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Full Length Research Paper

Thirty-four new records and the diversity of the Rotifera in the Turkish part of the Tigris River watershed, with remarks on biogeographically interesting taxa

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A total of 175 morphospecies belonging to 47 genera of the monogonont Rotifera are reported here, representing the highest rotifer biodiversity recorded from any body of water in Turkey; 34 of these species are new records for the Turkish fauna. The genera *Donneria* De Smet*, Octotrocha* Thorpe and *Stephanoceros* Ehrenberg are recorded for the first time in Turkey. The eastern Oriental taxon *Brachionus murphyi* Sudzuki and the tropicopolitan *Trichocerca braziliensis* (Murray) are new records for both the Palearctic region and western Asia. Additionally, the Palearctic European species *Cephalodella cf. ungulata* Fischer and Ahlrichs and *Lecane margalefi* De Manuel are recorded for the first time in Asia and for the second time outside of their type localities. The Tigris River is the third locality reported for the distribution of *Donneria sudzukii* (Donner). All observed species were members of 23 families with the majority (72%) of the examined fauna belonging to the following families: Notommatidae (33 species) > Lecanidae (30 species) > Brachionidae (25 species) > Dicranophoridae (14 species) > Lepadellidae (13 species) > Trichocercidae (11 species). Littoral rotifers made a significant contribution to the overall species diversity observed. Due to the strategic geographic position of Turkey, it is important to conduct species inventories in different localities of the country to fill distributional gaps for many rotifer species. The rotiferan species richness found in the study region and the biogeographically interesting elements of this river are remarkable and are discussed here. Additionally, this report represents the most up-to-date review of Turkish rotifers.

Key words: Turkey, Tigris River, species composition, biodiversity, biogeography.

INTRODUCTION

The phylum ‘Rotifera’ exhibits a high degree of diversity and represents an important group of littoral and limnetic micro-invertebrates in aquatic environments; it also comprises an important component of the metazoan potamoplankton (Claps et al., 2009; Ferrari et al., 1989; Kobayashi et al., 1998; Lair, 1980; May and Bass, 1998; Sabri et al., 1993; Shiel et al., 1982; Thorp et al., 1994). In particular, benthic/littoral rotifers are among the most speciose taxa known to inhabit the sediment surface in running waters for long periods, thus contributing to planktonic diversity (Robertson et al., 2000; Shiel et al., 1982). Because of spatial habitat heterogeneity, lotic habitats support higher benthic species richness than lake habitats (Schmid-Araya, 1998). Turkey is a transcontinental Eurasian country. The Asian portion of Turkey (Anatolia), which includes 97% of the country is separated from the European region of Turkey (eastern Thrace or Rumelia in the Balkan Peninsula) by the Bosphorus, the Sea of Marmara, and the Dardanelles (which together form a waterway linking the Black Sea and the Mediterranean Sea). Anatolia (also known as Asia Minor) is a biologically diverse region, due mainly to its variable topography and climate, which provide many

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different macro- and micro-habitats. This region represents a bridge between Asia and Europe in the south and links to the Ethiopian region via the Arabian Peninsula, thus providing a natural pathway for both the north-south and east-west spread of species. Its tectonic evolution has exhibited continuous changes throughout the Tertiary and Quaternary periods, and it served as an important refugium during the Quaternary ice ages, receiving populations via the Balkans and/or the Caucasus. Anatolia and its mother continent, the Aegeid plate; providing connections with the European, Arabian, Iranian and Caucasian plates many times throughout the Tertiary period (especially during the Miocene); and providing many opportunities for faunal exchange (Çiplak, 2003; Dumont and Ridder, 1987; Erman et al., 2010). For all of these reasons, there have been many speciation events in Anatolia, and therefore, this region is characterised by rich biodiversity.

Due to the strategic geographic position of Turkey, it is important to conduct species inventories in different localities of the region to fill gaps in the known distributions of many species in Eurasia, particularly for the Turkish rotifers. The Rotifera have been partially documented from a wide variety of inland aquatic biotopes in Turkey in investigations that date back more than a century. In recent years, many new records have been given for Turkey (Altindağ et al., 2005; Bozkurt, 2006; Emir and Kaya, 2007; Kaya and Altindağ, 2009; Kaya et al., 2007, 2008). According to Ustaoğlu (2004) and Kaya and Altindağ (2010), 285 monogonont taxa are known from this country. Most recently, four new records, *Lecane thienemanni* (Hauer), *Encentrum felis* (Müller), *Mytilina unguipes* (Lucks) and *Cephalodella stenroosi* Wulfert have been added to the Turkish fauna (Bekleyen and Ipek, 2010; Bozkurt and Güven, 2010; Buyurgan et al., 2010; Kaya et al., 2010). However, information on the composition and distribution of rotifers in Turkey is still scarce, especially for the southeastern Anatolia Region (Mesopotamian Turkey). Moreover, our knowledge of the qualitative richness of rotifers in Turkish rivers is also confined to only a few lists (Akbulut and Yildiz, 2005; Altindağ et al., 2009; Balik et al., 1999; Bozkurt et al., 2002; Göksu et al., 1997; Ipek and Saler, 2008; Özbay and Altindağ, 2009; Ustaoğlu et al., 1996). The Tigris is one of the most important transboundary rivers in western Asia and originates in the Toros mountains of Turkey. The Tigris basin is associated with a rich avifauna because it is located in the path of an important flyway for migrant species, including raptors (Karakaş, 2010; Kiliç and Eken, 2004). However, no record for Rotifera has thus far been reported for the main stretch of the river within the borders of Turkey. In fact, the aquatic faunal diversity of the river is poorly known, except for its fish. Therefore, we conducted an investigation of the Rotifera diversity of the Tigris River basin with special reference to the composition of the taxocoenosis and biogeographically interesting elements through regular monitoring of the river during a period of one year at seven different sites spread over a stretch of the river of approximately 500 km. In this report, we present the most up-to-date review of the Rotifera in Turkey.

MATERIALS AND METHODS

Monitoring area

The portion of the Tigris River flowing through southeastern Anatolia represents one of the largest rivers in Turkey with a catchment area of approximately 57,614 km^2 (Akbulut et al., 2009). The river originates in the Toros mountains of Turkey and follows a south-eastern route in Turkey to Cizre, where it forms the border between Turkey and Syria for 32 km before entering Iraq. The total length of the river is approximately 1900 km of which 523 km is within Turkey. The Batman, Garzan, Botan and Hezil rivers are its major tributaries in Turkey. Currently, there are two major dams under operation on the Tigris River in this country: the Kralkizi and the Dicle. The Kralkizi Dam is used for hydro-electric energy production, and the Dicle Dam is used for hydro-electric energy production, irrigation and supplying drinking water for the city of Diyarbakir. Diyarbakir, Bismil, Hasankeyf and Cizre are the four major urban settlements on the banks of the river. The river serves as a major source of the domestic water supply of the city of Diyarbakir (population of approximately 851,000) as well as directly receiving the partially treated domestic wastewater from Diyarbakir; the untreated domestic wastewater from the Bismil, Hasankeyf and Cizre townships; and effluents from several industries along its course. The maximum flows in the river occur from February through April, whereas the minimum flows occur from August through October. The river discharge varies considerably at different locations, showing an increasing trend towards its downstream stretches due to inputs from its tributaries. In Diyarbakir (upstream region of the river), the highest mean monthly flow during the study period was 72 m^3/sn, in February, 2008, whereas the lowest mean monthly flow was 7.72 m^3/sn, in September, 2008. In Cizre (downstream region of the river), the highest mean monthly flow was 487 m^3/sn, in April, 2008, whereas the lowest mean monthly flow was 79.2 m^3/sn, in August, 2008. The annual mean flows of the river in Diyarbakir and Cizre were calculated to be 28.3 and 211.8 m^3/sn, respectively (Anonymous, 2009a). The continental climate of the Tigris Basin is referred to as a subtropical plateau climate.

