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INFLUENCE OF MINE ACID ON PLANKTONIC ROTIFERS

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Abstract. Planktonic rotifers were sampled in spring and summer from 2 lakes in southeastern Ohio. Unpolluted waters of Dow Lake were lower in sulfate and iron and higher in pH, hardness and alkalinity than acid mine polluted waters of Lake Hope. Rotifers of Dow Lake exceeded those of Lake Hope in species number, numerical abundance, species diversity, and faunal similarity among sample dates; similarity between lakes was negligible. Keratella cochlearis and Brachionus urceolaris, the most abundant rotifers in each of the respective lakes, both showed broad tolerances to pH. While B. urceolaris showed a large selective advantage at low pH, this was reduced and both species fared better at near-neutral pH. Neither species appeared sensitive to alternative pH conditions in preference tests.

Mine effluent is an important source of pollution in coal producing areas of the eastern United States. Major environmental effects are:

1) reduction of pH in receiving waters by an increase in sulfate and hydrogen ions
2) increase in coal-associated metallic ions such as iron and manganese
3) smothering of stream beds with a yellowish ferric hydroxide precipitate.

Studies of fauna in lakes and streams polluted by mine drainage generally indicate fewer pollution-tolerant than pollution-sensitive species (Lackey 1938, Dinsmore 1968, Parsons 1968, Roback and Richardson 1969, Warner 1971) and reduced species diversity in polluted relative to unpolluted waters (Dills and Rogers 1974, Orciari and Hummon 1975).

Rotifers have received little attention with respect to acid mine pollution. They have been reported in streams polluted with mine acids, but until recently (Evans 1978) without quantitative data at the species level (Lackey 1938, Parsons 1968). Still less is known about the effects of mine acidity on lake-dwelling rotifers.

Correlation between planktonic rotifer species and hydrogen ion concentration, derived from organic sources, was recognized by Harring and Myers in 1928. Alkaline (hard) water tends to support a rotifer subcommunity with few species and many individuals, while acid (soft) water supports a greater number of species each with fewer individuals. Myers (1931) divided these rotifers into 3 groups: an alkaline fauna restricted to pH values above 7, an acid fauna restricted to pH values below 7, and a transursion fauna tolerant of both acid alkaline conditions.

We decided that a survey of 2 matched lakes, one unpolluted and one polluted by mine effluents, would help delineate the influence of nonorganic acids on planktonic rotifers. Abundance, species diversity and faunal similarity were compared during 2 seasons. Levels of acute toxicity and behavioral preference to mine acids were determined for the 2 most important species in the study.

METHODS AND MATERIALS

Studies were made in 2 dendritic, earth-dam impoundments in southeastern Ohio. Dow Lake (Strouds Run State Park, Athens County), established in 1960, has 60 ha surface area, 11 km of wooded shoreline and no source of acid mine pollution. Lake Hope (Zaleski State Park, Vinton County), established in 1939, has 50 ha surface area, 8 km of wooded shoreline and receives effluent from nearly 150 mine sites. Three sampling sites were selected in the upper, middle and lower thirds of each lake, adjacent
RESULTS

Lake temperatures increased from mid-teens to mid-twenties in late spring and dropped from upper-to lower-twenties in late summer. Thermoclines developed in late spring, but temperatures were rather homogeneous in late summer. Chemical compositions of the two lakes during sampling periods are compared in table 1. Dissolved oxygen, sulfate and iron were less in Dow Lake than in Lake Hope samples, as analysed by means tests, whereas pH, hardness and total alkalinity were greater.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Comparison of Chemical Composition between Dow Lake and Lake Hope.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chem.</td>
<td>Compos.</td>
</tr>
<tr>
<td></td>
<td>(ppm)</td>
</tr>
<tr>
<td>Dissolved</td>
<td></td>
</tr>
<tr>
<td>O₂</td>
<td>8.4±1.9</td>
</tr>
<tr>
<td>Sulfate</td>
<td>52.0±5.0</td>
</tr>
<tr>
<td>Iron</td>
<td>0.1±0.2</td>
</tr>
<tr>
<td>Calcium</td>
<td></td>
</tr>
<tr>
<td>hardness</td>
<td>79.0±8.0</td>
</tr>
<tr>
<td>Total hardness</td>
<td>118.0±21.0</td>
</tr>
<tr>
<td>Total alkalinity</td>
<td>77.0±12.0</td>
</tr>
<tr>
<td>pH</td>
<td>8.0±0.5</td>
</tr>
</tbody>
</table>

*All values except significance mean±standard deviation.

Plankton samples from Dow Lake contained 11 species of rotifers, those from Lake Hope 3 species. Keratella cochlearis, the most common rotifer in Dow Lake, was followed in abundance by Polyarthra vulgaris Carlin, 1943. Other species were: Asplanchna priononta Gosse, 1850; Conochilus unicornis Rousselet, 1892; Kelliocottia bostoniensis (Rousselet, 1908); K. longispina (Kellicot, 1879); Gastropus sp.; Lecane sp.; Monostyla sp., Synchaeta sp.; and Trichotria sp. Brachionus urceolaris, the most common rotifer in Lake Hope, was followed in abundance by Keratella cochlearis and Monostyla sp. Identification were based on Ahlstrom 1940, 1943; Edmondson 1950; Pennak 1953; and Rousselet 1902.

