ISSN: 2458-8989

Natural and Engineering Sciences

NESciences, 2023, 8 (2): 86-105 doi: 10.28978/nesciences.1338127

Investigation of Groundwater Zooplankton Fauna from Water Wells in Kilis Province from Türkiye

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Abstract

A total of 27 taxons, 12 from Rotifera, 1 from Cladocera, and 14 from Copepoda, were determined in the study, which was conducted by sampling 4 times from 29 water wells. A total of 3 families were detected from Rotifera and Lecanidae was the richest family with 8 species. Among the 6 families of Copepoda, Cyclopoidae had 8 species. The rotifer species with the largest distribution areas were *Lecane closterocerca* (found in 15 wells), *Pleuroxus aduncus*, the only species from Cladocera, was found in 21 wells and *Kinnecaris xanthi* had the widest distribution area (found in 27 wells). In terms of total zooplankton species, it was determined that wells 3, 12, and 18 were the richest with 14 species. While Rotifera was found in limited quantities in all water wells, *Pleuroxus aduncus* from Cladocera, *Diacyclops longuioides*, *Megacyclops viridis*, *Monchenkocyclops mehmetadami* and *Thermocyclops dybowski* from Copepoda were found in very large quantities. In addition, the genus *Ectinosoma* is reported for the first time from inland waters of Türkiye with this study.

Keywords:

Zooplankton, water wells, Kilis province

Article history:

Received 13 March 2023, Accepted 10 June 2023, Available online 07 August 2023

Introduction

Groundwater covers a wide region, accounting for roughly 40% of global inland waterways (Castany, 1982), and is made up of a variety of habitats that are more or less interconnected (Botosaneanu, 1986; Gibert et al., 1994; 1997; Palmer et al., 1997). Stygobionts, stygophiles, and stygoxenes are three types of zooplankton that are classed based on their degree of adaptability to

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groundwater living. Throughout their entire life cycle, stygobionts are inextricably linked to the groundwater environment, and they frequently adapt to its biotic and abiotic conditions. Stygophiles can live and reproduce in both underground and epigean marginal habitats, including springs, edaphic habitats, near-surface sediments of running waterways, and lentic water bodies; additionally, they may or may not contain incipient troglomorphic traits. Furthermore, the stygophile state should not always be viewed as a transitional evolutionary stage in the'stigobization' process (Stoch, 1995).

Animals thrive in aquifer pore gaps and cracks. Crustaceans make up the majority of animals, both in terms of quantity and species diversity. The biodiversity of groundwater is now clearer than previously thought. Inland water groundwater environments have evolved into three primary types of aquifers: karst, fissured, and porous, though these classifications are not always clearly defined in natural conditions. Furthermore, groundwater is closely associated with lentic water basins, stream channels, and springs through groundwater below and lateral to surface open waters. These so-called "dynamic transition zones" (Stanford & Ward 1993; Gibert et al., 1994; 1997) are locations where surface and groundwater systems interact (Vervier et al., 1993).

Meiofauna includes the majority of groundwater creatures. Meiofauna has a usual size range of 0.3-1 mm. The groundwater fauna has morphologically adapted to the subsurface habitat by maximizing the limited dwelling areas in the pores. For millions of years, groundwater has been one of the world's oldest habitats, with generally stable environmental conditions. However, even in Central and Southern Europe, where the study is rather extensive, groundwater biodiversity research is still in its infancy, and new species are continuously being identified.

The spatial distribution of fauna is often quite unequal due to the heterogeneity in groundwater (in terms of organic matter distribution, oxygen, and matrix pore size). Groundwater fauna has a localized uneven distribution, indicating subterranean habitat heterogeneity. Furthermore, it suggests that true groundwater fauna (stygobionts) have adapted well to the unique living conditions in groundwater. As a result, groundwater fauna can be utilized to assess groundwater ecology.

Copepods, one of the most important groundwater fauna components, have successfully infiltrated subsurface habitats in both marine and territorial waters at various times and in various ways. Stygobionts are found in six of the ten known Copepoda orders: Platycopioida, Calanoida, Misophrioida, Cyclopoida, Harpacticoida, and Gelyelloida. About 897 species and subspecies of Cyclopoida and Harpacticoida, chiefly belonging to the Canthocamptidae, Parastenocarididae, and Ameiridae, including the cyclopoid family Cyclopidae, successfully colonized inland groundwater.

The fauna of groundwater comprises nearly all of the major taxonomic groupings found in limnic surface waters, although it has not been fully researched thus far. This research was carried out to determine the groundwater fauna in Türkiye, which had previously been done in small quantities.

Materials and Methods

Zooplankton samples were collected by vertical hauls using a 60 µm mesh size plankton net from 29 different water wells within the borders of Kilis Province in February 2019, June 2019, September 2019, and July 2020 (Figure 1).

