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# Diversity of rotifers from northeastern U.S.A. bogs with new species records for North America and New England

Leszek A. Błędzki & Aaron M. Ellison*
*Mount Holyoke College, Department of Biological Sciences, 50 College Street, South Hadley, MA 01075-6418, U.S.A.*
*Current address: Harvard University, Harvard Forrest, P.O. Box 68, Petersham, MA 01366, U.S.A.*
*Tel: 413-538-2149. Fax: 413-538-2548. E-mail: lbledzki@mtholyoke.edu*

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**Abstract**

The first geographically extensive survey of rotifers in New England (U.S.A.) bogs is presented. Rotifers were collected during the summers of 1999 and 2000 from 31 bogs occurring throughout Vermont and Massachusetts, and in northwestern Connecticut. The survey incorporates three microhabitats within bogs: the bog ponds, interstitial (pore) water, and water-filled leaves of the northern pitcher-plant, *Sarracenia purpurea* L. Species similarity of these three habitats was low (Jaccard indices of similarity <0.25). During the survey over 50 000 individuals in 38 species were collected including *Cephalodella anebodica* Berzins and *Colurella obtusa clausa* (Hauer) which are reported for the first time from North America. Fifteen new species records for New England, 5 for Connecticut, 26 for Massachusetts and 20 for Vermont are also reported. Species richness of rotifers increased significantly with bog elevation but not with latitude, longitude, or bog area. The current known North American distribution of the rotifers we found in these bogs is presented for comparison.

## Introduction

Worldwide, studies of rotifer diversity have progressed little since the late 1970s (Dumont, 1980), unlike other areas of limnological research that have seen significant increases in activity (Kornijów & Błędzki, 2000). In recent decades, the few studies of rotifer diversity in North America have been limited principally to ponds, lakes, reservoirs, and rivers (Arnott & Vanni, 1993). In general, less attention has been paid to rotifers of bogs and then usually only bog ponds have been sampled (Wallace, 1977; Francez, 1981, 1984, 1987, 1988; Francez & Pourriot, 1984; Francez & Devaux, 1985; Pejler & Berzins, 1993b). However, rotifers are known to live in different microhabitats within bogs (Bateman, 1980; Pejler & Berzins, 1993b; Pejler, 1995; Deneke, 2000).

Inventories of rotifers are important for evaluating environmental changes and understanding functional properties of freshwater ecosystems. For example, our recent field and laboratory studies showed that rotifers are important components of phosphorus and nitrogen cycles in bog ecosystems (Błędzki & Ellison 1998, 2002). Inventory data also can contribute to systematics and biogeography, by uncovering new, rare, or endemic species. Existing inventories of rotifer diversity in North America are quite old (Harring & Myers, 1922, 1924, 1926, 1928; Myers 1931, 1933a, b, 1934a–d), or are restricted to a few well-known study sites (Ahlstrom, 1934; Chengalath, 1977; Stemberger, 1979, 1990; Bateman, 1980; Chengalath & Koste, 1983, 1987; Turner & Taylor, 1998). Rotifer diversity in New England (U.S.A.) is documented especially poorly (Edmondson, 1936, 1948; Makarewicz in Likens, 1985), and these papers provide only scattered geographical coverage. Here, we present the first geographically extensive survey of rotifers in New England (U.S.A.) bogs. Our survey incorporates three microhabitats within these bogs: the bog ponds, interstitial (pore) water, and water-filled leaves (phytotelmata, *sensu* Fish, 1983) of the northern pitcher-plant, *Sarracenia purpurea* L. (Sarraceniaceae). The bdelloid rotifer *Habrotrocha rosa* Donner is known to occur in these leaves (Bateman, 1987; Petersen et al., 1997; Błędzki & Ellison, 1998), but other rotifers species have not been reported before from *Sarracenia* leaves. Only Addicott (1974) and Cochran-Stafira & von Ende (1998) mentioned that they noticed other rotifer species from pitcher-plants but they did not identify the rotifer species.

## Materials and methods

### *Study area*

Rotifers were collected during the summers of 1999 and 2000 from 31 bogs ranging the length of Vermont and Massachusetts, and in northwestern Connecticut (Fig. 1, Table 1). The sampled bogs occur in the eastern range of North American *Sphagnum*-dominated peatlands (Halsey et al., 2000). In these bogs, *Sphagnum* creates characteristic habitats (Bridgham et al., 1996) and is considered to be a keystone species (Rochefort, 2000) . We sampled relatively undisturbed bogs that were located in consultation with state agencies and conservation organizations (The Nature Conservancy, Audobon Society, and state Natural Heritage programs). Latitude, longitude, and elevation of each sample site was determined using a Trimble GPS unit (Trimble Instruments, Sunnyvale, Califorina, U.S.A). Bog area was determined from digitized aerial photographs, using ArcView 3.2 (ESRI, Inc., Redlands, California, U.S.A.).