Rotifer species in samples from the 5 dates at Dow Lake (X=5.0±1.2) were
greater \((P<.01)\) than those from Lake Hope \((X = 2.0 \pm 1.2)\), as determined by a means test. The numerical abundance of rotifers was also greater \((P<.02)\) at Dow Lake \((X = 221 \pm 158)\) than at Lake Hope \((X = 7.0 \pm 5.7)\). Means for samples from specific date of collection are shown in figure 1, along with the proportion of Dow Lake rotifers represented by *Keratella cochlearis* and *Polyarthra vulgaris*.

Species diversity \(H'\) differed \((P<0.05)\) when based on pooled samples from the 5 dates: Dow Lake \((X = 1.3 \pm 0.24)\), Lake Hope \((X = 0.46 \pm 0.64)\). But the difference was even greater \((P<.001)\), when based on individual samples: Dow Lake \((X = 0.95 \pm 0.44, n = 79)\), Lake Hope \((X = 0.16 \pm 0.41, n = 71)\).

Using the \(S_H\) similarity measure based on shared species diversity (Hummon 1974), rotifers from among pooled samples on 5 dates at Dow Lake shared 51.8\% \pm 3.9 of their diversity, whereas those at Lake Hope shared only 7.0\% \pm 3.4 of their diversity. More important, only 0.4\% \pm 0.1 was shared between permutations of the 2 sets of pooled samples. Using means tests, \(S_H\) values from among Dow Lake pools differed from those among Lake Hope pools \((P<.001)\) and from those between Dow Lake and Lake Hope pools \((P<.001)\), and \(S_H\) values from among Lake Hope pools differed from those between Dow Lake and Lake Hope pools \((P<.01)\).

Tolerance tests indicated that the 24 hr lethal tolerance range (LT\(_{50}\)) for *Keratella cochlearis* from Dow Lake was pH 4.8 to 10.6, and for *Brachionus urceolaris* from Lake Hope it was pH 3.3 to 10.2. For *K. cochlearis*, 8% died over 24 hr in Dow Lake water and 50% in Lake Hope water, whereas 28% of *B. urceolaris* died in Lake Hope water but only 7% in Dow Lake water. Results of preference experiments were analysed for departure from randomness by a runs test. In every case there was a greater than random number of runs \((P<.001)\).

**DISCUSSION**

Data from rotifer communities under mine acid conditions (Parsons 1968, and this study) indicate that the groups based on organic acidity, outlined by Myers (1931), are inappropriate. Further evidence is that while *Brachionus urceolaris* was considered by Myers as an alkaline water type, it has since been reported from organic- (Ahlstrom 1940) and mine- (Parsons 1968) acid water of pH 3.3 to 4.0. The pH levels of unpolluted natural waters are largely governed by the carbonate buffering system, hard carbonate-rich waters being alkaline and soft carbonate-poor waters being acidic. With the addition of mine acid, this equilibrium is disturbed and the buffering system destroyed, resulting in waters which may be both hard and acidic.

Based on late spring-late summer data, planktonic rotifers of Dow Lake exceeded those of Lake Hope in all categories analysed: species number, numerical abundance, species diversity, and faunal similarity. That these relationships are not characteristic of all faunal subcommunities was indicated by Orciari and Hummon (1975), working with benthic oligochaetes from these same 2 lakes. They found that only species diversity differed. While shared diversity among oligochaetes of Lake Hope did not differ from that among oligochaetes of Dow
Lake, both differed from that of permutations between samples from the 2 lakes, as found in our study. Tolerance tests indicate that K. cochlearis and B. urceolaris were both eurytopic for hydrogen-ion concentration. Assuming otherwise-identical life cycles for these species and comparing the effect of Dow Lake and Lake Hope waters on their survivorships, selection pressures favor B. urceolaris in both Dow Lake (1.1%) and Lake Hope (30.0%) waters. With respect to preference tests, neither species appeared sensitive to pH gradients, even when their numbers were being decimated by lethal alternative pH conditions. Rotifers of both species on encountering a pH gradient tended to make the same choice, to cross or not to cross, that they made on their last previous encounter, regardless of the water composition on either side of the gradient.

The picture that emerged was of more or less eurytopic species transported from one water body to another by physical or biological agents. On reaching a body such as Lake Hope, mine effluents appeared to act as a dominant physical control on abundance and diversity of the rotifer subcommunity, perhaps through changes in both birth and death rates. If this is the case, we hypothesize relatively high rates of species turnover in Lake Hope, correlated with high rates of colonization and extinction.

In Dow Lake, physical and chemical conditions appeared nearer optimal, with greater abundance and diversity of rotifers being regulated by cyclic physical-chemical factors or by biological accommodation, such as predation or competition. Ironically despite its tested compatibility to the physical-chemical conditions of Dow Lake, the dominant rotifer of Lake Hope, Brachionus urceolaris, was absent from all our Dow Lake samples. Sample error, biological interaction or some complex of factors probably best account for this observation.

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LITERATURE CITED


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