The continental climate features of the basin are most similar to those of Mediterranean region. The summer season is hot and dry, and the winter season is not as cold as in the eastern Anatolia region (Anonymous, 2007). The annual total rainfall during the study period exhibited a decreasing trend towards the downstream stretches of the river, whereas the air temperature showed an increasing trend towards the downstream region. The highest annual total rainfall value was recorded as 611.1 mm, in Maden (upstream region of the river), and the lowest annual total rainfall value was found to be 294.1 mm, in Cizre (downstream region of the river). The mean annual air temperature ranged between 14.6°C (Maden) and 21.8°C (Cizre) (Anonymous, 2009b). The Tigris River has the highest water temperature of all of the eastern Anatolian rivers (Akbulut et al., 2009). The locations of the selected sampling sites in the Tigris River are shown in Figure 1. In the present study, a total of seven sites, specifically, Maden "Site–1", Hantepe "Site–2", Diyarbakir "Site–3", Bismil "Site–4", Batman "Site–5", Hasankeyf "Site–6" and Cizre "Site–7" were selected on the Tigris River as part of a river monitoring network and two of these sites, Hantepe and Batman are situated downstream of the Dicle and Batman dam reservoirs, respectively. The sampling sites were located from 371 to 860 m a.s.l. between latitude 37° 19' to

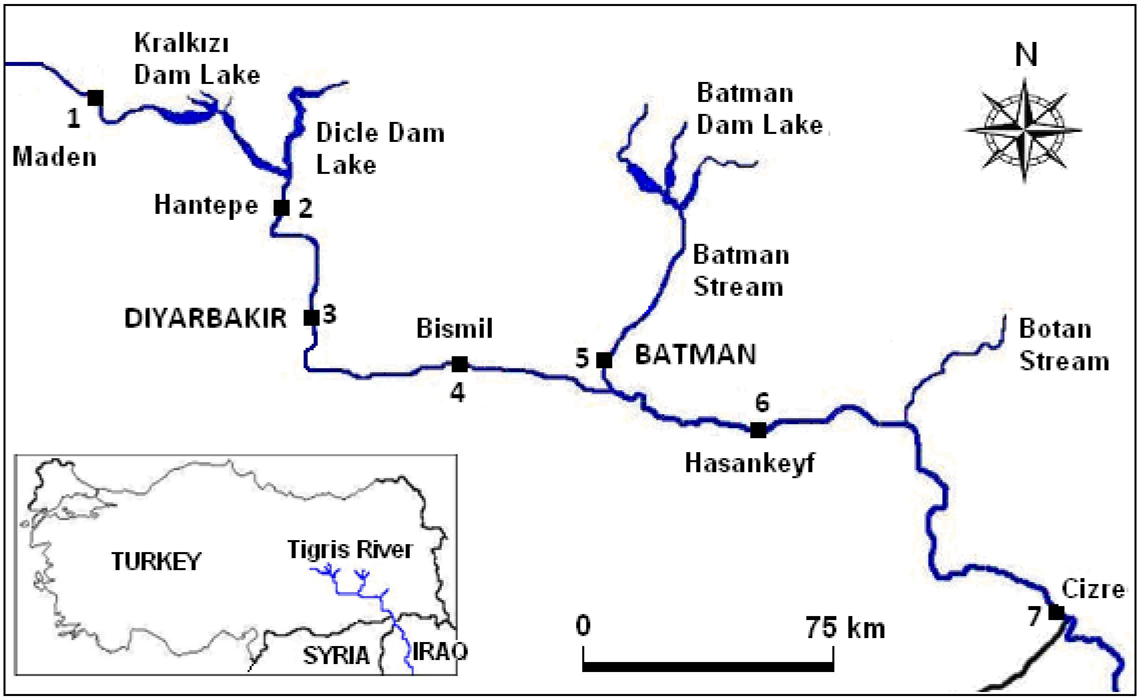


Figure 1. Map showing location of sampling sites in the Tigris River.

38° 20' N and longitude 39° 41' to 42° 11' E.

Collection and identification of samples

A total of eighty-four qualitative plankton samples were collected within the period from February 2008 to January 2009 from the littoral and limnetic zones of the study sites which were spread over a river stretch of approximately 500 km. Samples were collected with a 55-µm mesh plankton net, and they were immediately preserved in a 4% formaldehyde solution. Samples were taken mainly from stagnant or slow-running, vegetation-rich areas of the river basin. Specimens were examined and identified under an Olympus-BX51 compound microscope at magnifications of 40 to 1000 X. Images were collected with Olympus DP71 digital camera (12.5 megapixels) using Image Analysis Pro 5.0 software (Olympus Soft Imaging Solutions GmbH, Germany). Preparation of rotifer trophi was carried out following the method described by De Smet (1998). We calculated species richness as the total number of species found at each site over a one-year period. Rotifer identification was based on the revisions of De Smet (1996), De Smet and Pourriot (1997), Koste (1978), Nogrady et al. (1995) and Segers (1995). Subsequently, the annotated checklist of the rotifers (Segers, 2007) was also consulted and several other publications concerning rotifer taxonomy and descriptions of new species were also checked. The physical and chemical parameters of the study sites (temperature, pH and conductivity) were measured directly in the field with a portable multimeter (Hach HQ 40d).

RESULTS

A total of 175 rotifer species belonging to 47 genera and 23 families of monogonont rotifers were identified in the Tigris River (Table 1). The present rotifer fauna, comprising approximately 48% of the Turkish Rotifera reflects the highest species, generic and family richness recorded to date from any body of water in this country. However, this total is incomplete as many unidentifiable taxa were encountered. Bdelloid rotifers were also found in almost all samples, but they were not identified. The identified species belonged to 23 families. Among these families, the majority (72%) of the examined fauna belonged to the Notommatidae (33 species) > Lecanidae (30 species) > Brachionidae (25 species) > Dicranophoridae (14 species) > Lepadellidae (13 species) > Trichocercidae (11 species). Of these, the Brachionidae and Notommatidae were represented with 7 genera followed by the Dicranophoridae (five genera) and Lepadellidae (three genera). The most diverse genus was *Lecane* (30 species), followed by *Cephalodella* (17 species), *Brachionus* (15 species), *Trichocerca* (11 species), *Lepadella* (9 species) and *Notommata* (8 species). A total of three genera, *Donneria, Octotrocha* and *Stephanoceros,* and 34 species in our samples represent new records for the Turkish rotifer fauna. Some of the new records for Turkey are particularly noteworthy:

Brachionidae Ehrenberg

A total of 25 taxa belonging to 7 genera were recorded.

Brachionus bennini, *B. durgae*, *B. murphyi, B. nilsoni* and *B. sericus* are new to Turkey (Figure 2). *B. murphyi*

Table 1. List of rotifer species recorded from the Tigris River basin; sampling sites: 1. Maden, 2. Hantepe, 3. Diyarbakir, 4. Bismil, 5. Batman, 6. Hasankeyf, 7. Cizre, asterisk (*): new recorded species for Turkey.

