutrophication, plankton studies are important to provide information about ecosystems on topics such as the biodiversity of the lakes, pollution, and trophic levels. Turkey is considered as rich in terms of inland water resources. It is necessary to know the inland waters, aquatic organisms, and their distribution in our country for using these inland water resources efficiently.

No previous studies have been conducted in Demrek Dam Lake, where zooplankton species diversity and some water quality characteristics were investigated. On the other hand, this study, which is carried out in the dam lake, is important in terms of being an example for the next studies.

Materials and Methods

The study was carried out between April 2013 and March 2014 in Demrek Dam Lake, which has 48 ha lake area, in Hatay province Hassa district (Figure 1). Demrek Dam Lake has 1995 hm³ water storage volume, 276 ha irrigation capacity, its construction started in 1997, its construction was completed in 2006 and it was put into operation in 2006 (Anonymous 2006).

Zooplankton samples were taken from 2 stations with horizontal and vertical hauls by using 60 μm mesh size plankton nets monthly for systematic analyses. Using the Nansen bottle, two liters of water samples were collected from each depth of the different water layers (surface, medium and deep) of both stations. Water quality parameters and chlorophyll-a were analyzed from water samples. For the chlorophyll-a analysis and chemical analyzes, one lt and 100 ml of the total water samples were used, respectively. The remaining part (4.9 lt) was filtered from a collector having a mesh size of 60 μm for zooplankton analyses. All zooplankton samples were fixed in 4% formaldehyde. Dissolved oxygen, water temperature, and conductivity were measured directly in the field using digital instruments (oxygen and temperature: YSI model 52 oxygen meter; conductivity: YSI model 30 salinometer). YSI 950 photometer and its procedure were used to determine nitrite nitrogen, nitrate nitrogen, phosphate phosphorus, Organic phosphate; the method in APHA 1995 was used to determine chlorophyll-a.
spectrophotometrically. Secchi depth was measured using a Secchi disk with a diameter of 20 cm.

The lowest depth at the stations was 4 m (station 1) and 7 m (station 2) in October, and the highest depth was 9 m and 12 m in May, respectively. Species identifications were made using a binocular microscope according to the works of Edmondson (1959), Scourfield and Harding (1966), Dussart (1967), Kiefer and Fryer (1978), Koste (1978), Negrea (1983), Segers (1995), De Smet (1996, 1997), Nogrady and Segers (2002), Holyńska et al. (2003) and Benzie (2005). Zooplankton count was performed using an inverted microscope in a petri dish with 2 mm lines at the bottom. The sample cup was made homogenized by shaking and 2 cc sub-sample was taken from the cup and it was placed in a petri dish and the individuals of each species were separately counted. This process has been repeated 4-5 times.

CTM tolerance of the species (SPSS 20.1). Duncan’s multiple range test (DMRT) was carried out for post hoc mean comparisons. Regression analysis was also carried out to evaluate the relationship between acclimation temperature and CTMin and CTMax (p≤0.05).

Results

Secchi disk depth reached the maximum depth of 160 cm in May and the minimum depth of 55 cm in September, with a mean value of 100.42 ±38.99 cm (Table 1, Figure 2). The water temperature was close to regional seasonal norms, increased from spring to summer, and decreased from autumn to winter. Thus, it was ranged from 13.58 ºC in December to 31.42 ºC in August (annual average 21.06±5.96 ºC).

The highest and the lowest dissolved oxygen values were recorded in February and July as 9.70 and 6.83 mg/l, respectively (average 8.33±0.99 mg/l, over the study period; Table 1, Figure 2).

| Table 1. Maximum, minimum, and average values of water quality parameters |
|-----------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Secchi-disk(cm) | Temp (°C) | DO (mg/l) | Chl-a (mg/l) | NO2-N (mg/l) | NO3-N (mg/l) | SiO-Si (mg/l) | PO4-P (mg/l) | Hardness |
| Max | 160.00 | 31.42 | 9.70 | 0.086 | 0.056 | 0.595 | 1.588 | 0.192 | 205.00 | 1.83 |
| Min | 55.00 | 13.58 | 6.83 | 0.013 | 0.009 | 0.035 | 0.635 | 0.104 | 133.33 | 0.38 |
| Average | 100.42 | 21.06 | 8.33 | 0.05 | 0.02 | 0.43 | 1.17 | 0.14 | 172.36 | 1.09 |
| ±38.99 | ±5.96 | ±0.99 | ±0.03 | ±0.01 | ±0.19 | ±0.28 | ±0.03 | ±17.27 | ±0.56 |