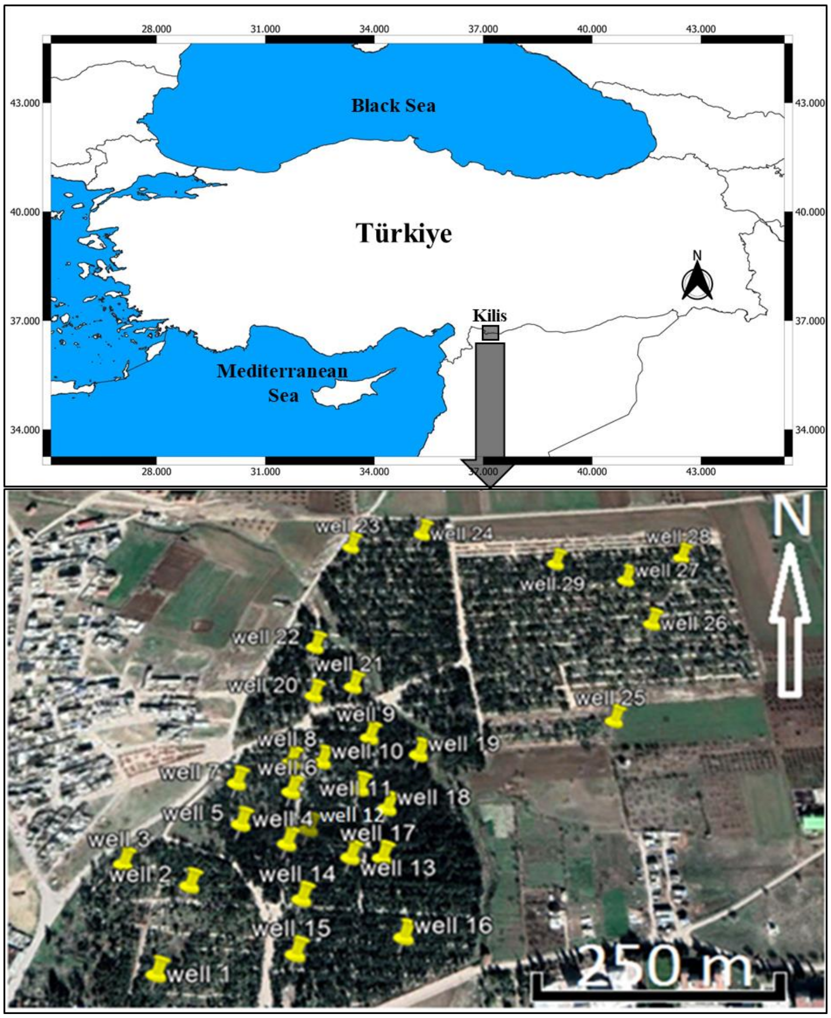

Figure 1. Sampling points of zooplankton.

A 0.5 kg metal weight was attached to the collector of the net and the net was lowered to the bottom of the well. The net was used to stir the well water vigorously to enable proper mixing of the zooplankton in the benthic layers with the water. The net was then raised and 10 replicates were made for each well. The coordinates of the sampling wells, the depth of the wells from the surface to the bottom, the water depth at the time of sampling, and the widths of the wells are given in Table 1.

Table 1. Coordinates, depth, width, and water depth of wells.

Sampling stations	**Latitude**	**Longitude**	**Well depth (m)**	**Water depth (m)**	**Well width (m)**
Well 1	36° 43′ 07.64″ N	37° 07′ 44.79″ E	14	5	1.90
Well 2	36° 43′ 11.38″ N	37° 07′ 45.68″ E	13	7	1.80
Well 3	36° 43′ 12.34″ N	37° 07′ 42.56″ E	13	7	2.00
Well 4	36° 43′ 13.27″ N	37° 07′ 49.84″ E	12	4	1.40
Well 5	36° 43′ 14.18″ N	37° 07′ 47.64″ E	12	6	1.20
Well 6	36° 43′ 15.72″ N	37° 07′ 49.81″ E	10	4	1.10
Well 7	36° 43′ 16.14″ N	37° 07′ 47.22″ E	12	6	1.20
Well 8	36° 43′ 17.15″ N	37° 07′ 49.66″ E	5	2	2.10
Well 9	36° 43′ 18.41″ N	37° 07′ 53.32″ E	9	5	2.10
Well 10	36° 43′ 17.18″ N	37° 07′ 51.13″ E	12	4.5	2.00
Well 11	36° 43′ 15.86″ N	37° 07′ 52.99″ E	9	5	2.00
Well 12	36° 43′ 13.94″ N	37° 07′ 50.76″ E	11	4	1.60
Well 13	36° 43′ 12.65″ N	37° 07′ 52.76″ E	13	7	1.50
Well 14	36° 43′ 10.79″ N	37° 07′ 50.72″ E	13	5	1.40
Well 15	36° 43′ 08.46″ N	37° 07′ 50.65″ E	12	2	1.20
Well 16	36° 43′ 09.17″ N	37° 08′ 55.29″ E	12	4	1.10
Well 17	36° 43′ 12.62″ N	37° 07′ 54.19″ E	14	5	1.20
Well 18	36° 43′ 14.92″ N	37° 07′ 54.32″ E	9	5	1.60
Well 19	36° 43′ 17.55″ N	37° 07′ 55.71″ E	7	2	1.90
Well 20	36° 43′ 20.61″ N	37° 07′ 50.47″ E	15	7	1.70
Well 21	36° 43′ 21.09″ N	37° 07′ 52.37″ E	11	6	1.80
Well 22	36° 43′ 23.29″ N	37° 07′ 50.33″ E	13	4	1.60
Well 23	36° 43′ 29.28″ N	37° 07′ 51.77″ E	11	6	1.50
Well 24	36° 43′ 30.10″ N	37° 07′ 55.56″ E	12	7	1.80
Well 25	36° 43′ 19.27″ N	37° 08′ 05.13″ E	16	7	2.10
Well 26	36° 43′ 24.62″ N	37° 08′ 07.44″ E	12	4	1.90
Well 27	36° 43′ 27.22″ N	37° 08′ 06.32″ E	11	2	1.70
Well 28	36° 43′ 28.61″ N	37° 08′ 09.37″ E	17	5	2.20
Well 29	36° 43′ 28.24″ N	37° 08′ 02.67″ E	12	6	1.80

The zooplankton samples were fixed and kept in 4% formaldehyde after sampling and then analyzed in a mixture of distilled water and glycerol. The general abundance of zooplankton was examined rather than the counting method in a quantitative zooplankton study. Absent (-), very little (*), little (+), abundant (++), and extremely abundant (+++) were the scores. An inverted microscope was used to view zooplankton species, which were then identified using a binocular microscope (Olympus CH40). The specimens were identified and examined using Borutsky (1964), Scourfield & Harding (1966), Dussart (1969), Damian-Georgescu (1970), Ruttner-Kolisko (1974), Smirnov (1974), Kiefer (1978), Koste (1978), Negrea (1983), Korinek (1987), Segers (1995), and Galassi & De Laurentiis (2004).