Species	**Sampling sites**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Anuraeopsis fissa (Gosse, 1851)	-	-	-	+	-	-	-
Ascomorpha ecaudis (Perty, 1850)	+	+	+	+	+	+	-
Ascomorpha ovalis (Bergendal, 1892)	-	+	+	+	+	+	+
Ascomorpha saltans (Bartsch, 1870)	-	+	-	-	+	-	-
**Aspelta angusta* (Harring and Myers, 1928)	-	-	+	-	+	+	-
Aspelta aper (Harring, 1913)	-	-	+	-	-	-	-
**Aspelta curvidactyla* (Berzins, 1949)	+	+	-	-	-	+	+
**Aspelta psitta* (Harring and Myers, 1928)	-	+	-	-	-	-	-
Asplanchna brightwellii (Gosse, 1850)	-	-	-	+	-	+	-
Asplanchna priodonta (Gosse, 1850)	-	+	+	+	+	+	+
Asplanchnopus hyalinus (Harring, 1913)	-	-	-	+	-	-	-
Brachionus angularis (Gosse, 1851)	-	-	+	+	+	+	+
**Brachionus bennini* (Leissling, 1924)	-	-		+			+
Brachionus bidentatus (Anderson, 1889)	-	-	+	+	+	+	+
Brachionus budapestinensis (Daday, 1885)	-	-	-	+		+	+
Brachionus calyciflorus (Pallas, 1766)	-	+	+	+	+	+	+
Brachionus diversicornis (Daday, 1883)	-	-	-	-	-	-	+
**Brachionus durgae* (Dhanapathi, 1974)	-	-	+	+	-	+	+
Brachionus falcatus (Zacharias, 1898)	-	-	-	-	-	-	+
Brachionus leydigi (Cohn, 1862)	-	-	-	+	-	-	-
**Brachionus murphyi* (Sudzuki, 1989)	-	-	-	+	-	-	-
**Brachionus nilsoni* (Ahlstrom, 1940)	-	-	-	-	-	+	+
Brachionus quadridentatus (Hermann, 1783)	-	+	+	+	+	+	+
Brachionus rubens (Ehrenberg, 1838)	-	-	-	+	-	+	+
**Brachionus sericus* (Rousselet, 1907)	-	-	-	+	-	+	-
Brachionus urceolaris (Müller, 1773)	-	-	-	+	-	+	+
Cephalodella auriculata (Müller,1773)	-	-	-	-	-	-	+
Cephalodella catellina (Müller,1786)	+	+	+	+	+	+	+
**Cephalodella forficata* (Ehrenberg, 1832)	-	+	+	+	+	+	+
Cephalodella forficula (Ehrenberg, 1830)	+	+	+	+	+	+	+
Cephalodella gibba (Ehrenberg, 1830)	+	+	+	+	+	+	+
**Cephalodella gigantea* (Remane, 1933)	-	-	-	+	-	-	-
**Cephalodella hoodii* (Gosse,1886)	-	+	+	+	+	+	-
Cephalodella megalocephala (Glasscott, 1893)	+	+	+	+	+	+	+
Cephalodella misgurnus (Wulfert, 1937)	+	-	-	-	-	-	-
**Cephalodella obvia* (Donner, 1950)	-	-	-	+	-	+	-
Cephalodella stenroosi (Wulfert, 1937)	-	-	-	-	-	+	+
Cephalodella sterea (Gosse, 1887)	-	-	-	+	-	+	-
Cephalodella tenuiseta (Burn, 1890)	-	-	+	+	+	-	-
**Cephalodella theodora* (Koch-Althaus, 1961)	+	-	-	-	-	-	+
**Cephalodella tinca* (Wulfert, 1937)	-	-	+	+	-	+	-
**Cephalodella cf. ungulata* (Fischer and Ahlrichs, 2006)	-	+	-	+	+	+	-
Cephalodella ventripes (Dixon-Nuttall, 1901)	-	+	+	+	-	+	+
Collotheca mutabilis (Hudson, 1885)	-	+	-	-	+	+	-
Collotheca ornata (Ehrenberg, 1832)	-	-	-	-	-	-	+
Colurella adriatica (Ehrenberg, 1831)	+	+	+	+	+	+	+
Colurella colurus (Ehrenberg, 1830)	+	+	+	+	+	+	+
Colurella uncinata (Müller, 1773)	+	+	+	+	+	+	+
Conochilus unicornis (Rousselet, 1892)	-	+	+	-	+	+	-

Table 1. Contnd

Dicranophoroides caudatus (Ehrenberg, 1834)	-	-	-	+	+	+	-
**Dicranophorus aspondus* (Harring and Myers, 1928)	-	-	+	+	-	+	+
Dicranophorus epicharis (Harring and Myers, 1928)	-	+	+	+	+	+	+
Dicranophorus forcipatus (Müller,1786)	+	+	+	+	+	-	+
Dicranophorus luetkeni (Bergendal, 1892)	-	+	-	-	-	-	-
**Donneria sudzukii* (Donner, 1968)	-	-	+	-	+	+	-
**Encentrum martes* (Wulfert, 1939)	+	-	-	-	-	-	+
Encentrum putorius (Wulfert, 1936)	-	+	+	+	+	+	+
Encentrum saundersiae (Hudson, 1885)	-	-	-	+	+	+	+
Encentrum uncinatum (Milne, 1886)	-	-	+	+	-	+	+
Eosphora ehrenbergi (Weber and Montet, 1918)	-	-	-	+	-	+	-
Eosphora thoides (Wulfert, 1935)	-	+	+	+	+	+	-
Epiphanes brachionus (Ehrenberg, 1837)	-	-	-	+	-	+	+
Epiphanes macroura (Barrois and Daday, 1894)	-	-	-	+	-	-	+
Epiphanes senta (Müller, 1773)	-	-	-	+	-	-	+
Euchlanis deflexa (Gosse, 1851)	+	+	+	+	+	+	+
Euchlanis dilatata (Ehrenberg, 1832)	+	+	+	+	+	+	+
Euchlanis incisa (Carlin, 1939)	-	+	+	+	+	-	-
Euchlanis lyra (Hudson, 1886)	+	+	+	+	+	+	-
Filinia branchiata (Rousselet, 1901)	-	-	-	+	-	-	-
Filinia longiseta (Ehrenberg, 1834)	+	+	+	+	+	+	+
Filinia opoliensis (Zacharias, 1898)	-	-	-	-	+	-	-
Filinia terminalis (Plate, 1886)	+	+	+	+	+	+	+
Gastropus stylifer (Imhof,1891)	-	+	+	+	-	+	-
Hexarthra fennica (Levander, 1892)	-	-	-	+	+	-	-
Hexarthra intermedia (Wszniewski, 1929)	-	-	-	+	-	+	-
Itura aurita (Ehrenberg, 1830)	-	-	-	+	+	+	-
Kellicottia longispina (Kellicott, 1879)	-	+	+	+	-	-	+
Keratella cochlearis (Gosse, 1851)	+	+	+	+	+	+	+
Keratella quadrata (Müller, 1786)	-	+	+	+	-	+	-
Keratella tecta (Gosse, 1851)	-	+	+	+	-	+	+
Keratella tropica (Apstein, 1907)	-	-	+	+	+	+	+
Keratella valga (Ehrenberg, 1834)	-	-	+	+	+	-	+
Lecane aculeata (Jakubski,1912)	-	-	-	-	+	-	-
Lecane arcuata (Bryce, 1891)	-	+	-	-	-	+	-
**Lecane aspasia* (Myers, 1917)	-	-	-	+	-	-	-
Lecane bifastigata (Hauer, 1938)	-	-	-	+	-	-	-
Lecane bulla (Gosse, 1851)	+	+	+	+	+	+	+
Lecane closterocerca (Schmarda, 1859)	+	+	+	+	+	+	+
Lecane cornuta (Müller, 1786)	-	-	-	-	-	+	-
**Lecane decipiens* (Murray, 1913)	-	-	-	+	+	+	-
Lecane flexilis (Gosse, 1886)	+	+	+	-	+	+	+
Lecane furcata (Murray, 1913)	-	+	-	+	-	+	+
Lecane hamata (Stokes, 1896)	+	+	+	+	+	+	+
Lecane hastata (Murray, 1913)	-	+	-	+	+	+	+
Lecane hornemanni (Ehrenberg, 1834)	-	-	-	-	+	-	-
Lecane inopinata (Harring and Myers, 1926)	-	-	-	+	+	+	+
**Lecane ivli* (Wiszniewski,1935)	-	-	-	-	-	-	+
Lecane leontina (Turner, 1892)	-	-	-	-	+	-	-
Lecane ludwigii (Eckstein, 1883)	-	-	-	+	-	-	-
Lecane luna (Müller, 1776)	+	+	+	+	+	+	+
Lecane lunaris (Ehrenberg, 1832)	+	+	+	+	+	+	+