Nitrate and nitrite levels showed similar patterns during the study period and maximum levels were recorded in December and January (0.595 mg/l and 0.056 mg/l), respectively. The minimum nitrate level was 0.035 mg/l in November, but the minimum nitrite level was 0.009 mg/l in November and March (Figure 2). The mean nitrate and nitrite concentrations were 0.43±0.19 mg/l and 0.02±0.01 mg/l at the end of the study (Table 1).

Hardness showed irregular ups and downs in the summer, increasing properly from September to February, but remained almost stable in spring. The average, maximum, and minimum total hardness values were 172±17.27 mg/l, 205 mg/l, and 133.33 mg/l respectively.

The average silica level was 1.17±0.28 mg/l. Silica concentrations were observed as 0.635 mg/l in May, gradually increased to 1.588 mg/l in August, decreased to 0.932 mg/l until December, and reincreased to 1.422 mg/l in May.

Phosphate, the most vital nutrient affecting the productivity of natural water resources, was 0.14±0.03 mg/l, on average. The highest and the lowest phosphate values recorded in February and June were 0.192 mg/l and 0.104 mg/l, respectively (Table 1, Figure 2). Phosphate levels increased during the summer until August following a gradual decrease this month. It increased from October to February and decreased from here until June. The maximum, minimum, and mean organic phosphate values were 1.83 mg/l (November at the first station), 0.38 mg/l (January at the second station), and 1.09 ±0.56 mg/l, respectively (Table 1, Figure 2).

Chlorophyll-α ranging from 0.013 mg/l in March to 0.086 mg/l in June and September was averaged to be 0.05±0.03 mg/l (Table 1, Fig. 2). Chlorophyll a fluctuated irregularly from April to September, and it decreased from here to March.
The zooplankton taxa identified in Demrek Dam Lake are shown in Table 2. The zooplankton assemblage included 63 species. Rotifera had the highest proportion with 45 taxa, followed by Cladocera with 11 species and Copepoda with 7 species.

* A. priodonta, K. cochlearis, P. dolichoptera, S. styliata B. longirostris, D. birgei and D. rostrata were present throughout the whole study period. It was determined that these species were followed by A. ovalis, F. longiseta, K. valga, which were found for 11 months, and T. similis, which were found for 10 months.

Copepoda were found for 8 months. The least recorded species were as follows: A. fissa, B. budapestinensis, B. urceolaris, B. quadridentatus, B. nilsoni, C. adriatica, C. colurus, Conochiloides sp., D. epicharis, E. dilatata, H. oxyuris, K. recta, L. closterocerca, L. luna, L. hastata, L. hamata, L. stenroosi, L. tenuiseta, L. patella, L. rhomboides, L. ovalis, L. salpina, P. quadricornis, S. longicaudum, T. patina, T. porcellus, T. tigris, A. guttata, C. sphaericus, I. sordidus, P. laevis, C. vicinus, D. bicuspidatus, M. albidus, M. leuckarti, P. chiltoni, B. minutus, N. hibernica

In terms of numbers, according to the monthly distribution of the groups, the highest numbers of Rotifera were found with 22 taxa in July, followed by 21 taxa recorded in November, 20 taxa in October, but only 10 taxa were determined in April. Cladocera showed the highest number of taxa in May with 9 taxa, followed by April, June, July, October, and March with 7 taxa and November with 6 taxa. Only 3 species of Cladocera was found in January. Copepoda showed the maximum diversity with 3 taxa in July and
October, followed by June and November with 2 taxa and April, September, January, March with 1 taxa. Copepoda species did not appear in May, August, December, and February. Total zooplankton was the highest with 32 species in July, followed by October with 30 species. It was determined to be the least with 18 species in April and August (Table 2).