### *Sample collection and identification*

At each bog, we collected samples from the central pond (if it occurred), the pore water, and from water-filled leaves of *Sarracenia purpurea*. Three replicate tow samples were taken from the pond using a 0.06 mm-mesh plankton net. Three replicate samples were taken from the interstitial (pore) water using 50 ml plastic centrifuge tubes pressed down into the *Sphagnum* mat. These samples were located in the center of the *Sphagnum* mat, and were spaced 10 m apart. Tubes readily filled with water in less than 30 s. Previously described methods of sampling and extracting moss-dwelling rotifers (Pejler & Berzins, 1993b; Peters et al., 1993) were relatively more destructive than this collecting method, and may have underestimated rotifer diversity in the *Sphagnum* mat. Finally, five replicate samples were taken from randomly-located *Sarracenia* leaves, as described by Błędzki & Ellison (1998).

All samples were stored in a cooler and transported within 1 d to the laboratory, where they were concentrated to a 5 ml volume. Preliminary identifications and counts were made on live samples using a Ward counting wheel (to prevent double counting) under a Wild M8 zoom stereomicroscope. Subsequently, samples were fixed in 1% formalin. Three replicate 1-ml subsamples of the fixed material were examined in a Sedgwick-Rafter cell under a Leica compound microscope. All rotifers in these subsamples were counted and identified to species. The remaining sample volume was searched for additional species, which were also identified. When necessary, specimens were transferred into one drop of 30% glycerine on a separate slide and examined in detail under high magnification. For identification of some species, trophi were extracted using sodium hypochlorite (Nogrady et al., 1993) and examined under high magnification (800–2000× magnification).

### *Statistical analyses*

We used regression routines in S-Plus for Windows version 6.0 (Insightful Corp., Seattle, Washington, U.S.A.) to test for relationships between rotifer species richness and geographic variables (latitude, longitude, elevation, and area of sampled bogs). Rarefaction (Gotelli & Graves, 1996) was used to compare species richness among habitats and sites, using EcoSim version 5.0 (Gotelli & Entsminger, 2000). The Jaccard index (Brower & Zar, 1984) was used to determine similarity in species composition among the three habitats (bog pond, pore-water, *S. purpurea* leaves). This index ranges from 0 to 1, where 0 indicates that the habitats have no species in common and 1 indicates that each species that occurs in one habitat also occurs in the other.

## Results

In total, >50 000 individuals in 38 Rotifera species were collected from ponds, pore water, and *Sarracenia* leaves at these sites (Table 2). *Habrotrocha rosa* was the most frequent species, occurring in the pore water of 30 of the 31 sampled bogs. This species also was the most common inhabitant of *Sarracenia* leaves, but


*Figure 1.* Map of New England (without Maine) showing approximate positions of the sampling locations. The study region is shown in grey in the map of the United States. See Table 1 for geographic coordinates and additional site information.

it never was found in the bog ponds (Table 2). The five other species that were collected from *Sarracenia* leaves each were found only at 1 site (Table 2). Species richness of rotifers increased significantly with bog elevation (number of rotifers = 4.8 + 0.01*elevation, $r^2 = 0.21$, $P = 0.008$), but was not associated significantly with latitude, longitude, or bog mat area. Considering bog ponds or pore water as a single habitat across the entire sampling region, among bogs that had ponds (11 of them), species richness (*S*) in the bog ponds ($S = 16$) was greater than species richness in interstitial water ($S = 14$) (Fig. 2). Within each of these 11 bogs, however, there were no differences in the number of rotifers species collected in the bog ponds (range 1–7) vs. from the interstitial water (range 1–13) ($P = 0.37$, matched-pairs *t*-test on rarefied data).

Fourteen species (48%) were recorded each from only a single bog (Table 2). Twenty-nine species (76%) were recorded from interstitial pore-water, 16 (42%) from the ponds, and six (16%) from *S. purpurea* leaves. Twelve species (32%) were recorded from only a single habitat (Table 2). Species similarity between the habitats was relatively low. The Jaccard index of similarity was: 0.22 between pore-water and the bog pond; 0.16 between *S. purpurea* leaves and the bog pond; 0.13 between *S. purpurea* leaves and the pore-water.

Two of the species, *Cephalodella anebodica* Berzins and *Colurella obtusa clausa* (Hauer) are reported for the first time from North America. *Cephalodella anebodica* (Fig. 3) previously was known only from three collections from an oligo-dystrophic lake in Sweden (Nogrady et al., 1995). We collected two individuals of this species from a water-filled leaf of *S. purpurea* growing at Peacham Bog in Vermont. This bog also was notable for its high species richness of rotifers in *Sarracenia* leaves. In addition to *Ceph-*