Table 1. Contnd

**Lecane margalefi* (De Manuel, 1994)	-	-	+	+	-	-	-
Lecane nana (Murray, 1913)	-	+	-	-	-	-	-
Lecane papuana (Murray, 1913)	-	+	+	+	+	+	+
Lecane pyriformis (Daday, 1905)	-	-	-	-	-	-	+
Lecane quadridentata (Ehrenberg, 1830)	-	-	+	+	-	+	+
Lecane scutata (Harring and Myers, 1926)	-	-	+	+	+	+	+
Lecane shieli (Segers and Sanoamuang, 1994)	-	-	-	-	-	+	+
Lecane stenroosi (Meissner, 1908)	-	+	+	+	+	+	-
Lecane stichaea (Harring, 1913)	-	+	-	-	-	-	+
Lecane tenuiseta (Harring, 1914)	-	-	-	+	-	-	-
Lecane thienemanni (Hauer, 1938)	-	-	+	+	+	+	+
Lepadella acuminata (Ehrenberg, 1834)	+	+	+	+	+	+	+
Lepadella costata (Wulfert, 1940)	-	-	+	+	-	+	-
Lepadella ehrenbergii (Perty, 1850)	-	-	-	-	+	+	-
**Lepadella latusinus* (Hilgendorf, 1899)	-	+	-	+	-	+	+
Lepadella ovalis (Müller, 1786)	-	+	-	+	+	-	-
Lepadella patella (Müller, 1773)	+	+	+	+	+	+	+
Lepadella quadricarinata (Stenroos, 1898)	+	+	+	+	+	+	+
Lepadella quinquecostata (Lucks, 1912)	-	-	-	-	+	+	-
Lepadella rhomboides (Gosse, 1886)	-	-	+	+	+	+	+
Lindia torulosa (Dujardin, 1841)	+	+	+	+	+	+	+
Lophocharis salpina (Ehrenberg, 1834)	-	+	+	+	+	+	+
Monommata arndti (Remane, 1933)	+	+	-	+	+	+	-
Mytilina bisulcata (Lucks, 1912)	-	+	-	+	-	-	-
Mytilina unguipes (Lucks, 1912)	-	+	-	+	-	-	-
Mytilina ventralis (Ehrenberg, 1830)	-	+	-	+	+	+	-
Notholca squamula (Müller, 1786)	+	-	+	+	-	+	+
**Notommata aurita* (Müller,1786)	+	-	-	-	+	-	-
**Notommata codonella* (Harring and Myers, 1924)	+	-	-	-	-	-	+
Notommata copeus (Ehrenberg, 1834)	-	+	-	-	+	-	-
Notommata cyrtopus (Gosse, 1886)	-	-	+	+	+	-	-
Notommata glyphura (Wulfert, 1935)	-	+	-	+	+	+	-
**Notommata pachyura* (Gosse,1886)	-	-	-	-	+	+	-
**Notommata pseudocerberus* (Beauchamp,1908)	-	+	-	+	+	+	+
Notommata tripus (Ehrenberg, 1838)	-	+	-	-	-	-	-
**Octotrocha speciosa* (Thorpe, 1893)	-	-	-	+	+	-	+
Plationus patulus (Müller, 1786)	-	-	-	+	-	-	-
Platyias quadricornis (Ehrenberg, 1832)	-	+	+	+	+	+	-
Pleurotrocha petromyzon (Ehrenberg, 1830)	-	+	+	+	+	+	+
* *Pleurotrocha sigmoidea* (Skorikov, 1896)	-	-	+	+	-	-	-
Polyarthra dolichoptera (Idelson, 1925)	+	+	+	+	+	+	+
Polyarthra vulgaris (Carlin, 1943)	+	+	+	+	+	+	+
Pompholyx complanata (Gosse, 1851)	-	+	-	+	-	+	-
Pompholyx sulcata (Hudson, 1885)	-	+	+	-	-	+	-
Proales fallaciosa (Wulfert, 1937)	-	+	-	-	-	-	-
Proales theodora (Gosse, 1887)	+	+	+	+	+	+	+
**Resticula melandocus* (Gosse, 1887)	-	+	-	+	+	+	+
Resticula nyssa (Harring and Myers, 1924)	-	+	+	-	+	-	-
Scaridium longicaudum (Müller,1786)	+	+	+	+	+	+	+
Squatinella rostrum (Schmarda, 1846)	-	-	-	-	+	-	-
**Stephanoceros fimbriatus* (Goldfusz, 1820)	-	+	+	+	-	-	-
**Synchaeta kitina* (Rousselet, 1902)	-	+	-	-	-	+	-

Table 1. Contnd

Synchaeta oblonga (Ehrenberg, 1832)	+	+	+	+	+	+	+
Synchaeta pectinata (Ehrenberg, 1832)	-	+	+	+	+	+	+
Synchaeta stylata (Wierzejski,1893)	-	+	+	+	+	+	+
Taphrocampa selenura (Gosse, 1887)	+	-	+	+	+	+	+
Testudinella patina (Hermann, 1783)	+	+	+	+	+	+	+
**Trichocerca bicristata* (Gosse, 1887)	-	+	+	+	-	-	-
**Trichocerca braziliensis* (Murray, 1913)	-	-	-	+	+	+	-
Trichocerca capucina (Wierzejski and Zacharias,1893)	-	+	+	+	-	-	-
Trichocerca longiseta (Schrank, 1802)	-	+	+	-	-	-	-
Trichocerca porcellus (Gosse, 1851)	-	+	-	-	-	-	-
Trichocerca pusilla (Jennings, 1903)	-	-	+	+	-	-	+
Trichocerca rattus (Müller,1776)	-	+	+	+	-	+	-
Trichocerca similis (Wierzejski, 1893)	-	+	+	+	+	+	-
Trichocerca taurocephala (Hauer, 1931)	+	+	-	-	+	-	-
Trichocerca tenuior (Gosse,1886)	+	+	-	+	-	-	-
Trichocerca tigris (Müller,1786)	-	-	-	-	+	-	-
Trichotria curta (Skorikov, 1914)	-	-	-	-	-	-	+
Trichotria pocillum (Müller, 1776)	+	+	+	+	+	-	-
Trichotria tetractis (Ehrenberg, 1830)	+	+	+	+	+	+	+
Tripleuchlanis plicata (Levander, 1894)	-	+	+	+	-	-	-
Wolga spinifera (Western, 1894)	-	-	+	+	+	+	+
Wulfertia kivuensis (De Smet, 1992)	-	-	-	-	-	+	-
Total: 175	44	93	89	127	95	110	90

(Sudzuki, 1989), which is known as an eastern Oriental taxon (Segers, 2001) is new to both the Palearctic region and western Asia.

Brachionus durgae **Dhanapathi (1974)**

The material collected in the present study is closely related to specimens from India (Dhanapathi, 1974; original description) and Japan (Sudzuki, 1992; as *B. isigakiensis,* = syn.) in the characteristics of the anterior dorsal and ventral margin such as the anterior dorsal margin having a V-shaped sinus and six spines of nearly equal length and the presence of a ventral margin with a short medium sinus and four projections that are rounded at their edges (Figure 2). However, our specimens differ from the Indian specimens in the characteristics of the foot opening and the ventral posterior end of the lorica, as our specimens exhibit a foot opening with a small V-shaped ventral aperture and a peculiar posterior spatulate projection of the lorica, which are characteristics that are observed only in specimens from Japan, Argentina (Kuczynski, 1991; *B. moronensis,*= syn.), Venezuela (Vasquez and Koste, 1988; sub *B. variabilis*), Africa (Segers et al., 1994), SE-China (Xu et al., 1997; as *B. anchorporus*, = syn.). Segers et al. (1994), in a redescription of this species, furthermore describe this projection as soft rounded lobe. It is likely that our specimens are another variant of *B. durgae.* It is evident that *B. durgae* deserves further detailed study to analyse the limits of its intraspecific variability. During the sampling period, except in winter, this species was found at Sites 3, 4, 6 and 7. It was found over a temperature range of 6 to 26°C, a pH range of 6.8 to 8.3 and conductivities of 337 to 568 μS cm^{-1}.