Table 2. Zooplankton species list and monthly availability.

| Rotifer | Apr 2013 | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec 2014 | Feb | Mar |
|---------|----------|-----|-----|-----|-----|-----|-----|-----|----------|-----|------|
| Anuraeopsis fissa Gosse, 1851 | + | + | + | + | + | + | + | + | + | + | + |
| Ascomorpha ovalis (Bergendahl, 1892) | + | + | + | + | + | + | + | + | + | + | + |
| Asplanchna priodonta Gosse, 1850 | + | + | + | + | + | + | + | + | + | + | + |
| Brachionus angularis Gosse, 1851 | + | + | + | + | + | + | + | + | + | + | + |
| Brachionus budapestinensis Daday, 1885 | + | + | + | + | + | + | + | + | + | + | + |
| Brachionus urceolaris Müller, 1773 | + | + | + | + | + | + | + | + | + | + | + |
| Brachionus quadridenticatus Hermann, 1783 | + | + | + | + | + | + | + | + | + | + | + |
| Brachionus nilsoni Ahlstrom, 1940 | + | + | + | + | + | + | + | + | + | + | + |
| Cephalodella gibba (Ehrenberg, 1830) | + | + | + | + | + | + | + | + | + | + | + |
| Collotheca pelagica (Rousselet, 1893) | + | + | + | + | + | + | + | + | + | + | + |
| Colurella adriatica Ehrenberg, 1831 | + | + | + | + | + | + | + | + | + | + | + |
| Colurella colorus (Ehrenberg, 1830) | + | + | + | + | + | + | + | + | + | + | + |
| Conochiloides sp. | + | + | + | + | + | + | + | + | + | + | + |
| Dicranophorus epicharis Harring & Myers, 1928 | + | + | + | + | + | + | + | + | + | + | + |
| Euchilis dilatata Ehrenberg, 1832 | + | + | + | + | + | + | + | + | + | + | + |
| Filinia longiseta (Ehrenberg, 1834) | + | + | + | + | + | + | + | + | + | + | + |
| Filinia opolensiis (Zacharias, 1898) | + | + | + | + | + | + | + | + | + | + | + |
| Hexarthra oxyaris (Sernov, 1903) | + | + | + | + | + | + | + | + | + | + | + |
| Itura aurita (Ehrenberg, 1830) | + | + | + | + | + | + | + | + | + | + | + |
| Keratella tecta (Gosse, 1851) | + | + | + | + | + | + | + | + | + | + | + |
| Keratella cochlearis (Gosse, 1851) | + | + | + | + | + | + | + | + | + | + | + |
| Keratella valga (Ehrenberg, 1834) | + | + | + | + | + | + | + | + | + | + | + |
| Lecane closterocerca (Schmarda, 1859) | + | + | + | + | + | + | + | + | + | + | + |
| Lecane luna (Müller, 1776) | + | + | + | + | + | + | + | + | + | + | + |
| Lecane lunaris (Ehrenberg, 1832) | + | + | + | + | + | + | + | + | + | + | + |
| Lecane hastata (Murray, 1913) | + | + | + | + | + | + | + | + | + | + | + |
| Lecane hamata (Stokes, 1896) | + | + | + | + | + | + | + | + | + | + | + |
| Lecane stenroosi (Meissner, 1908) | + | + | + | + | + | + | + | + | + | + | + |
| Lecane tenuiseta Harring, 1914 | + | + | + | + | + | + | + | + | + | + | + |
| Lepadella patella (Müller, 1773) | + | + | + | + | + | + | + | + | + | + | + |
| Lepadella rhomboidea (Gosse, 1886) | + | + | + | + | + | + | + | + | + | + | + |
| Lepadella ovalis (Bergendahl, 1892) | + | + | + | + | + | + | + | + | + | + | + |
| Lophocharis salpina (Ehrenberg, 1834) | + | + | + | + | + | + | + | + | + | + | + |
| Notholca squamula (Müller, 1786) | + | + | + | + | + | + | + | + | + | + | + |
| Platias quadricornis (Ehrenberg, 1832) | + | + | + | + | + | + | + | + | + | + | + |
| Polyarthra dolichoptera Idelson, 1925 | + | + | + | + | + | + | + | + | + | + | + |
| Rotaria neptunia (Ehrenberg, 1830) | + | + | + | + | + | + | + | + | + | + | + |
| Scardium longicaudum (Müller, 1786) | + | + | + | + | + | + | + | + | + | + | + |
| Sychaeta stylata Wierzejski, 1893 | + | + | + | + | + | + | + | + | + | + | + |
| Testudinella patini (Hermann, 1783) | + | + | + | + | + | + | + | + | + | + | + |
| Trichocerca similis (Wierzebski, 1893) | + | + | + | + | + | + | + | + | + | + | + |
| Trichocerca pusilla (Jennings, 1903) | + | + | + | + | + | + | + | + | + | + | + |
| Trichocerca porcellus (Gosse, 1851) | + | + | + | + | + | + | + | + | + | + | + |
| Trichocerca tirgir (Müller, 1876) | + | + | + | + | + | + | + | + | + | + | + |
| Trichotria tetractis (Ehrenberg, 1830) | + | + | + | + | + | + | + | + | + | + | + |
| Total rotifer | 10 | 13 | 19 | 22 | 13 | 16 | 20 | 21 | 16 | 16 | 17 | 14 |