*Table 1.* Geographical characteristics of the sampled bogs. Codes are used in Figure 1 and Table 2. Latitude and longitude are in decimal degrees; elevation in metres above sea level, and bog area in $m^2$. Longitude values are given only to the nearest degree to protect sensitive habitats. Within a state, bogs are ordered from north to south

| Bog name | Code | Latitude | Longitude | Elevation | Bog area |
|---|---|---|---|---|---|
| **Vermont** | | | | | |
| Carmi Bog | CAB | 44.95 | 72 | 133 | 38 023 |
| Moose Bog | MOO | 44.76 | 71 | 353 | 864 970 |
| Colchester Bog | COB | 44.55 | 73 | 30 | 623 284 |
| Molly Bog | MOL | 44.50 | 72 | 236 | 8 852 |
| Chickering Bog | CHB | 44.32 | 72 | 362 | 38 081 |
| Peacham Bog | PEA | 44.29 | 72 | 468 | 576 732 |
| Snake Mountain Bog | SNA | 44.06 | 73 | 313 | 248 |
| Springfield Bog | SPR | 43.33 | 73 | 158 | 435 |
| **Massachusetts - mainland** | | | | | |
| Lake Jones Bog | WIN | 42.69 | 72 | 323 | 84 235 |
| Hawley Bog | HAW | 42.58 | 72 | 543 | 36 813 |
| Quag Pond Bog | QP | 42.57 | 71 | 335 | 40 447 |
| Bourne Hadley Ponds | BH | 42.56 | 72 | 274 | 105 369 |
| Lilly Pond Bog | LPB | 42.44 | 72 | 468 | 56 559 |
| Quabbin Bog #42 | QB | 42.42 | 72 | 175 | 6 706 |
| Arcadia Bog | ARC | 42.31 | 72 | 95 | 1 190 |
| Swift River Bog | SR | 42.27 | 72 | 121 | 19 699 |
| Otis Bog | OB | 42.23 | 73 | 491 | 89 208 |
| Ponkapoag Bog | PK | 42.19 | 71 | 47 | 491 189 |
| Black Pond Bog | BPB | 42.18 | 70 | 45 | 9 679 |
| Round Pond Bog | RP | 42.17 | 72 | 78 | 10 511 |
| Clayton Bog | CB | 42.05 | 73 | 210 | 73 120 |
| Shankpainter Ponds | SKP | 42.05 | 70 | 1 | 55 152 |
| Chockalog Bog | CK | 42.03 | 71 | 152 | 7 422 |
| Halls Brook Cedar Swamp | HBC | 42.00 | 70 | 8 | 11 760 |
| **Massachusetts - Islands** | | | | | |
| Cranberry | CRA | 41.45 | 70 | 29 | 88 427 |
| Schmitt Bog | SB | 41.41 | 70 | 17 | 533 |
| Arethusa Bog | AB | 41.32 | 70 | 5 | 2 598 |
| Donut Pond Bog | DON | 41.28 | 70 | 7 | 8 740 |
| Taupshwa Bog | TAB | 41.28 | 70 | 6 | 16 689 |
| **Connecticut** | | | | | |
| Tobey Pond Bog | TPB | 41.98 | 73 | 389 | 2 877 |

*alodella anebodica* and *Habrotrocha rosa*, we collected *Lecane lunaris* Ehrenberg and *Notholca acuminata* (Ehrenberg) from *S. purpurea* leaves at Peacham Bog (Table 2). *Colurella obtusa clausa* previously was reported from lake littoral throughout Europe (Berzins, 1972; De Ridder & Segers, 1997). We collected hundreds of individuals of this species from ponds and pore water of 12 bogs in Massachusetts and Vermont (Table 2). In addition to the two new rotifers records for North America mentioned above we added 15 new species records for New England, 5 for Connecticut, 26 for Massachusetts and 20 for Vermont (Table 3).

*Table 2.* Site × species matrix illustrating the distribution of rotifers in the microhabitats of the sampled bogs. The presence of a rotifer at a given site in each microhabitat is indicated by the entry '1' in any given cell. Site codes are given in Table 1