Results

In this study, 14 copepods (51.85%), 12 rotifers (44.45%), and 1 cladoceran (3.70%) were recorded in the water wells (Table 2). Rotifera, which was determined to have three different families, Lecanidae has the most species with eight species, followed by the families Lepadellidae and Notammatidae, both of which have two species. Cladocera was represented by a species belonging to the Chydoridae family. While Copepoda had eight species in Cyclopoidae, Canthocamptidae had two; Ameiridae, Parastenocarididae, Ectinosomatidae, and Phyllognathopodidae each had one species (Table 2).

Table 2. Identified zooplankton species

Rotifera	
Notommatidae	*Cephalodella forficula* (Ehrenberg, 1838) *Cephalodella gibba* (Ehrenberg, 1838)
Lepadellidae	*Colurella uncinata* (Müller, 1773) *Lepadella patella* (Müller,1786)
Lecanidae	*Lecane bulla* (Gosse,1886) *Lecane closterocerca* (Schmarda, 1859) *Lecane flexilis* (Gosse,1886) *Lecane hamata* (Stokes,1896) *Lecane inermis* (Bryce,1892) *Lecane ludwigi* (Eckstein,1893) *Lecane pyriformis* (Daday,1905) *Lecane tenuiseta* Harring, 1914
Cladocera	
Chydoridae	*Pleuroxus aduncus* (Jurine, 1820)
Copepoda	
Cyclopidae	*Diacyclops languidoides* (Lilljeborg, 1901) *Eucyclops serrulatus* (Fischer, 1851) *Megacyclops viridis* (Jurine, 1820) *Microcyclops* sp. *Monchenkocyclops mehmetadami* Karaytuğ, Bozkurt &Sönmez, 2018 *Paracyclops chiltoni* (Thomson, 1883) *Thermocyclops dybowski* (Lande, 1890) *Tropocyclops prasinus* (Fischer, 1860)
Canthocamptidae	*Attheyella crassa* (Sars,1863) *Elaphoidella* sp.
Ameiridae	*Nitocrella stammeri* Chappuis, 1938
Parastenocarididae	*Kinnecaris xanthi* Bruno & Cottarelli, 2015
Ectinosomatidae	*Ectinosoma* sp.
Phyllognathopodidae	*Phyllognathopus viguieri* (Maupas, 1892)

According to Table 3, the rotifer species with the largest distribution areas were *Lecane closterocerca* (found in 15 wells), *L. pyriformis* (13 wells), and *L. hamata* (12 wells). *Pleuroxus aduncus*, the only species from Cladocera, was found in 21 wells. *Kinnecaris xanthi* had the widest distribution area (found in 27 wells), followed by *D. longuioides* and *M. mehmetadami* (25 wells), and *Nitocrella stammeri* (23 wells). Some zooplankton species in the study were selective to their environmental conditions, showing limited distribution, and were recorded in very few wells. *Cephalodella gibba*, *C. uncinata*, *Lecane bulla*, and *L. ludwigi* from Rotifera; *Microcyclops* sp. and *Phyllognathopus viguieri* from Copepoda were recorded in one well each (Table 3). Most species (5 species) from Rotifera were recorded in wells 14, 15, and 25 followed by wells 3, 5, 19, 20, and 26 with 4 species and wells 2, 4, 8, 10, 12, 16, 18 and 27 with 3 species. The most species from Copepoda were recorded in wells 12 and 18 (10 species), followed by 9 species in wells 3, 5, and 8, and 8 species in wells 7, 9, 10, 19, and 27 (Table 3). In terms of total zooplankton species, wells 3, 12, and 18 were the richest with 14 species, followed by wells 5, 14, 19, and 25 with 13 species and well 8, 10, 15, 26, and 27 with 12 species (Table 3). While the wells were rich in the variety of rotifer and copepod, they were very poor in terms of cladoceran. On the other hand, while no rotifers were recorded in wells 6, 11, 21, 28, and 29, only one rotifer species was recorded in wells 9, 17, 22, 23, and 24. It was determined that the wells with 2 species from Copepoda and the least species were recorded in wells 11 and 29 (Table 3).

Table 3. Determined zooplankton species in different water wells.