Chyadorca

| Bosmina longirostris (Müller, 1775) | + | + | + | + | + | + | + | + | + | + | + |
| Ceriodaphnia pulchella Sars, 1862 | + | + | + | + | + | + | + | + | + | + | + |
| Diaphanosoma birgei Korinek, 1981 | + | + | + | + | + | + | + | + | + | + | + |
| Macrothrix laticornis (Jurine, 1820) | + | + | + | + | + | + | + | + | + | + | + |
| Moina micrura Kurz, 1875 | + | + | + | + | + | + | + | + | + | + | + |
| Alona guttata Sars, 1862 | + | + | + | + | + | + | + | + | + | + | + |
| Coronatella rectangula (Sars, 1862) | + | + | + | + | + | + | + | + | + | + | + |
| Chydorus sphaericus (Müller, 1776) | + | + | + | + | + | + | + | + | + | + | + |
Table 2. Continued.

| Species                  | Months | April 2013 | May  | Jun  | Jul  | Aug  | Sep  | Oct  | Nov  | Dec  | Jan 2014 | Feb  | Mar  |
|--------------------------|--------|------------|------|------|------|------|------|------|------|------|----------|------|------|
| **Cladocera**            |        |            |      |      |      |      |      |      |      |      |          |      |      |
| *Disparalona rostrata* (Koch, 1841) |        | +          | +    | +    | +    | +    | +    | +    | +    | +    |          |      |      |
| *Byocryptus sordidus* (Lievin, 1848) |        | +          |      |      |      |      |      |      |      |      | +        |      |      |
| *Pleuroxus laevis* Sars, 1862 |        | +          | +    |      |      |      |      |      |      |      |          |      |      |
| **Total cladocera**      |        | 7          | 9    | 7    | 7    | 5    | 4    | 7    | 6    | 4    | 3        | 5    | 7    |
| **Copepoda**             |        |            |      |      |      |      |      |      |      |      |          |      |      |
| *Cyclops vicinus* Ulyanin, 1875 |        | +          |      |      |      |      |      |      |      |      | +        |      |      |
| *Diacyclops bicuspidatus* (Claus, 1857) |        |            |      |      |      |      |      |      |      |      |          |      |      |
| *Macrocyclops albida* (Jurine, 1820) |        |            |      |      |      |      |      |      |      |      | +        |      |      |
| *Mesocylops leuckarti* (Claus, 1857) |        |            |      |      |      |      |      |      |      |      |          |      |      |
| *Paracyclops chiltoni* (Thomson, 1882) |        |            |      |      |      |      |      |      |      |      | +        |      |      |
| *Bryocamptus minutus* (Claus, 1863) |        |            |      |      |      |      |      |      |      |      | +        |      |      |
| **Total copepod**        |        | 1          | 0    | 2    | 3    | 0    | 1    | 3    | 2    | 0    | 1        | 0    | 1    |
| **Total zooplankton**    |        | 18         | 22   | 28   | 32   | 18   | 21   | 30   | 29   | 20   | 20       | 20   | 22   |