Dimensions (µm)

Total length, 243 to 262; maximum width, 176 to 197; anterior median spines, 14 to 18; anterior lateral spines, 9 to 10; width of the posterior dorsal projection 29 to 43.

Lecanidae Remane (1933)

A total of 30 taxa were recorded for this group. The pantropical *L. decipiens*; cosmopolitan *Lecane aspasia;* arctic-temperate *L. ivli* and *L. margalefi* are new records for Turkey (Figure 2). The Palearctic species *L. ivli* is known from Macedonia, Hungary, Poland (Segers, 1995) and Italy (Rossetti et al., 2009) in Europe. According to Segers (1996), *L. ivli* populations are centred in the Balkan region. With the present record, its range extends beyond the classical limits of this region.

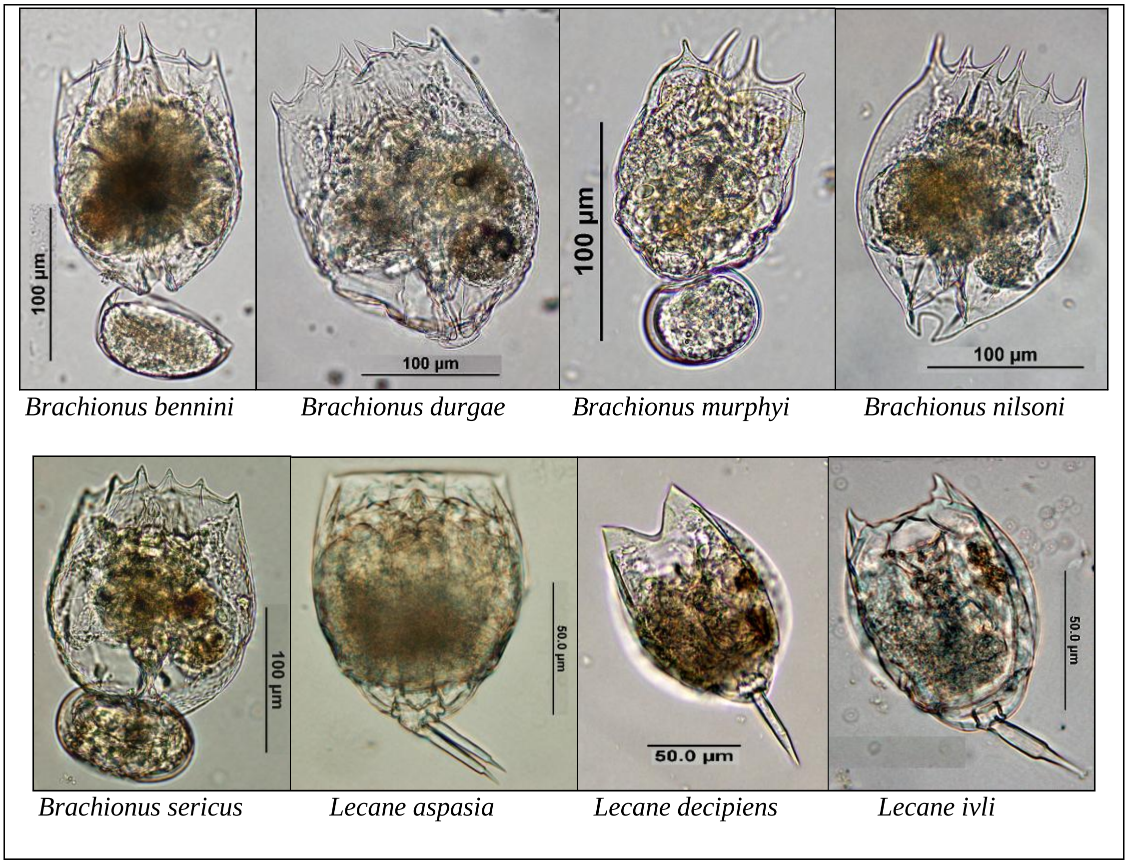


Figure 2. Rotifers representing new records for Turkey from Brachionidae and Lecanidae.

Lecane cf. margalefi De Manuel (1994)

This species was first described in Mallorca (Spain) in the western Mediterranean Sea and never recorded elsewhere subsequently. Thus, it is considered to be endemic to Mallorca in the annotated checklist compiled by Segers (2007). The present record is only the second for this illoricate lecanid and it is the first from Asia. It is characterised by a transparent and almost cylindrical body with irregular outlines of the integument, by the shape of its lorica being variable in length and by long, parallel-sided toes bearing distinct pseudoclaws and accessory claws. The original description by De Manuel lacks trophi details (De Manuel, 1994). The trophi morphology of the Turkish specimens was as follows: trophi modified malleate (Figure 3); fulcrum short and squarish in oblique view, distally extended fan-shaped in lateral view; rami asymmetrical, only right ramus with an alulus; unci weakly asymmetrical, right stronger than left, consisting of fused plates with one large and two unequal much smaller teeth; manubria elongate and distally curved. In the Tigris River, this species was found in April and August at Sites 4 and 3, respectively. It occurred over a temperature range of 19 to 21°C, a pH range of 7.8 to 8.2 and conductivities of 364 to 438 μS cm^{-1}.

Dimensions (µm)

Total length (without toes), 164 to 220; maximum width, 102 to 143; width of the animal in lateral view, 94 to 132; toe length, 55 to 79; claw length, 7 to 10; fulcrum length, 8 to 10; manubrium length, 24 to 26.

Dicranophoridae Harring (1913)

Fifteen species belonging to five genera were identified in this group; seven of these taxa, *Aspelta angusta, A. curvidactyla, A. psitta, Dicranophorus aspondus, Donneria sudzukii,* and *Encentrum martes* represent new records for Turkey (Figure 4). Five of these taxa are also new records for continental Asia. Most recently, other two

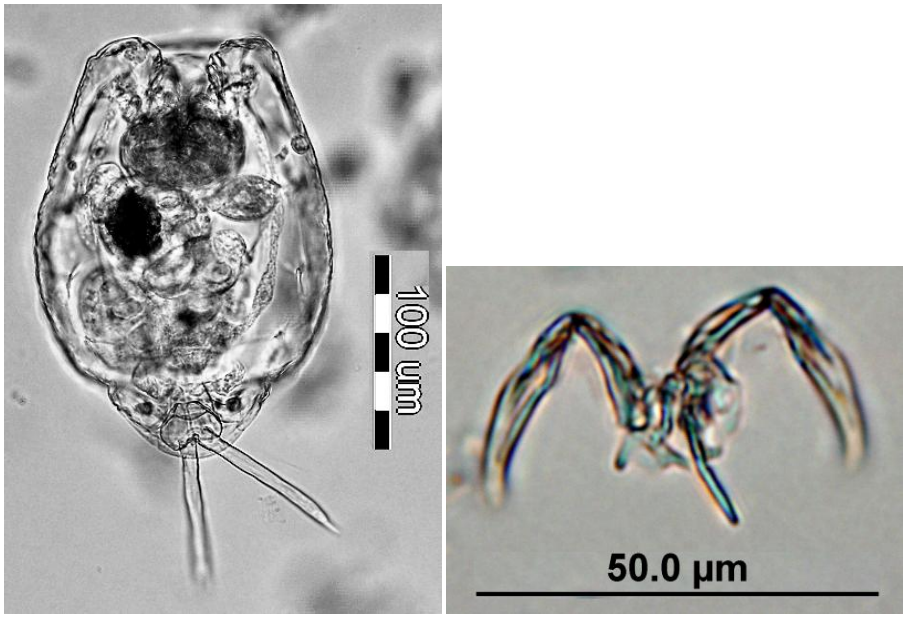


Figure 3. Lecane margalefi; a female and its trophus.

taxa *A. curvidactyla* and *E. martes* have been reported by Jersabek and Bolortsetseg (2010) for Mongolia.