| | AB | ARC | BH | BPB | CB | CK | CRA | HAW | HBC | LPB | OB | PK | QB | QP | RP | SKP | SR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Interstitial pore-water** | | | | | | | | | | | | | | | | | |
| *Cephalodella gibba* (Ehrenberg, 1832) | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | | | 1 | | | 1 |
| *Colurella colurus* (Ehrenberg, 1830) | | | | | | 1 | | | | | | | | 1 | | | 1 |
| *Colurella obtusa clausa* (Hauer, 1936) | | 1 | 1 | | 1 | | | 1 | | 1 | 1 | | | 1 | | | 1 |
| *Euchlanis lyra myersi* (Kutikova, 1959) | | | | | | | | 1 | | | | | | | | | |
| *Habrotrocha rosa* Donner, 1949 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Keratella cochlearis* (Gosse, 1851) | | | | | | | | 1 | | | | | | | | | |
| *Keratella mixta* (Oparina-Charitonova, 1925) | | 1 | 1 | | 1 | | | 1 | | 1 | | | 1 | 1 | | | 1 |
| *Keratella serrulata* (Ehrenberg, 1838) | | | | | | | | | | | | | | | | | |
| *Keratella taurocephala* Myers, 1938 | | | | | | | | | | 1 | | | | | | | |
| *Lecane agilis* (Bryce, 1892) | | | | | | | | | | | | | | | | | |
| *Lecane bulla* (Gosse, 1851) | | | | | | | | | | | | | 1 | | | | |
| *Lecane closterocerca* (Schmarda, 1859) | | | | | | | | | | | | | | | | | |
| *Lecane lauterborni* Hauer, 1924 | | | | | | | | 1 | | | 1 | | | 1 | | 1 | |
| *Lecane ludwigii* (Eckstein, 1885) | | | | | | | | | | | | | | | | | |
| *Lecane luna* (Müller, 1776) | | 1 | | | | | | | | | 1 | | | | | | |
| *Lecane lunaris* Ehrenberg,1832 | 1 | 1 | | 1 | 1 | | | 1 | | 1 | | | | 1 | 1 | 1 | 1 |
| *Lecane pyriformis* (Daday, 1905) | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | | 1 | 1 | | 1 | 1 | 1 |
| *Lecane satyrus* Harring & Myers, 1926 | | | | | | | | | 1 | | | | | | | | |
| *Lecane signifera* (Jennings, 1896) | 1 | | | | | 1 | 1 | | | | | | | | | | |
| *Lecane tryphema* Harring & Myers, 1926 | | | | | | 1 | | 1 | | | | | | | | | |
| *Lepadella ehrenbergi* (Perty, 1850) | | | | | | | | | | | | | | | | | |
| *Lepadella ovalis* (Müller, 1786) | | | | | | | | 1 | | | | | | | | | |
| *Lepadella patella* (Müller, 1773) | | | | | | | | | | | | | | | | | |
| *Lepadella triba* Myers, 1934 | | 1 | | | | | | | | 1 | | | | | | | |
| *Macrochaetus collinsi* (Gosse, 1867) | | | | | | | | | | | | | | | | | |
| *Monommata grandis* Tessin, 1890 | | | | 1 | | 1 | | 1 | | 1 | | | | 1 | | | 1 |
| *Mytilina macrocera* (Jennings, 1894) | | | | | | | | | | | | | | | | | |
| *Polyarthra vulgaris* Carlin, 1944 | 1 | 1 | | | | 1 | | 1 | 1 | 1 | 1 | | | 1 | 1 | | 1 |
| *Trichocerca rosea* (Stenroos, 1898) | | | | | | | | | | | | | | | | | |
| **Subtotal: species per site in pore-water** | **6** | **9** | **4** | **5** | **6** | **7** | **2** | **13** | **5** | **10** | **6** | **2** | **4** | **9** | **4** | **4** | **8** |
| **Pond** | | | | | | | | | | | | | | | | | |
| *Asplanchna priodonta* Gosse, 1850 | | | | | | | | | | | 1 | | | | | | |
| *Euchlanis incisa* Carlin, 1939 | | | | | | | | | | | 1 | 1 | | | | | |
| *Kellicottia bostonensis* (Rousselet, 1908) | 1 | | | | | | | | | | 1 | | | 1 | | | |
| *Keratella cochlearis* (Gosse, 1851) | | | | | | | | | | | 1 | | | | 1 | | |
| *Keratella serrulata* (Ehrenberg, 1838) | | | | | | | | 1 | | 1 | | 1 | | | | | |
| *Keratella taurocephala* Myers, 1938 | | | | | | | | | | | | | | | | | |
| *Lecane luna* (Müller, 1776) | | | | | | 1 | | | | | | | | 1 | | | |
| *Lecane lunaris* Ehrenberg,1832 | | | | | | | 1 | | | | | | | | 1 | | |
| *Lecane pyrrha* Harring & Myers, 1926 | | | | | | 1 | | | | | | 1 | | 1 | 1 | | |
| *Lecane pyriformis* (Daday, 1905) | 1 | | | | | | | | | | 1 | | | | 1 | | |
| *Lecane signifera* (Jennings, 1896) | | | | | | | | | | 1 | | 1 | | | 1 | | |
| *Lepadella amphitropis* Harring, 1916 | | | | | | | | | | | | 1 | | | 1 | | |
| *Notholca acuminata* (Ehrenberg, 1832) | | | | | | | | | | | | | | | | | |
| *Polyarthra euryptera* Wierzejski, 1892 | | | | | | | | | | | | | | | | | |
| *Polyarthra vulgaris* Carlin, 1944 | | | | | | | | | | | | 1 | | | | 1 | |
| *Trichotria tetractis* (Ehrenberg, 1830) | | | | | | | | | | | | | | | | | |
| **Subtotal: Species per site in ponds** | **2** | **0** | **0** | **0** | **0** | **2** | **0** | **2** | **0** | **2** | **6** | **6** | **0** | **3** | **7** | **0** | **0** |
| **Pitcher-plant leaves** | | | | | | | | | | | | | | | | | |
| *Cephalodella anebodica* Berzins, 1976 | | | | | | | | | | | | | | | | | |
| *Habrotrocha rosa* Donner, 1949 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | 1 | 1 |
| *Keratella mixta* (Oparina-Charitonova, 1925) | | | | | | | | | | | | | | | | | |
| *Lecane lunaris* Ehrenberg, 1832 | | | | | | | | | | | | | | | | | |
| *Notholca acuminata* (Ehrenberg, 1832) | | | | | | | | | | | | | | | | | |
| *Polyarthra vulgaris* Carlin, 1944 | | | | | | | | 1 | | | | | | | | | |
| **Subtotal: Species per site in *Sarracenia*** | **0** | **1** | **1** | **0** | **1** | **1** | **0** | **2** | **1** | **0** | **1** | **1** | **0** | **1** | **1** | **1** | **1** |
| **TOTAL SPECIES PER SITE** | **7** | **9** | **4** | **5** | **6** | **9** | **2** | **14** | **5** | **10** | **11** | **2** | **4** | **12** | **8** | **4** | **8** |