Table 3. Monthly abundance of zooplankton

| Species                  | Months | April 2013 | May  | June | July | Aug  | Sept |
|--------------------------|--------|------------|------|------|------|------|------|
| A. fissa                 |        | 6702       | 1126 | 355  |      |      |      |
| A. ovalis                |        | 1858       | 4204 | 74275| 1879 | 15074|      |
| A. priodonta             |        | 728        | 9299 | 13241| 9081 | 4442 | 4402 |
| B. angularis             |        | 666        | 1423 | 909  | 15268| 728  | 1634 |
| B. budapestinensis       |        |            |      |      |      |      | 293  |
| B. quadridentatus        |        |            |      |      |      |      | 327  |
| C. gibba                 |        | 306        | 303  | 502  |      |      |      |
| C. pelagica              |        | 758        | 248  |      |      |      |      |
| C. colurus               |        | 259        |      |      |      |      |      |
| Conochiloides sp         |        |            |      |      |      |      | 1862 |
| D. epicharis             |        | 476        |      |      |      |      |      |
| E. dilatata              |        |            |      |      |      |      |      |
| F. longiseta             |        | 1000       | 1352 | 2519 | 571  | 939  |
| F. opolensis             |        | 294        | 250  |      |      |      | 692  |
| H. oxyuris               |        |            |      |      |      |      |      |
| I. aurita                |        | 2055       | 284  | 370  |      |      |      |
| K. tecta                 |        | 1251       | 327  |      |      |      | 357  |
| K. cochlearis            |        | 3686       | 13508| 9333 | 1270 | 852  |
| K. valga                 |        | 4686       | 2552 | 10566| 2277 | 2491 |
| L. closterocerca         |        |            |      |      |      |      |      |
| L. luna                  |        |            |      |      |      |      |      |
| L. lunaris               |        |            |      |      |      |      |      |
| L. hamata                |        |            |      |      |      |      |      |
| L. stenoosii             |        | 256        |      |      |      |      |      |
| L. patella               |        | 1143       |      |      |      |      | 365  |
| L. salpina               |        |            |      |      |      |      |      |
| N. squamula              |        | 769        | 333  |      |      |      |      |
| P. quadricornis          |        |            |      |      |      |      |      |
| P. dolichoptera          |        | 18620      | 4530 | 4440 | 19608| 4719 | 23590|      |
| R. neptunia              |        | 667        | 825  | 770  |      |      |      |      |
| S. stylata               |        | 11007      | 6251 | 9802 | 21244| 712  | 14023|      |
| T. patina                |        | 250        | 313  |      |      |      |      |      |
| T. similis               |        | 625        | 13036| 6355 | 822  | 1987 |
| T. pusilla               |        | 625        | 10852| 2766 | 15397| 706  |      |      |
| T. tigris                |        | 513        |      |      |      |      |      |      |
| T. tetractis             |        |            |      |      |      |      |      |      |
| **Average rotifer**      |        | 4514±5     | 3771±50 | 4100±23 | 8079±94 | 2785±77 | 4248.77 | 4356±6906.58 |

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### Table 3. Continued.