Species / Wells	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
Rotifera																														
C. forficula	-	-	-	+	-	-	+	-	-	-	-	-	+	-	+	+	-	-	+	-	-	-	-	+	+	-	+	-	-	**9**
C. gibba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	**1**
C. uncinata	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
L. bulla	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
L. closterocerca	-	-	+	+	+	-	+	+	-	+	-	+	-	+	+	+	-	+	+	-	-	-	+	-	+	-	+	-	-	**15**
L. flexilis	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	**2**
L. hamata	+	+	+	-	+	-	-	-	+	+	-	+	-	+	-	-	-	-	+	+	-	-	-	-	+	+	-	-	-	**12**
L. inermis	-	-	+	-	-	-	-	-	-	-	-	-	-	+	+	-	+	+	-	+	-	+	-	-	+		-	-	-	**8**
L. ludwigi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	**1**
L. pyriformis	+	+	+	+	+	-	-	+	-	+	-	-	+	+	-	-	-	-	+	+	-	-	-	-	+	+	-	-	-	**13**
L. tenuiseta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	**2**
L. patella	-	+	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	**5**
Total rotifer	**2**	**3**	**4**	**3**	**4**	**0**	**2**	**3**	**1**	**3**	**0**	**3**	**2**	**5**	**5**	**3**	**1**	**3**	**4**	**4**	**0**	**1**	**1**	**1**	**5**	**4**	**3**	**0**	**0**	
Cladocera																														
P. aduncus	-	+	+	+	-	+	-	-	-	+	-	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	-	**21**
Copepoda																														
D. languidoides	-	+	+	+	+	-	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	**25**
E. serrulatus	-	-	+	+	+	-	+	+	+	+	-	+	-	-	-	-	+	+	-	-	-	-	-	-	+	+	+	+	-	**14**
M. viridis	+	-	+	-	+	-	+	+	-	+	+	+	+	+	+	+	+	+	+	-	-	+	-	+	+	+	+	-	+	**21**
Microcyclops sp.	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
M. mehmetadami	-	+	+	+	+	-	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	-	**25**
P. chiltoni	+	-	+	+	-	-	+	-	+	+	-	+	-	+	-	-	-	+	-	-	-	-	+	-	-	+	-	-	-	**11**
T. dybowski	-	+	+	-	+	-	-	+	-	-	-	+	-	+	-	-	-	+	+	-	+	-	-	+	-	-	+	-	-	**11**
T. prasinus	+	-	-	+	+	+	+	-	-	+	-	-	-	-	-	-	+	-	+	-	+	+	+	-	-	-	-	-	-	**11**
A. crassa	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	+	-	+	+	-	-	-	-	-	-	-	**5**
Ectinosoma sp.	-	-	+	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	**4**
Elaphoidella sp.	-	-	+	-	-	-	-	+	+	-	-	+	-	+	+	-	-	+	-	-	-	-	+	-	-	-	+	-	-	**9**
K. xanthi	-	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	**27**
N. stammeri	-	+	-	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	+	+	+	-	+	+	+	+	+	+	-	**23**
P. viguieri	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Total copepod	**3**	**5**	**9**	**7**	**9**	**3**	**8**	**9**	**8**	**8**	**2**	**10**	**5**	**7**	**6**	**5**	**7**	**10**	**8**	**4**	**7**	**6**	**7**	**6**	**7**	**7**	**8**	**5**	**2**	
Total zooplankton	**5**	**9**	**14**	**11**	**13**	**4**	**10**	**12**	**9**	**12**	**2**	**14**	**8**	**13**	**12**	**9**	**9**	**14**	**13**	**9**	**8**	**7**	**9**	**8**	**13**	**12**	**12**	**6**	**2**	

+: Available, -: absent

Seven of the 12 species from Rotifera, one species from Cladocera, and 12 of 14 species from Copepoda were recorded in different seasons and at varying levels of abundance in wells. *L. closterocerca* from Rotifera at the first sampling time (24.02.2019) in wells 18 and 19; at the third sampling time (15.09.2019) in wells 5 and 16, and at the last sampling time (05.07.2020) in wells 3 were abundant (++). While *L. hamata* was abundant in well 19 at the second and fourth sampling times, *L. pyriformis* was abundant in well 10 at the third sampling time. *P. aduncus* from Cladocera was recorded as very abundant (+++) in well 25 in the first sampling, while it was recorded as abundant in wells 4, 16, and 19. In the second sampling, it was recorded as very abundant in well 15 and abundant in well 16. In the third sampling, it was abundant in wells 13 and 16, while it was abundant in well 18. In the last sampling, it was determined that they were abundant in wells 4, 16, 19, and 25 (Table 4). *M. mehmetadami* from Copepoda was very abundant in well 12 in the last sampling. In that first sampling, in wells 5 and 7; In the second sampling, in wells 19, 23, 24, and 26; in the third sampling wells 5, 7, 21, 23, and 25; in the last sampling, it was abundant in wells 3, 4, 5, 7, 11, 14, 19, 21, 24, 25 and 27. *E. serrulatus* from Copepoda was abundant in well 7 in the second sampling and well 28 in the third sampling. While *D. longuioides* from Copepoda were abundant in wells 9 and 19 in the third sampling, they were abundant in wells 4, 7, 13, 18, 21, 23, and 25. In the fourth sampling, they were abundant in wells 2, 4, 8, 19, 23, and 25. In the second sampling, *M. viridis* from Copepoda was abundant in well 11; in the third sampling, while *M. viridis* was very abundant in well 10, it was also abundant in wells 2 and 17. In the fourth sampling, It was abundant in well 29.

P. chiltoni was abundant in well 7 in the first sampling, abundant in well 1 in the second and third samplings, and abundant in wells 1, 7, and 26 in the final sampling. *T. dybowski* was very abundant in well 5 in the third sampling, but it was abundant in well 18. In the second sampling, *T. prasinus* was very abundant in wells 17 and 19, and abundant in well 21. In the third sampling, it was very abundant in well 5 and abundant in well 18. In the last sampling, it was abundant only in well number 19. While *Elaphoidella* sp. was abundant in well 27 in the last sampling, *K. xanthi* was abundant in wells 9, 21, and 24 in the second sampling (Table 4).

