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Terrestrial bdelloid rotifers from Erzurum (eastern part of Turkey)

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Abstract: There has been a growing interest in studies of the macroecology and biogeography of microorganisms (smaller than 2 mm) in recent years; however, knowledge of the diversity patterns of these organisms is inadequate. The reason for this lack of knowledge is that faunistic studies of these microorganisms have not been extensive enough to cover all areas of the world. Bdelloid rotifers of 200–600 µm in size are among these microorganisms. In many countries, few studies have been conducted on bdelloid fauna thus far. With only one detailed study, Turkey can be counted as one of those countries. In this present work, 30 samples belonging to 4 substrates (mosses on concrete, mosses on rock, mosses on the ground, and lichens on trees) were collected in an eastern province of Turkey (Erzurum) at a high altitude (1761–1965 m) and examined. In total, 3000 individual (100 for each sample × 30 samples = 3000) were investigated, and 30 taxa were recorded. Twelve of them are new records for Turkey, of which 10 are new records for Asian fauna.

Key words: Alpha diversity, species richness, microorganisms, faunistic study, new records

1. Introduction

Diversity pattern studies of microscopic organisms (smaller than 2 mm) have become a popular subject recently (Fontaneto et al., 2011; Curini-Galletti et al., 2012), but there have been few conclusive results. Bdelloid rotifers are multicellular pseudocoelamate animals about 200–600 µm long. They live in aquatic (pools, lakes, etc.) and terrestrial (moss, lichen, soil, etc.) habitats. They have an ability called dormancy that enables them to resist drought or freezing conditions (Ricci, 1987, 2001). Because of this ability, bdelloids are easily transported over long distances.

Classical faunistic studies of microscopic animals have not been given much attention by journals with high impact factors. Because of this, researchers have not been encouraged to carry out faunistic studies on microscopic organisms. On the other hand, papers have recently been published in influential journals stating that more faunistic studies are needed to gain insight into the diversity patterns of microscopic animals (Fontaneto et al., 2006, 2007, 2011). Thus, there is an immediate demand for more faunistic studies to be done to reveal the diversity patterns of microscopic organisms (smaller than 2 mm).

Here, I have carried out a faunistic study on collected samples from 4 different substrates (mosses on concrete, mosses on rock, mosses on the ground, and lichens on trees) in Erzurum, in the eastern part of Turkey. I also discuss the habitat selectivity, alpha-, beta-, and gamma diversities of bdelloids and other microorganisms (smaller than 2 mm).

2. Materials and methods

2.1. Sample collection

Thirty samples of bdelloid rotifers from 4 different substrates (mosses on concrete, mosses on rock, mosses on the ground, and lichens on trees) were collected in Erzurum, in the eastern part of Turkey (Table 1), and examined. Sample collections were done between October 2009 and January 2010. Out of these 30 samples, 9 were collected from mosses on the ground, 9 samples from mosses on rock, 7 samples from lichens on trees, and 5 samples from mosses on concrete.

Approximately 10-g samples were collected from the substrates and then taken to the laboratory in paper envelopes.

2.2. Species identification

Approximately 2-g samples were put in a plastic petri dish and distilled water was added to activate the bdelloids. After 30 min, living animals were isolated. One hundred individuals were examined for each sample; for 30 samples, a total of 3000 individuals were examined. The work of Donner (1965) was used for species identification of bdelloids.

2.3. Sampling area

The selected sampling area, Erzurum, is located in the eastern part of Turkey. In Erzurum, summers are hot and

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Table 1. Sampling localities in Erzurum.