*Table 2.* contd.

| | TAB | TPB | WIN | CAB | CHB | COB | CTN | DON | MOL | MOO | PEA | SB | SNA | SPR | TOTAL SITES PER SPECIES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Interstitial pore-water** | | | | | | | | | | | | | | | |
| *Cephalodella gibba* (Ehrenberg, 1832) | | 1 | 1 | | 1 | | | 1 | | 1 | 1 | 1 | 1 | | **19** |
| *Colurella colurus* (Ehrenberg, 1830) | | | 1 | | 1 | | | | | | | | | | **4** |
| *Colurella obtusa clausa* (Hauer, 1936) | | 1 | 1 | 1 | | | | | | | | | | 1 | **12** |
| *Euchlanis lyra myersi* Kutikova, 1959 | | | | | | | | | | | | | | | **2** |
| *Habrotrocha rosa* Donner, 1949 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **30** |
| *Keratella cochlearis* (Gosse, 1851) | | | | | | | | | | | | | | | **1** |
| *Keratella mixta* (Oparina-Charitonova, 1925) | | | 1 | 1 | 1 | | | | | | | 1 | | | **12** |
| *Keratella serrulata* (Ehrenberg, 1838) | | | | | | | | | | | 1 | | | | **1** |
| *Keratella taurocephala* Myers, 1938 | | | | | | | | | | | | | | | **1** |
| *Lecane agilis* (Bryce, 1892) | | 1 | | | | | | | | | | | | | **1** |
| *Lecane bulla* (Gosse, 1851) | | | | | | | | | | | | | | | **1** |
| *Lecane closterocerca* (Schmarda, 1859) | | | | | | | 1 | | | | | | | | **1** |
| *Lecane lauterborni* Hauer, 1924 | | | 1 | | | | | | 1 | | | | | | **6** |
| *Lecane ludwigii* (Eckstein, 1885) | | | | | 1 | | | | | | | | | | **1** |
| *Lecane luna* (Müller, 1776) | 1 | | | 1 | 1 | | | | | | 1 | 1 | | | **7** |
| *Lecane lunaris* Ehrenberg,1832 | | | 1 | | 1 | | 1 | | 1 | 1 | | 1 | 1 | | **17** |
| *Lecane pyriformis* (Daday, 1905) | | | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | 1 | | 1 | **22** |
| *Lecane satyrus* Harring &Myers, 1926 | | | | | | | | | | | | | | | **1** |
| *Lecane signifera* (Jennings, 1896) | | | | | | | | | | | | | | | **3** |
| *Lecane tryphema* Harring et Myers, 1926 | | | | | | | | | | | | | | | **2** |
| *Lepadella ehrenbergi* (Perty, 1850) | | | | | 1 | | | | | | | | | | **1** |
| *Lepadella ovalis* (Müller, 1786) | | | 1 | | | | | | | | | | | 1 | **3** |
| *Lepadella patella* (Müller, 1773) | | | | | | | | | | | | | | 1 | **1** |
| *Lepadella triba* Myers, 1934 | | | | | | | | | | | | | | | **2** |
| *Macrochaetus collinsi* (Gosse, 1867) | | | | | 1 | | | | | | | | | | **1** |
| *Monommata grandis* Tessin, 1890 | | | | | | | | | | | | | | 1 | **7** |
| *Mytilina macrocera* (Jennings, 1894) | | | | | | | | | | | | | | 1 | **1** |
| *Polyarthra vulgaris* Carlin, 1944 | | 1 | 1 | 1 | | | 1 | | | 1 | | | 1 | | **16** |
| *Trichocerca rosea* (Stenroos, 1898) | | 1 | | | | | | | | | | | | | **1** |
| **Subtotal: species per site in pore-water** | **1** | **5** | **10** | **6** | **10** | **1** | **5** | **3** | **4** | **5** | **5** | **6** | **4** | **7** | |
| **Pond** | | | | | | | | | | | | | | | |
| *Asplanchna priodonta* Gosse, 1850 | | | | | | | | | | | | | | | **1** |
| *Euchlanis incisa* Carlin, 1939 | | | | | | | | | | | | | | | **2** |
| *Kellicottia bostonensis* (Rousselet, 1908) | | | 1 | | | | | | | | | | | | **4** |
| *Keratella cochlearis* (Gosse, 1851) | | | | | | | | | | | | | 1 | | **3** |
| *Keratella serrulata* (Ehrenberg, 1838) | | | | | | | | | | | | | | | **3** |
| *Keratella taurocephala* Myers, 1938 | | | | | | | | | | | | | 1 | | **2** |
| *Lecane luna* (Müller, 1776) | | | | | | | | | | | | | | | **2** |
| *Lecane lunaris* Ehrenberg,1832 | | | | | | | | | | | | | | | **2** |
| *Lecane pyrrha* Harring &Myers, 1926 | | | | | | | | | | | | | | | **3** |
| *Lecane pyriformis* (Daday, 1905) | | | | | | | | | | | | | | | **4** |
| *Lecane signifera* (Jennings, 1896) | | | | | | | | | | | | | | | **3** |
| *Lepadella amphitropis* Harring, 1916 | | | | | | | | | | | | | | | **2** |
| *Notholca acuminata* (Ehrenberg, 1832) | | | | | | | | | | | | | 1 | | **1** |
| *Polyarthra euryptera* Wierzejski, 1892 | | | | | | | | | | | | | 1 | | **1** |
| *Polyarthra vulgaris* Carlin, 1944 | 1 | | | | | | | | | | | | 1 | | **4** |
| *Trichotria tetractis* (Ehrenberg, 1830) | 1 | | | | | | | | | | | | | | **1** |
| **Subtotal: species per site in ponds** | **2** | **0** | **1** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **5** | **0** | |
| **Pitcher-plant leaves** | | | | | | | | | | | | | | | |
| *Cephalodella anebodica* Berzins, 1976 | | | | | | | | | | | 1 | | | | **1** |
| *Habrotrocha rosa* Donner, 1949 | | 1 | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | | 1 | **22** |
| *Keratella mixta* (Oparina-Charitonova, 1925) | | | | | | | | | | 1 | | | | | **1** |
| *Lecane lunaris* Ehrenberg, 1832 | | | | | | | | | | | 1 | | | | **1** |
| *Notholca acuminata* (Ehrenberg, 1832) | | | | | | | | | | | 1 | | | | **1** |
| *Polyarthra vulgaris* Carlin, 1944 | | | | | | | | | | | | | | | **1** |
| **Subtotal: Species per site in *Sarracenia*** | **0** | **1** | **1** | **1** | **1** | **1** | **0** | **0** | **1** | **2** | **4** | **1** | **0** | **1** | |
| **TOTAL SPECIES PER SITE** | **3** | **5** | **11** | **6** | **10** | **1** | **5** | **3** | **4** | **6** | **8** | **6** | **8** | **7** | |