Donneria sudzukii Donner (1968)

This species was originally described as *Paradicranophorus sudzukii* by Donner (1968) from the benthos of Neusiedler See, Austria. De Smet (2003) re-described it from psammon of the Colorado River, U.S.A. as having characteristic features of the preuncinal teeth, intramallei, supramanubria, manubria and unci using scanning electron microscopy and assigned *P. sudzukii* to the new genus *Donneria* on the basis of the notable differences in its trophi. The Tigris River in Turkey now represents the third locality in distribution of this rare species. The Turkish specimens conform quite well to the description of De Smet: body fusiform, foot placed ventrally, roundish-depressed rami outline, partially fused intramallei and manubria with a common opening, supramanubria composed of two sclerite elements that can also be seen in the LM (Figure 5). The present species was found from July to September at Sites 3, 5 and 6. It occurs over a temperature range of 21 to 25°C, a pH range of 8.1 to 8.5, and conductivities of 337 to 474 $\mu S\ cm^{-1}$.

Dimensions (µm)

Total length (slightly contracted), 172 to 208; toe, 24 to 30; trophi, 27 to 32; ramus, 9 to 11; fulcrum, 7 to 9; uncus, 8 to 12; subuncus, 6.6 to 7; intramalleus, 4.5 to 5.5; manubrium, 18 to 20. Parthenogenetic egg length, 53 to 60; width, 42 to 44.

Notommatidae Hudson and Gosse (1886)

A total of 33 taxa belonging to 7 genera were recorded. The genera *Cephalodella* and *Notommata* were represented by 18 and 7 species, respectively. Of these, 13 taxa are new records for Turkey and continental Asia (Figure 6). Of these taxa, *Pleurotrocha sigmoidea* is of taxonomically importance. Recently, *Proales sigmoidea* (Proalidae) has been reassigned to genus *Pleurotrocha* Ehrenberg by Wilts et al. (2009).

Cephalodella cf. ungulata Fischer and Ahlrichs (2006)

This species was recently described from a ditch near Leer in northwest Germany. To date, it has not been recorded elsewhere. Thus, the occurrence of this species in the Tigris River represents the second record from outside its type locality. The general morphology of the Turkish specimens is in agreement with the description given by Fischer and Ahlrichs: slightly laterally compressed body with hyaline soft lorica, short dorsally bent toes bearing claws approximately 1/5 of their total length, head and foot relatively long in comparison to trunk, double-keeled tail nearly covers foot, trophi type D with asymmetrical unci with two uncinal teeth. However, in our specimens, the toes are relatively thicker and the fulcrum is without a basal apophysis (Figure 7). It is likely that the Turkish specimens may be an intraspecific variant of the species, which deserves further detailed study. We found this species from July to December at Site 4 (Bismil) and only in November along the river at Sites 2, 4, 5 and 7. It occurs over a temperature range of