ID	Sampling date	Locality	Substrates	Approximate coordinates	Altitudes
ERZ1	03.12.2009	Atatürk University	LT	39°53¢49″N 41°14¢41″E	1887 m
ERZ2	22.12.2009	Ilıca	LT	39°56¢46″N 41°05¢41″E	1772 m
ERZ3	22.12.2009	Ilıca	LT	39°56¢46″N 41°05¢39″E	1771 m
ERZ4	24.10.2009	Ilıca	LT	39°56¢44″N 41°05¢43″E	1775 m
ERZ5	26.12.2009	Ilıca	LT	39°56¢31″N 41°06¢07″E	1764 m
ERZ6	01.01.2010	Ilıca	LT	39°56¢33″N 41°05¢12″E	1792 m
ERZ7	01.01.2010	Ilıca	LT	39°56¢30″N 41°05¢11″E	1792 m
ERZ8	03.12.2009	Atatürk University	MG	39°53¢50″N 41°14¢42″E	1886 m
ERZ9	05.12.2009	Ilıca	MG	39°56¢45″N 41°05¢38″E	1773 m
ERZ10	24.10.2009	Ilıca	MG	39°56¢44″N 41°05¢44″E	1775 m
ERZ11	24.10.2009	Ilıca	MG	39°56¢44″N 41°05¢45″E	1775 m
ERZ12	24.10.2009	Ilıca	MG	39°56¢42″N 41°05¢45″E	1779 m
ERZ13	11.11.2009	Ilıca	MG	39°56¢44″N 41°05¢36″E	1772 m
ERZ14	22.12.2009	Ilıca	MG	39°56¢46″N 41°05¢39″E	1770 m
ERZ15	05.12.2009	Ilıca	MG	39°56¢44″N 41°05¢36″E	1772 m
ERZ16	26.12.2009	Ilıca	MG	39°56¢31″N 41°06¢12″E	1762 m
ERZ17	25.12.2009	Atatürk University	MC	39°53¢52″N 41°14¢49″E	1884 m
ERZ18	15.12.2009	Ilıca	MC	39°56¢49″N 41°05¢34″E	1773 m
ERZ19	26.12.2009	Ilıca	MC	39°56¢32″N 41°06¢10″E	1763 m
ERZ20	01.01.2010	Ilıca	MC	39°56¢29″N 41°05¢11″E	1793 m
ERZ21	27.12.2009	Erzurum City Center	MC	39°54¢18″N 41°16¢24″E	1916 m
ERZ22	28.12.2009	Erzurum City Center	MR	39°53¢08″N 41°15¢29″E	1965 m
ERZ23	26.12.2009	Ilıca	MR	39°56¢30″N 41°06¢13″E	1762 m
ERZ24	26.12.2009	Ilıca	MR	39°56¢33″N 41°05¢57″E	1810 m
ERZ25	26.12.2009	Ilıca	MR	39°56¢30″N 41°06¢13″E	1761 m
ERZ26	24.10.2009	Ilıca	MR	39°56¢43″N 41°05¢41″E	1777 m
ERZ27	26.12.2009	Ilıca	MR	39°56¢34″N 41°06¢11″E	1762 m
ERZ28	01.01.2010	Ilıca	MR	39°56¢42″N 41°05¢33″E	1788 m
ERZ29	05.12.2009	Ilıca	MR	39°56¢44″N 41°05¢35″E	1772 m
ERZ30	05.12.2009	Ilıca	MR	39°56¢47″N 41°05¢38″E	1772 m

dry while winters are harsh and cold. For approximately 6 months of the year, the ground is covered by a blanket of snow. The lowest temperatures (in some cases –37 °C) were recorded in December and January. The altitude of the sampling area was in the range of 1761–1965 m.

3. Results and discussion

Thirty samples belonging to 4 different substrates from the eastern part of Turkey (mosses on concrete, mosses on rock, mosses on the ground, and lichens on trees) were examined. Thirty-three taxa belonging to 7 genera were recorded (Table 2). Twelve of these species (*Ceratotrocha velata*, *Habrotrocha constricta*, *H. eremita*, *H. gracilis*, *H. pusilla*, *Macrotrachela crucicornis*, *M. inermis*, *Mniobia* cf. *armata*, *M. orta*, *M. variabilis*, *Philodina cristata*, and *P. rapida*) are new records for Turkey. Furthermore, 10 of these species (*Ceratotrocha velata*, *Habrotrocha eremita*, *H. pusilla*, *Macrotrachela crucicornis*, *M. inermis*, *Mniobia* cf. *armata*, *M. orta*, *M. variabilis* (only recorded from Austria), *Philodina cristata*, and *P. rapida*) are new records for the Asian fauna. Some taxa (*Habrotrocha* sp1, *Habrotrocha* sp2, *Habrotrocha* sp3, *Macrotrachela* sp1, *Macrotrachela* sp2, *Macrotrachela* sp3, *Mniobia* sp1, and *Philodina* sp1) that were observed during the study could

Table 2. Recorded bdelloid taxa from 4 different substrates in the eastern part of Turkey (Erzurum).