*Table 3.* North American distribution of Rotifera species recorded from surveyed bogs (Berzins, 1978; Gallagher et al. 1994; Segers, 1995; De Ridder et al. 1997; Błędzki, unpublished catalog of Rotifera). (species* – new records for New England; MA*, VT*, CT* – new record for that state; species** – new record for North America). Abbreviations: AB – Alberta; AZ – Arizona; BC – British Columbia; CA – California; CO – Colorado; CT – Connecticut; DC – Washington D. C.; FL – Florida; GA – Georgia; ID – Idaho; IL – Illinois; IN – Indiana; KY – Kentucky; LA – Louisiana; Labr. – Labrador; LGL – Laurentian Great Lakes; MA – Massachusetts; ME – Maine; MI – Michigan; MN – Minnesota; MO – Missouri; N.B. – New Brunswick; NS —- Nova Scotia; NC – North Carolina; NF – Newfoundland; NH – New Hampshire; NJ – New Jersey; NWT – Northwest Territories; NY – New York; OH – Ohio; OK – Oklahoma; ON – Ontario; PA – Pennsylvania; PQ – Quebec; TX – Texas; VA – Virginia; VT – Vermont; WI – Wisconsin; WV – West Virginia. Within states or provinces: n. e. – northeastern part, n. w. – northwestern part, w. – western part