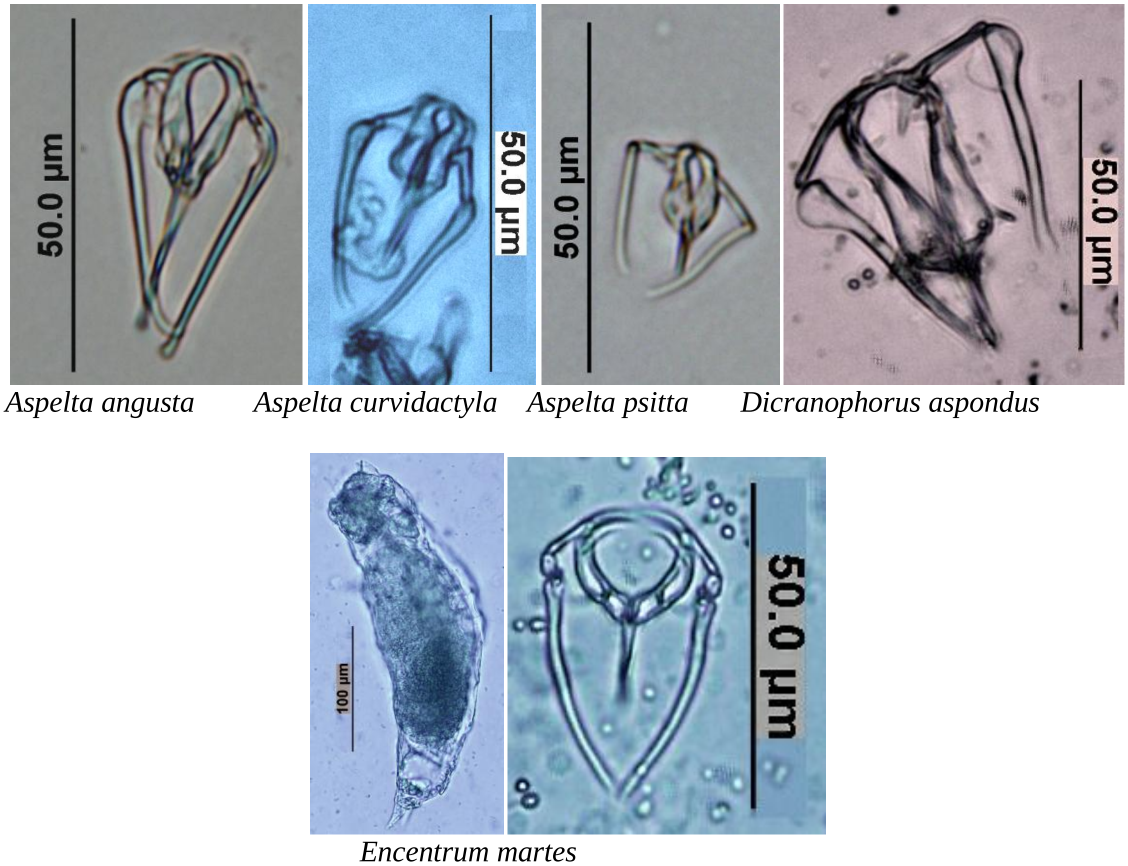


Figure 4. Rotifers representing new records for Turkey from Dicranophoridae

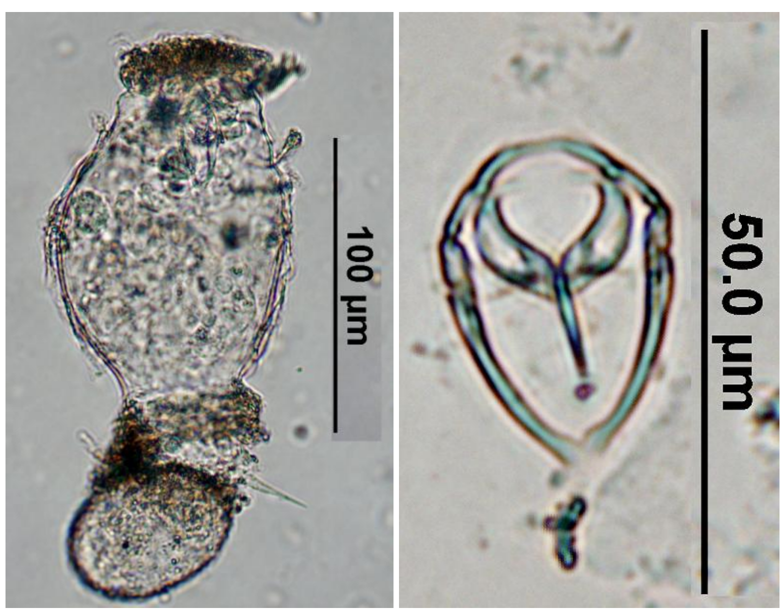
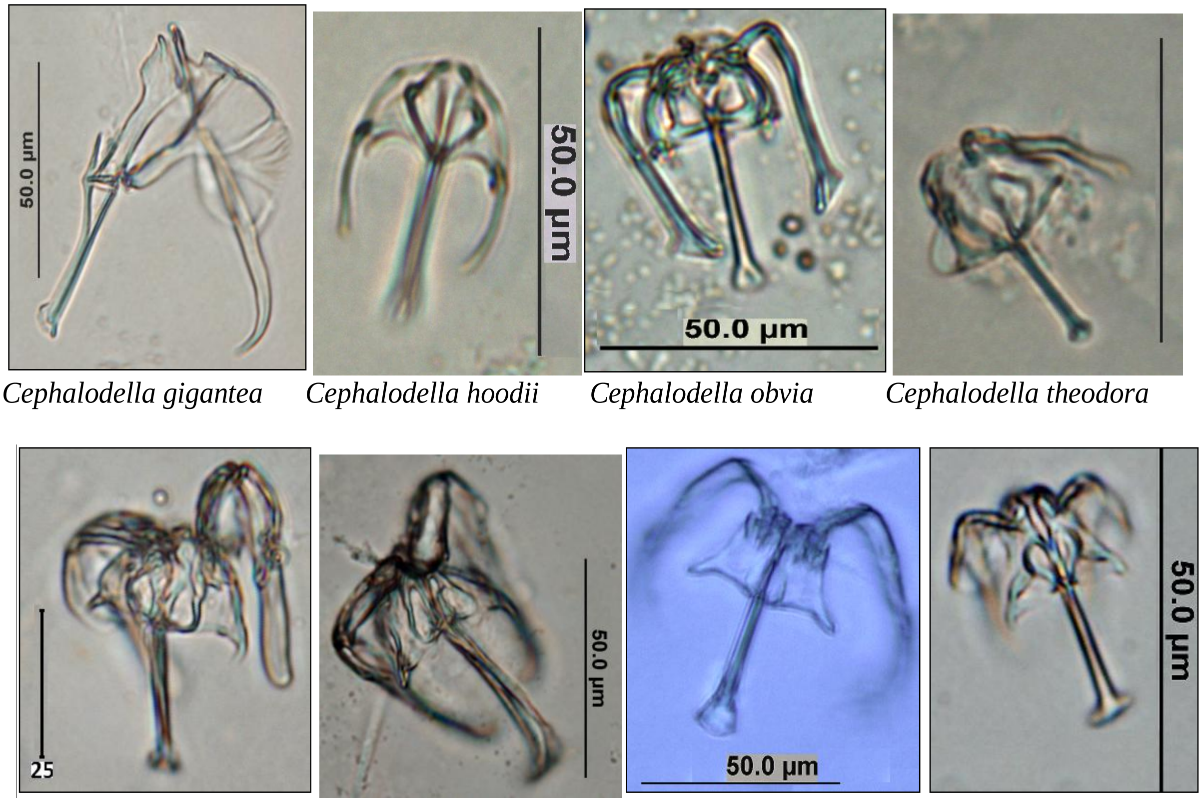


Figure 5. Donneria sudzukii; a female and its trophus.

5 to 24°C, a pH range of 7.5 to 8.2 and conductivities of 340 to 574 μS cm^{-1}.



Cephalodella gigantea *Cephalodella hoodii* *Cephalodella obvia* *Cephalodella theodora*

Notommata codonella *Notommata pachyura* *Pleurotrocha sigmoidea* *Resticula melandocus*

Figure 6. Various rotifers representing new records for Turkey from Notommatidae.

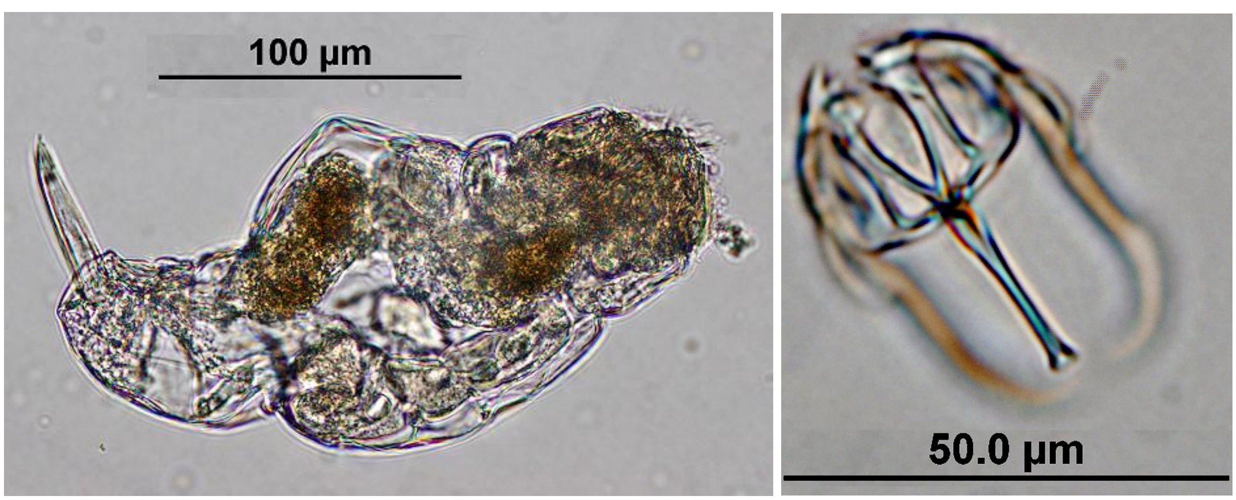


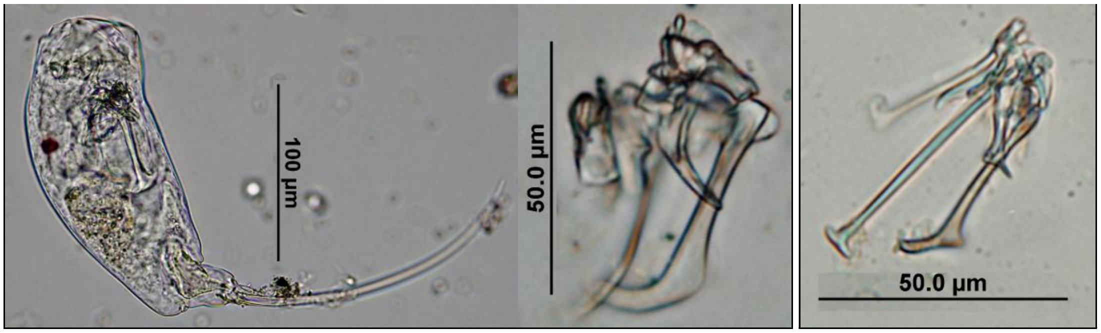
Figure 7. Cephalodella cf. ungulata; a female and its trophus.

Dimensions (µm)

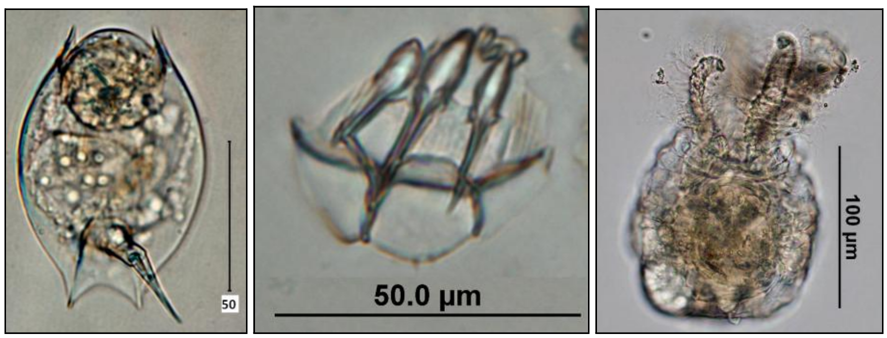
Total length, 246 to 292; toe, 47 to 56; trophi, 43 to 45; manubria, 34 to 37; fulcrum, 17 to 22.

Trichocercidae Harring (1913)

We recorded 11 taxa in this group. Of these, *Trichocerca bicristata* and *Trichocerca braziliensis* are new to Turkey.



Trichocerca bicristata and its trophus without fulcrum *Trichocerca braziliensis*



Lepadella latusinus *Octotrocha speciosa* *Stephanoceros fimbriatus*

Figure 8. Various rotifers representing new records for Turkey from other families.

Additionally, the tropicopolitan *T. braziliensis* is new to both the Palearctic region and western Asia. Images of the trophi of these species (without the fulcrum for *T. bicristata*) are presented in Figure 8.