Table 4. Zooplankton in water wells according to sampling times

Species Wells	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Rotifera															**24.02.2019**														
C. forficula	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	*	-	-	-	-	*	-	-	-	-	-
C. gibba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-
C. uncinata	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L. bulla	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L. closterocerca	-	-	*	*	+	-	*	*	-	+	-	*	-	-	*	+	-	++	++	-	-	-	-	-	+	-	+	-	-
L. flexilis	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
L. hamata	*	-	*	-	-	-	-	-	*	+	-	-	-	*	-	-	-	-	+	*	-	-	-	-	*	*	-	-	-
L. inermis	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	*		-	-	-
L. ludwigi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-
L. pyriformis	-	*	-	-	*	-	-	-	-	*	-	-	*	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-
L. tenuiseta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L. patella	-	*	-	-	+	-	-	-	-	-	-	*	-	-	-	-	-	-	-	*	-	-	-	-	-	*	-	-	-
Cladocera																													
P. aduncus	-	*	+	++	-	*	-	-	-	*	-	-	+	+	+	++	*	*	++	*	*	-	*	*	+++	-	*	*	-
Copepoda																													
D. languidoides	-	-	-	-	*	-	+	+	+	*	-	+	*	+	*	+	*	+	*	+	+	+	+	-	*	*	+	+	-
E. serrulatus	-	-	-	-	-	-		+	-	-	-	-	-	-	-	-	*	+	-	-	-	-	-	-	-	*	-	+	-
M. viridis	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	+
M. mehmetadami	-	-	+	*	++	-	++	*	+	+	+	+	+	+	+	-	*	+	*	-	+	+	+	+	+	+	-	+	-
P. chiltoni	+	-	-	-	-	-	++	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T. dybowski	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-
T. prasinus	+	-	-	-	-	*	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
A. crassa	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-	*	-	*	+	-	-	-	-	-	-	-
Elaphoidella sp.	-	-	-	-	-	-	-	*	+	-	-	*	-	-	*	-	-	*	-	-	-	-	*	-	-	-	+	-	-
K. xanthi	-	-	*	*	*	-	*	*	+	*	-	+	+	*	*	+	-	-	*	-	-	*	-	+	*	+	-	-	*
N. stammeri	-	+	-	-	-	*	-	+	*	-	-	*	*	-	-	*	*	-	-	*	-	-	-	*	*	*	+	*	-
Rotifera															**30.06.2019**														
C. forficula	-	-	-	*	-	-	-	-	-	-	-	-	*	-	*	*	-	-	-	-	-	-	-	*	-	-	*	-	-
L. closterocerca	-	-	-	*	+	-	-	*	-	+	-	-	-	-	+	+	-	-	-	-	-	-	*	-	-	-	+	-	-
L. hamata	*	*	*	-	*	-	-	-	*	+	-	-	-	-	-	-	-	-	++	-	-	-	-	-	-	-	-	-	-
L. inermis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	+	-	*	-	-	-	-	-	-	-
L. ludwigi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-
L. pyriformis	*	*	+	*	*	-	-	*	-	*	-	-	*	*	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-
L. tenuiseta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L. patella	-	-	-	-	*	-	-	-	-	-	-	*	-	-	-	-	-	-	-	*	-	-	-	-	-	*	-	-	-

Table 4. Contiuned

Species Wells	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Cladocera																													
P. aduncus	-	-	-	-	-	*	-	-	-	-	-	-	+	-	+++	++	*	+	*	-	*	-	-	*	-	-	*	*	-
Copepoda																													
D. languidoides	-	+	-	*	*	-	+	+	+	+	-	*	*	+	-	-	-	+	-	-	-	-	-	-	-	*	-	-	-
E. serrulatus	-	-	-	-	-	-	++	-	+	-	-	*	-	-	-	-	-	*	-	-	-	-	-	-	*	-	-	+	-
M. viridis	-	-	*	-	*	-	-	+	-	-	++	*	-	-	+	*	-	-	-	-	-	*	-	*	-	+	-	-	+
Microcyclops sp.	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. mehmetadami	-	-	*	+	+	-	*	+	+	+	-	*	*	*	*	-	+	+	++	+	+	+	++	++	+	++	-	+	-
P. chiltoni	++	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T. dybowski	-	-	-	-	+	-	-	*	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	*	-	-
T. prasinus	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-	+++		+++	-	++	-	-	-	-	-	-	-	-
A. crassa	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	*	*	-	*	-	-	-	-	-	-	-	-
Ectinosoma sp.	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elaphoidella sp.	-	-	-	-	-	-	-	*	+	-	-	*	-	-	-	-	-	-	-	-	-	-	*	-	-	-	+	-	-
K. xanthi	-	*	*	*	*	-	*	*	++	*	-	+	+	*	*	*		+	-	+	++	*	+	++	+	+	+		*
N. stammeri	-	*	-	-	-	*	*	*	*	+	-	-	-	-	-	-	*	*	-	*	-	-	-	-	-	*	+	*	-
Rotifera															**15.09.2019**														
C. forficula	-	-	-	-	-	-	*	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	*	*	-	-	-	-
C. uncinata	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L. closterocerca	-	-	*	+	++	-	*	*	-	*	-	*	-	-	*	++	-	-	-	-	-	-	-	-	-	-	-	-	-
L. hamata	-	-	-	-	-	-	-	-	*	-	-	-	-	*	-	-	-	-	*	*	-	-	-	-	-	*	-	-	-
L. inermis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	*	-	-	-	-
L. pyriformis	-	*	-	-	*	-	-	-	-	++	-	-	-	-	-	-	-	-	-	*	-	-	-	-	*	+	-	-	-
L. tenuiseta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-		-	-	-	-	-	-	-	-	-
L. patella	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	*	-	-	-
Cladocera																													
P. aduncus	-	*	*	-	-	*	-	-	-	*	-	*	+++	*	*	+++	-	++	+	*	*	-	*	-	*	*	*	*	-
Copepoda																													
D. languidoides	-	+	*	++	-	-	++	*	+++	*	-	+	++	+	*	+	*	++	+++	+	++	*	++	+	++	*	+	+	-
E. serrulatus	-	-	-	-	-	-	+	-	*	*	-	-	-	-	-	-	*	*	-	-	-	-	-	-	*	*	-	++	-
M. viridis	-	++	-	-	-	-	-	-	-	+++	*	-	*	+	*	-	++	-	*	-	-	-	-	*	*	*	-	-	+
M. mehmetadami	-	*	*	-	++	-	++	*	+	-	+	+	+	-	*	-	*	*	-	-	++	-	++	*	++	-	+	+	-
P. chiltoni	++	-	*	+	-	-	*	-	*	*	-	-	-	*	-	-	-	*	-	-	-	-	+	-	-	-	-	-	-
T. dybowski	-	*	+	-	+++	-	-	*	-	-	-	*	-	*	-	-	-	++	+	-	*	-	-	*	-	-	*	-	-
T. prasinus	++	-	-	*	-	*	-	-	-	*	-	-	-	-	-	-	-	-	++	-	*	*	+	-	-	-	-	-	-