| | Canada | U.S.A. |
|---|---|---|
| *Asplanchna priodonta* | Arctic, AB, Labr, NB, NF, NS. PQ | CA, CT, CO, FL, ID, IL, IN, KY, LGL, MA*, MI, NC, NH, PA, VT* WI |
| *Cephalodella anebodica* ** | | VT* |
| *Cephalodella gibba* | Labr, NF, NS, n.w., ON, NWT | AZ, CA, CO, CT* FL, LGL, MI, MA*, NY, VT* |
| *Colurella colurus* * | Arctic | CO, FL, MA*, VT*, WI |
| *Colurella obtusa clausa* ** | | CT*, MA*, VT* |
| *Euchlanis incisa* | n.e., NS, ON, PQ | FL, IL, MA*, MI |
| *Euchlanis lyra myersi* * | | CA, MA* |
| *Habrotrocha rosa* | NF | CT*, GA, MA, NC, NH, NJ, PA, VT, WV |
| *Kellicottia bostonensis* | NF, NS, NWT, ON, PQ | CT, FL, GA, IL, LA, LGL, MA, ME, NC, NH, NY, OH, PA, TX, VA, VT, WI |
| *Keratella cochlearis* | Canada | U.S.A. |
| *Keratella mixta* * | Nearctic | MA*, NC, VA, VT* |
| *Keratella serrulata* | Arctic, Labr, n.e., NF, NS, PQ | CO, FL, ID, LGL, MI, NC, VA, VT |
| *Keratella taurocephala* | Labr, NB, NF, NS, ON, PQ | FL, LGL, MA*, ME, MI, NH, NY, PA, WI |
| *Lecane agilis* * | NF | CT* MA*, WI |
| *Lecane bulla* * | Labr, NF, NS, n.w., ON, PQ | AZ, CA, CO, FL, IL, IN, KY, LA, LGL, MA*, MI, MO, NC, TX, WI, VA, |
| *Lecane closterocerca** | n.e., NF, NS, n.w., NWT,ON | AZ, CO, FL, IL, KY, LGL, MA*, MI, MO, NC, TX, VA, WI |
| *Lecane lauterborni* | Arctic, NF | MA*, ME, NC, OH, VA, VT* |
| *Lecane ludwigii* | NS, n.w., ON, PQ | AZ, DC, FL, LA, LGL, ME, MI, NJ, OK,VA, VT*, WI |
| *Lecane luna* | AB, Arctic, Labr, NF, n.e., NS, n.w., ON, PQ | CA, CO, FL, IL, KY, LA, MA*, ME, MI, MO, NY, OH, OK, PA, TX, VT*,WI, WV |
| *Lecane lunaris* | AB, Arctic, Labr., n.e., NF, NS, n.w., ON, PQ | AZ, AR, CA, CO, DC, FL, IL, KY, LA, LGL, MA*, ME, MI, MS, NC, NJ, NY, OH, TX, VA, VT*, WI |
| *Lecane pyriformis* | Arctic, NF., NS, ON, PQ | FL, IL, KY, LA, LGL, MA*, ME, OH, TX, VT*, WI |
| *Lecane pyrrha* | NS, PQ | FL, LGL, MA*, ME, MI, NC, NJ, VA, WI |
| *Lecane satyrus* | NS, PQ | FL, MA*, MD, ME, NC, NJ, VA, WI |
| *Lecane signifera* | ON, PQ | FL, LGL, MA*, MI, NC, NJ, VA, WI |
| *Lecane tryphema* | | ME, MA*, NJ, WI |
| *Lepadella amphitropis* * | n.e., NF, NS | IL, MA*, WI, |
| *Lepadella ehrenbergi* * | ON, PQ, w. | FL, LGL, MI, VT* |
| *Lepadella ovalis** | AB, Arctic, n.e., NS, n.w., NWT, ON, PQ | CO, FL, IL, KY, LA, LGL, MA*, MI, NC, TX, VA, VT*, WI |
| *Lepadella patella* | Arctic, n.e., NS, n.w., NWT, ON, PQ | AZ, CA, ,CO FL, IL, KY, LGL, MI, MO, TX, VT*, WI, |
| *Lepadella triba* * | ON | IL, MA*, MO, |
| *Macrochaetus collinsi* * | Canada | FL, LGL, VT* |
| *Monommata grandis* * | Arctic, NS, PQ | FL, LGL, MA*, VT* |
| *Mytilina macrocera** | | FL, LGL, NC, VA, VT* |
| *Notholca acuminata** | AB, Arctic, n.e., NF, NS, ON, PQ | FL, CO, MI, LGL, OH, VT* |
| *Polyarthra euryptera* | AB, Arctic, BC, NF, ON | FL, IL, LA, LGL, MA* ME, MI, NC, NY, PA, TX, VT, WI, |
| *Polyarthra vulgaris* | AB, Arctic, n.e., NF, NS, ON, PQ | CA, CO, CT*, FL, IL, KY, LA,, LGL, MA*, ME, MI, NC, NH, NY, OH, PA, VA, VT, WI |
| *Trichocerca rosea* * | Arctic, n.e., NS, PQ | CO, FL, MI, VT* |
| *Trichotria tetractis* | AB, Arctic, n.e., NF, NS, NWT, ON | AZ, CO, FL, IL, LGL, MA*, MI, NC, NH, LA, OH, VA |