Recorded species	Locality codes
Adineta vaga (Davis, 1873)	ERZ2, 3, 4, 5, 6, 7, 12, 13, 14, 17, 19, 20, 23, 24, 25, 27, 28, 29
****Ceratotrocha velata*** Donner, 1949	ERZ28
Habrotrocha bidens (Gosse, 1851)	ERZ18
Habrotrocha constricta (Dujardin, 1841)	ERZ24
****Habrotrocha eremita*** (Bryce, 1894)	ERZ28
Habrotrocha gracilis Montet, 1915	ERZ14
****Habrotrocha pusilla*** (Bryce, 1893)	ERZ15, 30
Habrotrocha sp1	ERZ5
Habrotrocha sp2	ERZ9
Habrotrocha sp3	ERZ12
Macrotrachela aculeata Milne, 1886	ERZ11
****Macrotrachela crucicornis*** Murray, 1905	ERZ12
****Macrotrachela inermis*** Donner, 1965	ERZ29
Macrotrachela latior Donner, 1951	ERZ30
Macrotrachela musculosa (Milne, 1886)	ERZ13
Macrotrachela plicata (Bryce, 1892)	ERZ5, 19
Macrotrachela sp1	ERZ6
Macrotrachela sp2	ERZ18
Macrotrachela sp3	ERZ22
****Mniobia*** cf. *armata* (Murray, 1905)	ERZ13
****Mniobia orta*** Donner, 1951	ERZ21
Mniobia sp1	ERZ2, 3, 4, 23, 25
****Mniobia variabilis*** Donner, 1949	ERZ10
Philodina acuticornis Murray, 1902	ERZ19
****Philodina cristata*** Donner, 1949	ERZ16
Philodina parvicalcar De Koning, 1947	ERZ28
Philodina plena (Bryce, 1894)	ERZ10, 11, 12, 14, 27
Philodina proterva Milne, 1916	ERZ26
****Philodina rapida*** Milne, 1916	ERZ1, 17, 26
Philodina roseola Ehrenberg, 1832	ERZ19
Philodina sp1	ERZ7, 20
Philodina vorax (Janson, 1893)	ERZ5, 26
Rotaria sordida (Western, 1893)	ERZ8

*: New record for Turkey. **: New record for Asia.

not be identified to species level. They are possibly new species. *Habrotrocha gracilis* was the second record for the Asian fauna, after Song and Kim (2000). The first detailed study on bdelloids in Turkey was carried out by Kaya et al. (2009); 41 species were found. Thirty-six of these 41 species were added to the Turkish rotifer fauna. The latest checklist (Ustaoğlu et al., 2012) reported a total of 341 species of rotifers (48 species of bdelloids). Turkish rotifers have increased from 341 to 353 and Turkish bdelloids from 48 to 60 by adding the 12 new bdelloid records from this study.

Through examination of 30 samples from 4 substrates (mosses on concrete, mosses on rock, mosses on the ground, and lichens on trees), in total (gamma diversity) 33 taxa were recorded. Fourteen taxa were recorded from the substrate "moss on rock", followed by "moss on the ground" with 12 taxa, "moss on concrete" with 9 taxa, and "lichens on trees" with 8 taxa. Species richness for each sample (alpha diversity) ranged from 1 to 4 (mean: 2.13). Differences among samples (beta diversity) were many. Twenty-five species were found in 1 sample only, and 24 taxa were seen in 1 substrate only. *Adineta vaga* was found to be more cosmopolitan; it was found in all of the substrates and 18 samples (Figure 1). In term of species composition, only 5 overlaps were observed among samples.

Three thousand individuals belonging to bdelloid rotifers were examined in 30 samples (from 4 different substrates). *Adineta* was observed as the dominant genus in abundance percentage with 872 individuals (29%), followed by *Philodina* with 729 (24%), *Mniobia* with 498 (17%), *Habrotrocha* with 420 (14%), *Macrotrachela* with 365 (12%), *Rotaria* with 100 (3%), and *Ceratotrocha* with 16 (1%) (Figure 1). Looking at the abundance of genera for each substrate, *Adineta* was observed frequently in the habitats of lichens on trees and moss on rock. An abundance of *Habrotrocha* was found to predominate in moss on the ground (Figure 2).