Table 4. Contiuned

Species Wells	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
A. crassa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	*	-	-	-	-	-	-	-	-
Ectinosoma sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-
Elaphoidella sp.	-	-	*		-	-	-	*	+	-	-	-	-	*	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-
K. xanthi	-	-	*	+	*	*	-	-	+	*	-	*	+	*	*	+	+	*	+	*	*	*	-	+	*	*	+	*	*
N. stammeri	-	-	-	-	-	-	-	*	-	-	-	*	-	-	*	*	*	-	+	*	*	-	+	*	*	*	+	-	-
Rotifera															**05.07.2020**														
C. forficula	-	-	-	-	-	-	-	-	-	-	-	-	*	-	*	*	-	-	-	-	-	-	-	*	-	-	*	-	-
C. gibba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-
L. closterocerca	-	-	++	+	*	-	-	+	-	*	-	*		*	*	+							-	-	-	-	+	-	-
L. flexilis	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L. hamata	-	-	-	-	-	-	-	-	*	-	-	*	-	*	-	-	-	-	++	-	-	-	-	-	*	*	-	-	-
L. inermis	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	*	*	-	-	-	*	-	-	*	-	-	-	-
L. pyriformis	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-	*	*	-	-	-	-	-	-	-	-	-
L. tenuiseta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-
L. patella	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	*	-	-	-
Cladocera																													
P. aduncus	-	-	-	++	-	*	-	-	-	*	-	-	+	+	+	++	*	-	++	*	*	-	*	*	++	-	-	-	-
Copepoda																													
D.languidoides	-	++	-	++	+	-	*	++	+	*	-	-	*	-	*	+	*	+	++	+	+	+	++	-	++	-	-	+	-
E. serrulatus	-	-	+	+	*	-	-	+	+	-	-	-	-	-	-	-	*	*	-	-	-	-	-	-	*	-	*	-	-
M. viridis	+	-	-	-	-	-	*	-	-	-	*	*	-	-	+	-	-	+	-	-	-	-	-	*	*	*	*	-	++
M. mehmetadami	-	-	++	++	++	-	++	-	+	-	++	+++	*	++	*	-	*	+	++	-	++	+	-	++	++	+	++	-	-
P. chiltoni	++	-	+	-	-	-	++	-	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	++	-	-	-
T. dybowski	-	+	*	*	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T. prasinus	-	-	-	-	+	-	*	-	-	*	-	-	-	-	-	-	-	-	++	-	*	-	+	-	-	-	-	-	-
A. crassa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	*	-	-	-	-	-	-	-	-
Ectinosoma sp.	-	-	+	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elaphoidella sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	++	-	-
K. xanthi	-	-	+	*	*	*	*	-	+	*	-	*	+	*	*	+	-	*	+	+	+	*	+	+	*	*	*	*	*
N. stammeri	-	+	-	+	*	-	-	-	*	-	-	-	*	-	*	*	*	*	-	*	*	-	+	-	*	+	-	*	-

-: Absent, *: very few, +: few, ++: abundant, +++: very abundant.

Cephalodella forficula, Lecane closterocerca, L. hamata, L. inermis, L. pyriformis, L. tenuiseta, Lepadella patella, P. aduncus, D. longuioides, E. serrulatus, M. viridis, M. mehmetadami, P. chiltoni, T. dybowski, T. prasinus, A. crassa, Elaphoidella sp., *K. xanthi* and *N. stammeri* were present at all sampling times but *L. bulla*, *Microcyclops sp.* and *P. viguieri* were recorded only once during the different sampling time (Table 5).

Table 5. The abundance of species by sampling time.

	Sampling Time			
	24.02. 2019	**30.06.2019**	**15.09. 2019**	**05.07.2020**
Rotifera				
Cephalodella forficula	*	*	*	*
Cephalodella gibba	*	-	-	*
Colurella uncinata	*	-	*	-
Lecane bulla	*	-	-	-
Lecane closterocerca	++	+	++	++
Lecane flexilis	+	-	-	*
Lecane hamata	+	++	*	++
Lecane inermis	+	+	*	+
Lecane ludwigi	*	*	-	-
Lecane pyriformis	*	+	++	*
Lecane tenuiseta	+	*	*	*
Lepadella patella	+	+	+	*
Cladocera				
Pleuroxus aduncus	+++	+++	+++	++
Copepoda				
Diacyclops languidoides	++	+	+++	++
Eucyclops serrulatus	+	++	++	+
Megacyclops viridis	+	++	+++	++
Microcyclops sp.	-	*	-	-
Monchenkocyclops mehmetadami	++	++	++	+++
Paracyclops chiltoni	++	++	++	++
Thermocyclops dybowski	+	+	+++	+
Tropocyclops prasinus	+	+++	++	++
Attheyella crassa	+	*	*	*
Ectinosoma sp.	-	*	*	+
Elaphoidella sp.	+	+	+	++
Kinnecaris xanthi	+	++	+	+
Nitocrella stammeri	+	+	+	+
Phyllognathopus viguieri	-	*	-	-

-: Absent, *: very few, +: few, ++: abundant, +++: very abundant

According to Table 5, *L. closterocerca* in the first, third, and fourth sampling, *L. hamata* in the second and last sampling, *L. pyriformis* in the third sampling were abundant. *P. aduncus* from Cladocera was very abundant in the first, second, and third samplings, while it was abundant in the last sampling.