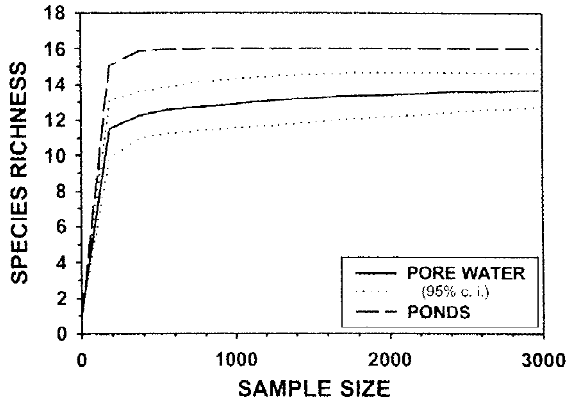


*Figure 2.* Rarefaction plot of species richness in bog ponds *vs.* interstitial water. For this analysis, data were pooled for the 11 bogs that had ponds and their species richness was compared with the pooled species richness of the interstitial water at those same sites. In total, 40 369 individual rotifers were recovered and identified from the pore water at these 11 sites, and 2 975 were recovered and identified from the ponds at these 11 sites. The rarefaction analysis compares the expected species richness in the pore water samples for the sample size of the pond (see Gotelli & Graves, 1996 for details on rarefaction analysis). The plot illustrates the 95% confidence intervals (dotted lines) around the estimated pore water sample (solid line). The species richness of the pond samples (dashed line) exceeds that of the pore water for all sample abundance levels.

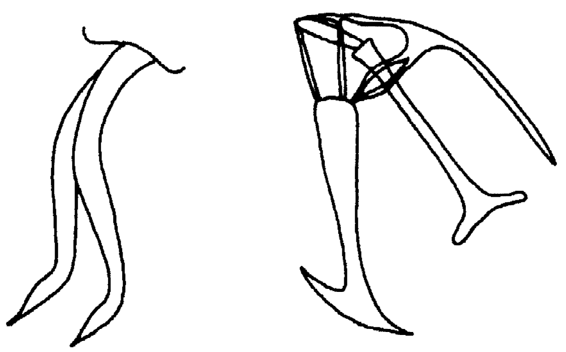

*Figure 3.* Illustration of the trophi and toes of *Cephalodella anebodica* (body length 230 $\mu$m, toes 60 $\mu$m). Drawing by L. Błędzki.

## Discussion

*Sphagnum* creates suitable habitat for rotifers because of its ability to hold large quantities of water (Halsey et al., 2000). *Sphagnum* also acidifies its surroundings (Williams et al., 1998), which limits the rotifer diversity in bog pore-water to those species that are tolerant of low pH (Nogrady et al., 1993). The most common rotifer within the *Sphagnum* pore water and the leaves of the pitcher-plant *Sarracenia purpurea* was the bdelloid *Habrotrocha rosa*. The high tolerance of bdelloids such as *H. rosa* to the stressful conditions within the pore water may be associated with the colonizing strategy of this group (Pejler & Berzins, 1993a; Deneke, 2000). Baldwin & Menhinick (2000) found a large number of desiccated bdelloids in the leaves of the yellow pitcher plant *Sarracenia flava* L., which suggests that among the rotifers, only bdelloid species can tolerate this habitat. Berzins & Pejler (1987) suggested that bdelloid rotifers, because of their obligatory parthenogenesis, can tolerate broad ranges of pH, such as those found in *Sarracenia* leaves (which range from 6.3 to 3.5 over the course of the growing season; Fish & Hall, 1978). In our previous study (Błędzki & Ellison, 1998) we showed that in laboratory culture (pH ranging from 3 to 6), production and abundance of *H. rosa* was highest at pH 4. Published information on rotifers of bog pore-water is rare (Bateman, 1980; Pejler & Berzins 1993b), as few limnologists or students of rotifers work in these habitats (Kornijów & Błędzki, 1999). Nogrady et al. (1995) illustrated that many of the North American acidophilic species reported previously by Harring & Myers (*in litt.*) had not been observed since they were described. For the rotifers that we identified in New England bogs, we present their currently known North American distribution in Table 3. All listed species marked with asterisks are new records for New England. Our data showing a relationship between rotifer species richness and elevation complement previous studies (Morales-Baquero, 1987; Jersabek, 1995) that examined rotifer diversity in high-latitude mountain lakes. They found several species with restricted distribution and they also described many new species records for those regions. Rotifer species richness in high alpine habitats was affected by pH, conductivity and temperature, but altitude and thermal factors might also directly affect those habitats (Jersabek, 1995). He also observed a decline in species richness with increasing altitude that is contrary to our observation. Additional data are needed to better understand altitudinal patterns of rotifer distribution.

Rotifers present in the *Sphagnum* mat seem to play an important role in functioning of that type of ecosystem. They are important components of phosphorus and nitrogen cycles in bog ecosystems (Błędzki & Ellison, 1998, 2002) and also are a major component of bog faunal communities. Future research should provide more details about differences in rotifer species composition among different microhabitats within bogs. Continued research should also yield new species records for localities, regions, and continents.

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