| Species            | Months | April 2013 | May    | June   | July   | Aug    | Sept   |
|--------------------|--------|------------|--------|--------|--------|--------|--------|
| **Cladocera**      |        |            |        |        |        |        |        |
| B. longirostris    | 1567   | 5983       | 11564  | 4372   | 33154  | 2271   |
| C. pulchella       | 15423  | 13799      | 1154   |        |        |        |        |
| D. birgei          | 1095   | 1508       | 640    | 3787   | 28102  | 10512  |
| M. laticornis      | 1664   | 283        | 431    | 438    | 455    |        |        |
| M. micrura         |        | 287        | 280    | 1928   | 851    | 713    |        |
| C. rectangula      | 1997   | 6990       | 464    | 894    |        |        |        |
| A. guttata         |        |            |        |        |        |        |        |
| D. rostrata        | 913    | 2087       | 1080   | 1269   | 690    | 763    |        |
| **Average cladocer**|        | **3777±**  | **4420±** | **2410±** | **1977±** | **12650±** | **3565±4687.58** |
| **Copepoda**       |        |            |        |        |        |        |        |
| C. vicinus         | 3788   |            |        |        |        |        |        |
| D. bicuspidatus    |        |            |        |        |        |        |        |
| M. albidus         |        |            |        |        |        |        |        |
| M. leuckarti       |        |            |        |        |        |        |        |
| P. chiloni         |        |            |        |        |        |        |        |
| N. hibernica       |        |            |        |        |        |        |        |
| **Average copepod**|        | **3788±0** | **0±0** | **303±0** | **672±129.40** | **0±0** | **0±0** |
| **Average zooplankton** |        | **4026±**  | **422.30** | **4095±** | **2386.59** | **2271±** | **1902.51** | **3576±** | **3954.25** | **7717±** | **6647.33** | **3960±** | **2320.57** |
| **Species**        | **Months** | **Oct** | **Nov** | **Dec** | **Jan 2014** | **Febr** | **Marc** | **Average** |
| **Rotifera**       |        |          |        |        |        |        |        |        |
| A. fissa           |        |          |        |        |        |        |        | **2728±3463.39** |
| A. ovalis          | 2616   | 889       | 290    | 784    | 4371   |        |        | **10624±2772.80** |
| A. priodonta       | 27286  | 1080      | 20476  | 1612   | 1201   | 891    |        | **7812±8641.56** |
| B. angularis       |        | 521       | 276    |        |        |        |        | **2678±5107.07** |
| B. budapestinensis | 2483   | 3141      |        |        |        |        |        | **1972±1491.09** |
| B. quadridentatus  |        |          |        |        |        |        |        | **327±0** |
| C. gibba           | 451    | 520       | 295    | 1863   | 692    |        |        | **617±521.99** |
| C. pelagica        | 272    | 279       |        |        |        |        |        | **389±246.19** |
| C. colurus         |        |          |        |        |        |        |        | **259±0** |
| Conochiloides sp   | 1403   | 3867      |        |        |        |        |        | **2018±1289.13** |
| D. epicharis       |        |          |        |        |        |        |        | **476±0** |
| E. dilatata        |        |          |        |        |        |        |        | **481±347.81** |
| F. longiseta       | 14606  | 2194      | 537    | 907    | 999    | 253    |        | **2352±4121.02** |
| F. opolensis       | 1462   | 771       |        | 293    |        |        |        | **627±466.21** |
| H. oxyuris         |        | 273       |        |        |        |        |        | **273±0** |
| I. aurita          | 12132  | 257       | 295    | 2056   |        |        |        | **2493±4330.34** |
| K. tecta           |        |          |        |        |        |        |        | **645±525.03** |
| K. cochlearis      | 48237  | 6669      | 2949   | 38695  | 10508  | 640    |        | **11850±15441.51** |
| K. valga           | 76334  | 13275     | 2008   | 1858   | 1567   |        |        | **11761±23048.84** |
| L. closterocerca   |        | 291       |        |        | 2562   | 1427±1605.84 |        |        |
| L. luna            |        | 258       |        |        | 258±0  |        |        |        |
| L. lunaris         | 998    | 276       | 577    |        | 945    | 699±38.49 |        |        |
| L. hamata          |        | 287       |        |        |        | 287±0  |        |        |
| L. stenroosi       |        | 256±0     |        |        |        |        |        |        |
| L. patella         |        | 295       |        |        |        |        |        | **601±470.69** |
| L. salipina        |        | 280       |        |        |        |        |        | **280±0** |
| N. squamula        |        | 274       | 4845   | 2944   | 557    | 262    |        | **1426±1782.20** |
| P. quadricornis    | 325    |           |        |        |        |        |        | **325±0** |
| P. dolichopterata  | 27206  | 25262     | 1566   | 26716  | 12435  | 15574  |        | **15356±9593.48** |
| R. neptunia        | 332    |           |        |        | 927    |        |        | **704±228.30** |
| S. stylata         | 204367 | 4407      | 16644  | 13529  | 8485   | 1936   |        | **26034±56482.24** |
| T. patina          |        | 282±44.55 |        |        |        |        |        |        |
| T. similis         | 2714   | 8982      | 172    | 1079   | 989    |        |        | **3676±4351.43** |
The most abundant species from Rotifera was *S. stylata* (annual average $26034\pm56482.24$ ind./m$^3$). *P. dolichoptera* ($15356\pm9593.48$ ind./m$^3$) and *K. cochlearis* ($11850\pm15441.51$ ind./m$^3$) were found as the second and third abundant species, respectively. The least abundant species was *L. stenoosii* ($256\pm0$ ind./m$^3$).