Other families

New records for the Turkish fauna from other families include the following: *Lepadella latusinus* (Lepadellidae), *Synchaeta kitina* (Synchaetidae), *Octotrocha speciosa* (Flosculariidae) and *Stephanoceros fimbriatus* (Collothecidae) (Figure 8).

DISCUSSION AND CONCLUSION

Segers et al. (1993) hypothesised that (sub) tropical floodplains are the world's richest habitats for rotifers. The present report from seven sites of the Tigris basin supports this generalisation, as the examined taxocoenosis is rich (175 species) and diversified, and moreover, it contains a number of hitherto unrecorded species which represent a substantial addition to the Turkish rotifer fauna. The fact that we found 34 new records for Turkey is not surprising, considering that the rotifer fauna of the southeastern Anatolia region of Turkey has received little attention. Consequently, these new records increase the total number of Turkish rotifers from 289 to 323. Interestingly, all of the 23 Eurotatorian families and 47 of 66 genera recorded previously from Turkey are represented in the present study. The majority of the newly recorded taxa and half of the investigated fauna in the present study are semiloricate and illoricate rotifers. However, this does not correspond well with the existing understanding of the composition of rotifers in Turkey because faunistic data from Turkey are mostly from planktonic samples and dead samples that are primarily from loricate species such as brachionids (41 taxa) and lecanids (44 taxa), whereas soft bodied rotifers such as notommatids (34 taxa) and dicranophorids (19 taxa) are poorly reported. Additionally, the identification of rotifers is difficult, especially for many semiloricate and illoricate species. Families such as the Brachionidae.

Colurellidae and Lecanidae include species that are often identifiable even after preservation in formalin, whereas soft-bodied or illoricate rotifers are generally distorted after preservation, and their diagnosis has to be based on trophi morphology which can be observed only using modern technological equipment such as scanning electron microscopy (SEM) and high-quality light microscopes. Therefore, it is likely that the number of illoricate rotifers in Turkey is greater than is known at present.

The information provided in this study increases our knowledge about the diversity of benthic-littoral taxa in

Turkey. Because of methodological problems and the type of freshwater habitats that were previously studied most intensively, the benthic-littoral species of the Turkish fauna are not as well known as planktonic rotifers. Among the most diverse families found in this study, all but one (Brachionidae) contain almost exclusively littoral-periphytonic species with a majority inhabiting oligo- to mesotrophic, slightly acidic and soft waters. *Brachionus* is a notable exception, as most of these species prefer alkaline and eutrophic conditions (Segers, 2008). This illustrates the well-known fact that diverse rotifer taxocoenosis is a consequence of littoral regions having greater environmental heterogeneity, thus allowing for finer habitat partitioning than pelagical areas, especially when these environments are colonised by aquatic vegetation (Arora and Mehra, 2003; Hasler and Jones, 1949; Pennak, 1966; Sanoamuang et al., 1995). Turkey is a transcontinental Eurasian country between arctic and tropical regions. Due to the strategic geographic position of Turkey, it can be expected that its rotifer fauna should consist of representatives from arctic and tropical regions. Although a number of the taxa recorded in the Tigris River are amongst the most common, widespread or cosmopolitan species, both the species richness of the tropic-centred genera *Lecane* and *Brachionus* and the finding of representatives of speciose cold-water genera, such as *Notholca, Cephalodella* and *Synchaeta* confirm this hypothesis. According to Dumont and De Ridder (1987), northern species used Anatolia (Asian Turkey) as a stepping stone to extend their ranges southwards into Africa during the colder and more humid periods of the late Pleistocene, and relicts of these populations still survive in the Ethiopian highlands, with some species occasionally descending into the Nile valley in the affluent of the Blue Nile (for example *Notholca acuminata* and *Wolga spinifera*).

Our findings confirm their observations, as the Tigris River includes many cold water and arctic–temperate species (for example, *Notholca acuminata, Lecane scutata, Lecane ivli, Aspelta angusta, Dicranophorus aspondus, Donneria sudzukii, Encentrum martes, Cephalodella obvia, Cephalodella theodora, Pleurotrocha sigmoidea* and *Wolga spinifera*). Previously, *D. sudzukii* was only known from the two localities mentioned earlier. Therefore, the Tigris River in Turkey now represents a third locality in the distribution of this rare species. Additionally, another arctic taxon, *Cephalodella cf. ungulata* is recorded here for the second time from outside of its type locality. However, the Tigris River also hosts a number of tropical taxa. The Lecanidae, which is biogeographically an important family, contains six tropicopolitan taxa: *L. decipiens, L. hastata, L. inopinata, L. leontina, L. papuana* and *L. thienemanni,* some of which are pantropical species (Segers, 1995). *L. aculeata* certainly is a warm stenotherm most frequently encountered in the (sub) tropics, but can also be found in warm water habitats in temperate regions. *L. hornemanni* and *L. stenroosi* are cosmopolites with some preference for warmer waters. Another tropicopolitan species, *Trichocerca braziliensis* which was previously recorded in Afrotropical, Australian, Neotropical and Oriental regions (Segers, 2007), is a new record for both the Palearctic region and western Asia. Additionally, the fauna contains one eastern Oriental taxon, *Brachionus murphyi,* which was previously recorded in Singapore (Sudzuki, 1989), Thailand (Sanoamuang et al., 1995) and Hainan, South China (Koste and Zhuge, 1998), as reported by Segers (2001). Thus, *B. murphyi* also represents a new record for the Palearctic region and western Asia.

Additionally, *Lecane margalefi* is recorded here for the first time in continental Asia, as noted earlier. Thus, the distributional ranges of these species are now extended to south eastern Turkey, reaching beyond their known limits. These Turkish records of biogeographically interesting taxa raise intriguing questions about the possible dispersal and biogeographical distribution processes in these species. Rotifers achieve dispersal in space and time through passive transport by water currents, wind or animal vectors (Örstan, 1998; Wallace et al., 2006) and it is commonly assumed that transport by wind and migrating birds are most likely the major means of long-distance dispersal for these species (Segers and De Smet, 2008). In the Tigris River, it is clear that migrating birds play an important role in the passive transport of rotifers, as the Tigris Basin is one of the most important areas in this region for many migrant bird species, both as a flyway and as a breeding area (Kiliç and Eken, 2004). Recently, Karakaş (2010) has suggested that the Bismil Plain of the Tigris basin alone hosts 147 bird species, 72 of which are transitory migrating or wintering birds. Our findings also support this richness as the highest species numbers recorded were at the Bismil site of the river during the sampling period. The species richness found in the present study is relatively high compared with other lotic systems around the world (Arora and Mehra, 2003; Lucinda et al., 2004; May and Bass, 1998; Sanoamuang, 1998; Sharma and Sharma, 2001). However, it is lower than has been found in the floodplain of the Mun River (Segers et al., 2004), the Niger River (Segers et al., 1993) and the upper Parana River (Bonecker et al., 1998).

The observed species richness of the Tigris River may be explained by: 1) a drought that occurred during the sampling period in this semi-arid region which reduced the current velocity of the river; 2) contributions of rotifers carried from dam reservoirs and tributaries containing drifting zooplankton; 3) rich aquatic vegetation along the river that contains littoral-periphytonic species; 4) a rich occurrence of food along the river continuum such that rotifer communities along the river are distributed in accord with their feeding habitats, which include utilisation of transported materials (Keppeler and Hardy, 2004); and 5) migrating birds. Our findings indicate that Turkey is an addition-substraction or transfer zone for faunas of southern, northern, and eastern origin, supplemented by some endemic species as discussed by Dumont and De Ridder (1987). Furthermore, this study indicates the possibility of the existence of higher rotifer species diversity in Turkish waters than was previously though. There is no doubt that further study of this region will increase the number of species recorded here and will also provide more information about Turkish rotifer biogeography. Additional efforts will thus be required to obtain a truly comprehensive picture of the rotifer species of Turkey and to contribute to a better understanding of the distribution patterns and biogeography of the Rotifera at a global level.

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