While *D. longuioides* from Copepoda was very abundant in the third sampling, they were recorded as abundant in the first and last sampling. *Eucyclops serrulatus* was abundant in the second and third sampling; *M. virid*is was recorded as very abundant in the third sampling and abundant in the second and fourth sampling. *M. mehmetadami* was found very abundant in the fourth sampling and abundant in the other sampling. *P. chiltoni* was abundant in all sampling, *T. dybowski* was very abundant only in the third sampling, *T. prasinus* was very abundant in the second sampling, while it was abundant in the third and fourth sampling. *Elaphoidella* sp. in the fourth sample, and K. xanthi in the second sample were abundant. The least common species *C. gibba*, *L. bulla*, *Microcyclops* sp., and *P. viguieri* were detected at only one sampling time and very few (*).

Discussion

Zooplankton samples were collected from 29 water wells built for various purposes (to irrigate the flowers on the graves, to use in the construction of graves, and to irrigate the trees in the entire cemetery) in the cemetery complex of Kilis province.

The depth, width, and water depth of the water wells were measured to be between 5 and 17 meters, 1.10 and 2.20 meters, and 2 and 7 meters, respectively.

Groundwater fauna can be used to examine groundwater from an ecological standpoint. Organic matter and dissolved oxygen imported from the surface are essential for faunal biocenoses, such as the living activities of animals in groundwater habitats. Both are made available as a result of groundwater and surface water exchange activities. Hydrological exchange, as well as site variety, must be taken into account while forming communities of unpolluted groundwater. Because they purify the groundwater, groundwater fauna plays a vital role in groundwater ecosystems. Groundwater fauna may also serve as bioindicators, integrating short-, mid-, and long-term changes in environmental conditions within an ecosystem (Malard et al., 1996; Mösslacher, 2000).

The main water sources of water wells are groundwater, rainwater, and leachate water enters the wells with open mouths, making an additional contribution to the existing water. Therefore, the access of planktonic organisms to well water is mainly dependent on groundwater and can then be said to be supported by rainwater. Although zooplankton species are poor in terms of species richness and abundance in groundwater, especially copepods constitute an important community in these waters (Galassi, 2001). With more than 900 species/subspecies known from continental groundwaters, stygobiont copepods inhabit all kinds of aquifers (karstic, fissured, porous), as well as surface/subsurface ecotones (land/water and water/water). As can be seen from the results of our study, copepod species seem to be richer in species diversity than other zooplankton groups.

In this study, a total of 27 species including 12 rotifer species, 1 cladoceran species and 14 copepod species were identified. While the distribution of zooplankton in lakes and streams is generally in the form of Rotifera, Cladocera, and Copepoda, the study of zooplankton biodiversity in groundwater found Copepoda to be the most represented species, followed by Rotifera and Cladocera. So far, two studies have been conducted on zooplankton related to groundwater and water wells in Turkey (Bozkurt, 2019; Bozkurt & Bozça, 2019). In both studies, it was reported that most species were rotifers, followed by copepods and cladocerans. In our study, unlike other studies, copepod species diversity was found to be higher.

The species detected in the study, *C. forficula, C. gibba, C. uncinata, Lepadella patella, Lecane bulla, L. closterocerca, L. flexilis, L. hamata, L. inermis, L. ludwigi, L. pyriformis, L. tenuiseta, P. aduncus, D. languidoides, E. serrulatus, M. viridis, P. chiltoni, T. dybowski, T. prasinus, A. crassa, N. stammeri,* and *P. viguieri* have been reported by various researchers to be cosmopolitan and have a wide distribution in different abundances at different times of the year (Ruttner-Kolisko, 1974; Koste & Shiel, 1987; De Smet, 1996; De Manuel Barrabin, 2000; Stoch & Pospisil, 2000; Ramdani et al., 2001; Rybak & Bledzki, 2010). In addition to all these, they are very tolerant of changes in water quality parameters (Berzins & Pejler, 1987; Koste & Shiel, 1989; Manuel Barrabin, 2000).

It was reported that *M. mehmetadami* (Karaytug et al., 2018) and *K. xanthi* (Bruno & Cottarelli, 2015) were identified first of all from the hyporheic fauna by Karaytug et al. (2018) and Bruno & Cottarelli (2015) respectively. For this reason, the ecological and habitat characteristics of the newly discovered species, which were thought to be hyporheic due to their habitat characteristics, have not been determined yet.

Species of *Microcyclops* and *Elaphoidella* genera found in the study could not be identified due to insufficient samples. However, it is known that some species belonging to these genera are common in groundwater. In addition, the genus *Ectinosoma* is reported for the first time from inland waters of Turkey and the species has not yet been identified.

Some rotifer species in the study, *C. forficula, C. gibba, Colurella uncinata, L. bulla, L. hamata, L. flexilis, L. ludwigi, L. pyriformis,* and *L. tenuiseta* are littoral periphytic rotifers and they mostly live on plant substrata (de Manuel Barrabin, 2000; Hingley, 1993), in the standing and running waters (Koste, 1978; Segers, 1995; Kuczynska-Kippen, 2000). On the other hand, they are occasionally found in the plankton (Braioni & Gelmini, 1983).

Some other rotifer species, *C. gibba, L. closterocerca*, and *L. inermis* are the most common benthic rotifers, but it was frequently observed in plankton samples (Ruttner-Kolisko, 1974). Although *L. closterocerca* mostly prefers temporary ponds, it can also be found in streams (de Manuel Barrabin, 2000). In addition, some of the species in the study, (*L. closterocerca, L. inermis, L. pyriformis, Lepadella patella*), tolerate a wide range of salinity (De Smet, 1996; Walsh et al., 2008). It is reported that the rotifer species included in the study are most common in pH values between 6.5 and 8.2 and temperature values between 7.8 and 24 degrees (Nogrady & Pourriot, 1995; De Smet, 1996; Koste & Shiel, 1990; De Manuel Barrabin, 2000).