In this study, the most common species belonging to Cladocera was *C. pulchella* ($7042\pm16508.74$ ind./m$^3$) according to their annual averages. The second abundant species was *B. longirostris* ($7125\pm993$ ind./m$^3$) and followed by *D. birgei* ($7093\pm12231.09$ ind./m$^3$). The most abundant copepod species was *C. vicinus* ($2553\pm1569.48$ ind./m$^3$) and followed by *D. birgei* ($7042\pm16508.74$ ind./m$^3$). The most abundant cover of species was *A. guttata* ($256\pm0$ ind./m$^3$) and copepod *P. chiltoni* ($266\pm0$ ind./m$^3$).

Considering their monthly abundance, the most abundant species was rotifer *S. stylata* (October 2013, 204367 ind./m$^3$) and followed by *K. valga* (October 2013, 76334 ind./m$^3$), and *A. ovalis* (July 2013, 74275 ind./m$^3$). The least abundant species was *T. similis* obtained in December 2013 (172 ind./m$^3$) (Table 3).
It has been determined that Rotifera, Cladocera, Copepoda and average zooplankton showed monthly irregular and unstable fluctuations, and peaked in the middle of summer and autumn. Copepod was not found in quantitative samples in May, August, September, December, and February (Figure 3, Table 3).

A significant functional relationship was found between zooplankton and water quality parameters (hardness-rotifer, $R^2 = 0.54$; temperature-cladocer, $R^2 = 0.61$; hardness-cladocer, $R^2 = 0.57$). A weak correlation was found between zooplankton and other water quality parameters (Table 4).

### Discussion

Water quality parameters and zooplankton communities together form a comprehensive ecosystem having interaction between both zooplankton and phytoplankton and the water quality parameters. These interactions are directly or indirectly subjected to the complex influences, some of which results in quantitative changes (Welch 1952). Water quality parameters in the study were observed to be within the normal values for animals in the water. According to this, water temperature values (13.58-31.42 °C) in the study generally reflect the climatic conditions of the region and they are ideal for zooplankton and their development. Mean dissolved oxygen concentrations were above 5 mg/l (6.83-9.70 mg/L) which was enough to support aquatic life, especially the zooplankton community (Karpowicz and Ejsmont-Karabin 2017).

The mean value of chlorophyll-a was relatively high (0.013-0.086 mg /L) and indicated that the lake has a eutrophic character, according to Wetzel (1975).

Inorganic forms of nitrogen (NO$_3^-$ and NO$_2^-$) can be used by aquatic plants and algae (Tepe and Boyd 2002). If these inorganic forms of nitrogen exceed 0.3 mg/l (as N) in spring, it means there is enough nitrogen to support summer algal blooms. The concentrations of nitrogen forms in Demrek Dam
Lake were enough to support algae blooms and indirectly zooplankton biomass. The quality of reservoir waters generally varied between clean and much-polluted water throughout the year in terms of nitrite values (YSKY 2012). As the nitrate-nitrogen values determined in the study were below 10 mg/l, thus the reservoir waters were in the category of clean and less polluted water.

Orthophosphate values changed between 0.104 mg/l and 0.192 mg/l and the reservoir waters generally have the second-class polluted water and the third-class polluted water in terms of phosphate according to the YSKY (2012). As a result, according to the Regulation on Surface Water Quality, reservoir water was first-class water in point of NO2-N, partly also dissolved oxygen, and third class water in point of NO2-N (YSKY 2012).

The annual mean values of total phosphorus and chlorophyll-a with 0.14 mg/L and 0.05 mg/L respectively also make the lake in hyper-eutrophic class according to YSKY (2012). The Dam Lake was determined to be eutrophic in terms of average Secchi disc depth and mesotrophic in terms of nitrogen (YSKY 2012).