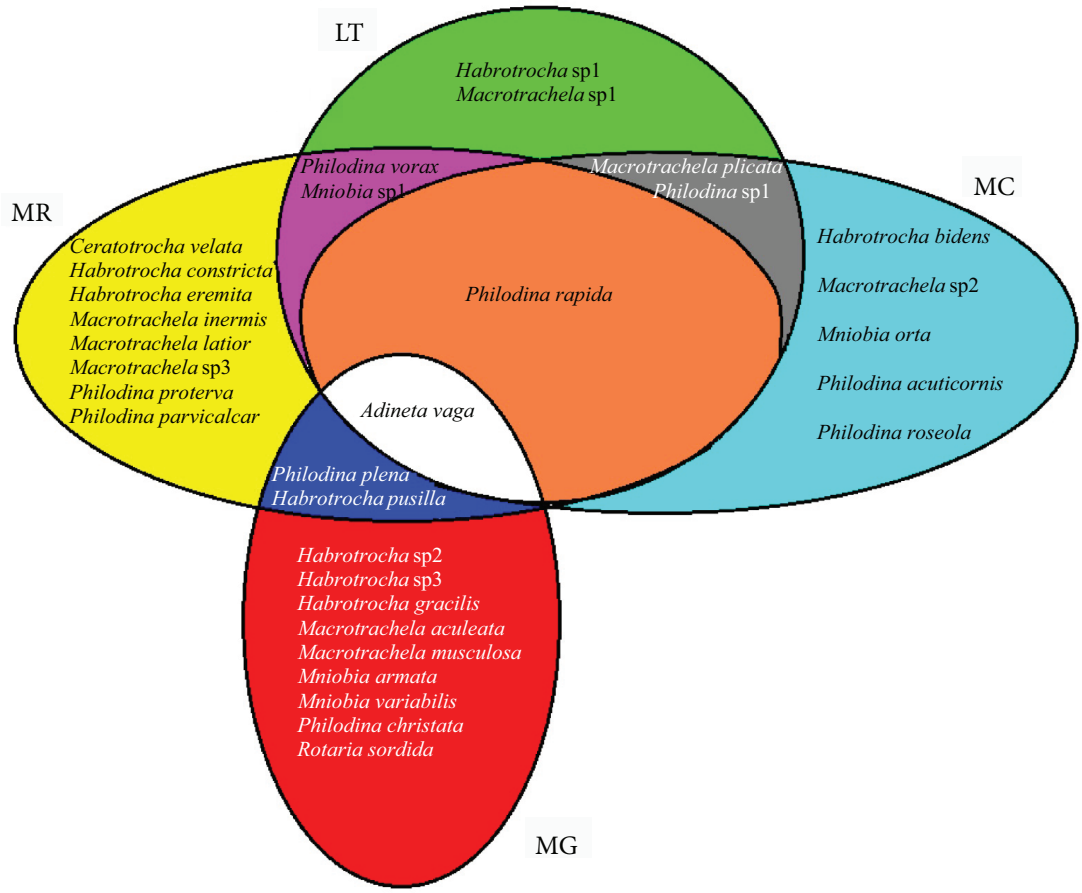

Figure 1. Diversity of recorded bdelloids from each substrate (MC: moss on concrete; MG: moss on the ground; MR: moss on rock; LT: lichens on trees).