Researchers have reported that *C. forficula* is a free-floating, tube-dwelling species (Dodson, 1984), *C. uncinata* can tolerate a wide variety of mineralization, and *L. bulla* has been associated with interconnected flowing spring pools (Segers, 1995). Further, the limnobiological correlation between physicochemical parameters and rotifer associations revealed, *L. bulla, L. closterocerca*, *L. hamata* and *L. ludwigi*, as euryokous species, showing tolerance to a wide range of abiotic factors and habitats (Segers, 1995).

Pleuroxus aduncus, the only member of Cladocera in the study, is a macrophyte-sediment-related taxon and lives at the bottom and in macrophyte beds. *P. aduncus* is known for a variety of water types, including temporary localities and slightly saline waters, and is the inhabitant of eutrophic waters (salinity up to 2.9%0) (Timms, 1973; Vadadi-Fülöp et al., 2008).

Some copepod species in the study, *D. languidoides*, *E. serrulatus, M. viridis, T. prasinus, P. chiltoni, T. prasinus, A. crassa, N. stammeri,* and *P. viguieri* are reported by various researchers to live in a wide range of habitats such as caves, wells, groundwater systems, spring waters, ponds, rivers, backwaters, benthic zone of lakes, marshes and swamps (Morton & Bayly, 1977; Pesce & Maggi, 1981; Berzins & Bertilsson, 1990; Lehman & Reid, 1992; Karaytuğ, 1999; Dussart & Defaye, 2006; Lee & Chang, 2007; Tang & Knott, 2008; Galassi et al., 2011; Iepure et al., 2014; Bruno & Cottarelli, 2015; Iepure et al., 2016; Bozkurt, 2017). *T. dybowskii*, one of the copepod species recorded in the study, which was not reported from groundwater and wells, is in perennial ponds, coastal waters (occasional), pelagic zone of ponds and lakes, lives in small water bodies (Maier, 1990). It has also been reported by various researchers that *E. serrulatus* and *N. stammeri* are the most representative taxa in the wells (Iepure et al., 2016).

Some zooplankton species [*Ascomorpha ovalis* (Bergendahl, 1892), *Cephalodella catellina* (Müller, 1786), *C. gibba, C. ventripes* (Dixon-Nuttall, 1901), *Colurella adriatica* Ehrenberg, 1831, *C. colurus* (Ehrenberg, 1830), *C. uncinata*, *Dicranophorus epicharis* Harring & Myers, 1928, *Euchlanis dilatata* Ehrenberg, 1832, *Filinia longiseta* (Ehrenberg, 1834), *Heterolepadella ehrenbergi* (Perty, 1850), *Keratella cochlearis* (Gosse, 1851), *K. quadrata* (Müller, 1786), *K. tecta* (Gosse, 1851), *K. tropica* (Apstein, 1907), *Lecane bulla*, *L. closterocerca*, *L. flexilis, L. hamata, L. lunaris* (Ehrenberg, 1832), *L. pumila* (Rousselet, 1906), *L. tenuiseta*, *Lepadella acuminata* (Ehrenberg, 1834), *L. patella*, *Lophocharis salpina* (Ehrenberg, 1834), *Mytilina unguipes* (Lucks, 1912), *Platyias quadricornis* (Ehrenberg, 1832), *Synchaeta stylata* Wierzejski, 1893, *Testudinella elliptica* (Ehrenberg, 1834), *T. patina* (Hermann, 1783), *Trichocerca similis (*Wierzejski, 1893), *T. tigris* (Müller, 1786), *Trichotria tetractis* (Ehrenberg, 1830); *Alona guttata* Sars, 1862, *Bosmina longirostris* (Müller, 1785), *Ceriodaphnia pulchella* Sars, 1862, *C. reticulata* (Jurine, 1820), *Chydorus sphaericus* (Müller 1776), *Diaphanosoma birgei* Korinek, 1981, *Leydigia acanthocercoides* (Fischer, 1854), *Pleuroxus aduncus*, *Simocephalus vetulus* (Müller, 1776), *Acanthocyclops robustus* (Sars, 1863), *Attheyella crassa*, *Bryocamptus minutus* (Claus, 1863), *B.*

zschokkei (Schmeil, 1893), *Canthocamptus microstaphylinus* Wolf 1905, *Cyclops vicinus* Uljanin, 1875, *Diacyclops bisetosus* (Rehberg, 1880), *D. bicuspidatus* (Claus, 1857), *D. languidus* (Sars, 1863), *Eudiaptomus drieschi* (Poppe and Mrazek, 1895), *Macrocyclops albidus* (Jurine, 1820), *Megacyclops viridis, Nitocra hibernica* (Brady, 1880), *Nitocrella kosswigi* Noodt, 1954, *Paracyclops fimbriatus* (Fischer, 1853), *Speocyclops* sp., *Tropocyclops prasinus*] were previously reported from the water wells of Kuyubeli Village and Yayladağı District (Bozkurt, 2019; Bozkurt & Bozça, 2019). Species reported from other two water well studies and thought to have high groundwater adaptation potential include *C. gibba, C. uncinata, L. bulla, L. closterocerca, L. flexilis*, *L. hamata*, *L. tenuiseta*, *Lepadella patella*, *P. aduncus*, *M. viridis*, *T. prasinus* and *A. crassa* were recorded in this study.

As a result, the fact that most of the rotifer species reported in our study have only been recorded in small numbers in well waters in our country suggests that they can be recorded in a variety of settings. The fact that the copepod species are different in the well studies in all three regions in Turkey supports the idea that the groundwater has a greater diversity of copepod species, as documented in many studies. As a result, the ability of the zooplankton species studied to adjust to environmental conditions and their ecological valence can be stated to be high. Although their habitats are not groundwater, the species detected in our study's water well samples are thought to have infiltrated these wells via zooplankton dispersal processes (winds, water particles, birds, and insects).

Conflict of Interest

The author declares that no competing interests.

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