Since there is a close relation between phytoplankton and zooplankton because of the food chain, increases were observed in zooplankton biomass following the phytoplankton bloom. The highest amount of Rotifera was reported in the area where phytoplankton bloom occurred, as they consequently found abundant food sources (Ruttner-Kolisko 1974; Horn and Goldman 1994; Noges 1997). Similar results were found in the present study. In May, chlorophyll increased due to decreased zooplankton. In the following months, the amount of zooplankton was decreased with a decrease in chlorophyll-a but increased with an increase in chlorophyll-a.

Zooplankton species diversity and abundance of Demrek Dam Lake seem to be considerably rich compared with other studies carried out in different Turkish lakes [17 Rotifera species in Yamansaz Lake (Yalım 2006); 16 Rotifera species in Hazar Lake (Tellioğlu and Şen 2002); a total of 17 species, 10 belong to Rotifera, 5 to Cladocera and 2 to Copepod, in Lake Burdur (Altındağ and Yiğit 2002). Yıldız et al. (2007) declared that 41 species were found in Lake Marmara, including 31 rotifer, 16 rotifer, 10 species from Cladocera, 3 from Copepoda, and 1 from Rotifer. Bekleyen and Taş (2008) had found 10 species from Cladocera, 3 from Copepoda, and 18 from Rotifer (a total 31 species) in Çernek Lake. The same situation was observed in dam lakes. Results of some studies were as follow: 54 species were declared in Aslantaş Dam Lake, including 35 Rotifera, 14 Cladocera, and 5 Copepoda (Bozkurt et al. 2009; Bozkurt and Göksu 2010); totally 39 taxa declared, containing 21 rotifer, 11 cladocer and 7 copepod in Birecik Dam Lake (Bozkurt and Sağat 2008). Some others; 11 rotifer, 7 cladocer and 1 copepod, 19 species in total in Çamlıgöze Dam Lake (Dirican and Musul 2008); 12 cladocer, 5 copepod, 17 species in total in Devegeçidi Dam Lake (Bekleyen 2006); 8 cladocer, 2 copepod, 10 species in total in Çatalan Dam Lake (Aladağ et al. 2006); 18 rotifer, 9 cladocer and 4 copepod, 31 species in total in Hırfanlı Dam Lake (Yiğit and Altındağ 2005); 11 rotifer in Kesikköprü Dam Lake (Yiğit 2002); 21 rotifer, 7 cladocer and 4 copepod, 32 species in total in Kurtboğazı and Çamlıdere Dam Lakes (Demir 2005); 8 cladocer and 4 copepod, 12 species in total in İkizçetepeler Dam Lake (Alper et al. 2007); 34 rotifer at Devegeçidi Dam Lake (Bekleyen 2001) and 28 rotifer, 16 cladocer and 3 copepod, 47 species in total were declared (Bekleyen 2003).

The simultaneous presence of several species of the genus Brachionus is a good indication for the eutrophic nature of an aquatic ecosystem (Angeli 1976; Magee 1983; Umza 2009). Patlas (1972) noticed that in the lakes of EUA the cyclopoid copepods were more abundant in eutrophic waters than calanoid copepods.

The results of the study are in accordance with the above information and a large number of species reported by various researchers as eutrification indicators have also been identified in the study. These species are A. fissa, N. squamula, P. quadricornis, A. priodonta, A. cochlearis, P. dolichoptera, B. angularis, R. neptunia, B. urceolaris, B. quadridentatus, L. luna, L. lunaris, L. patella, T. patina, B. nilsoni, T. pusilla, T. tetractis, E. dilatata, F. longiseta, F. opoliensis, I. aurita, B. longirostris, M. micrura, K. tecta, D. birgei, C. rectangula, C. sphaericus, C. viscinus, M. leuckarti (Pourriot 1964; Hutchinson 1967; Flössner 1972; Ruttner-Kolisko 1974; Koste 1978; Braioni and Gemlin 1983; Gulati 1983; Margaritora 1985; Koste and Shiel 1986; Saksena 1987; Pejler and Bærzín 1994; Smith 2001; Lucinda et al. 2004; Baião and Boavida 2005). Considering the water quality parameters and the determined species, it can be said that the Demrek Dam Lake is eutrophic. The remaining species in the study are widely distributed in the inland water of Turkey and have been identified in many studies (Ustaoglu et al. 2012; Ustaoglu 2015).

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