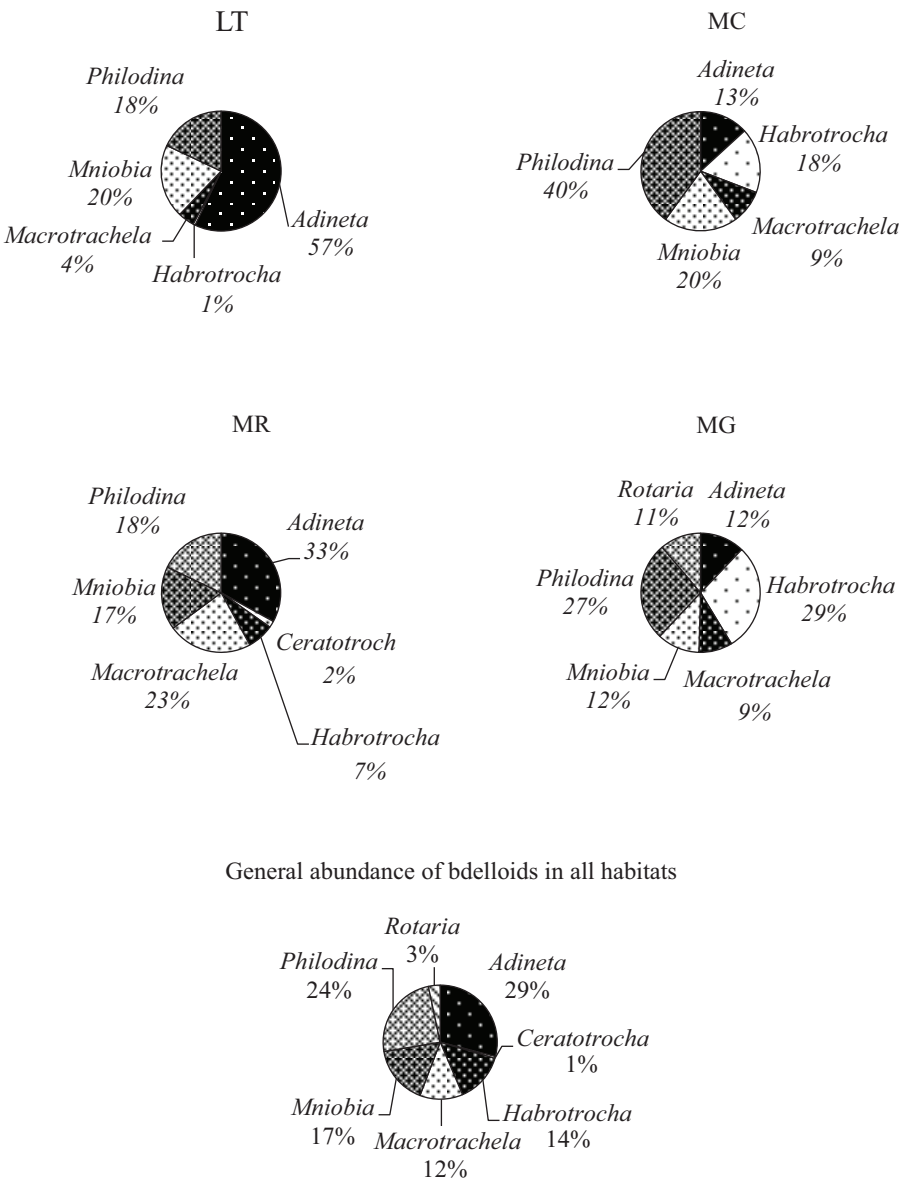

Figure 2. Percent abundance of counted genera for each substrate (MC: moss on concrete; MG: moss on the ground; MR: moss on rock; LT: lichens on trees).

The percentage of local/global species richness of microorganisms (smaller than 2 mm) was found to be much higher than for vertebrates and large invertebrates (larger than 2 mm) (Finlay, 2002; Fontaneto et al. 2011). In the present study, 30 taxa (6.5% of global species richness) were observed by examination of only 30 samples from Erzurum. This percentage is quite high compared to global richness (461 clonal species; Segers, 2007). Our results support the notion that the local/global species ratio is much higher in microorganisms than vertebrates and large invertebrates, as found in other studies.

Worldwide, not many countries have been searched for bdelloid rotifers. Some published papers on microorganisms emphasize this lack of extensive study on microorganisms worldwide (Fontaneto et al., 2006, 2007, 2011). A few studies have been done recently (Yakovenko, 2000a, 2000b; Devetter, 2007; Fontaneto et al., 2007; Kaya et al., 2009, 2010), but we still need much more complex and extensive faunistic studies of the diversity patterns of microorganisms to cover the different geographic regions and continents. The present study was carried out for an area in Turkey (in the eastern region) for which no such

studies on bdelloids have ever been conducted before. Some contributions were made to the Turkish and Asian faunas with this study.

A study carried out by Fontaneto and Ricci (2006) stated that there is a negative correlation between altitude and alpha diversity. In the present study, the altitude of the sampling localities is between 1761 and 1965 m and alpha diversity was found to be low (mean: 2.13). This alpha diversity is consistent with the alpha diversity at high altitudes recorded by Fontaneto and Ricci (2006).

In conclusion, this study is the first record of bdelloids from the eastern part of Turkey and the second detailed study for Turkey. Through this study, many additions were made to both the Asian and Turkish faunas. Considering the fact that limited faunistic studies have been conducted on bdelloids worldwide so far, the present study may help increase the understanding of the diversity patterns of microorganisms for future studies.

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