Transactions of Illinois Academy of Sciences
(1982), Volume 75, 1 and 2, pp. 85-90

Rotifera in the Plankton and Among Filamentous Algal Clumps in 16 Acid Strip-Mine Lakes

by
James R. McConathy and John B. Stahl
Missouri Department of Natural Resources, Kansas City, Missouri 64106
and Department of Zoology, Southern Illinois University
Carbondale, Illinois 62901

ABSTRACT

Six species of rotifers were identified from the plankton and among clumps of filamentous algae in 16 acid (pH 2.40-3.20) strip-mine lakes in southern Illinois. Algal clumps occurred only in the seven least acid lakes (pH 2.75-3.20). Only two species of rotifers were widespread: *Brachionus urceolaris* Müller) in the plankton of the 11 least acid lakes (pH 2.62-3.20) and *Cephalodella hoodi* (Gosse) in the plankton of 10 lakes (pH 2.40-2.82) and among algal clumps in the remaining 6 lakes.

INTRODUCTION

Lakes form between spoil piles and in box cuts in ungraded strip-mined land, and these lakes may be highly acid if the overburden contains pyrite, as pyrite produces sulfuric acid when oxidized (Campbell and Lind, 1969). In Illinois, as of 1971, 6.1 percent of 5764 ha of strip-mine waters had a pH of 4.5 or less (Haynes and Klimstra, 1975). Such harsh environments typically have fewer habitats and fewer species than more favorable environments (Thienemann, 1954). Investigations of the plankton in acid strip-mine lakes have consistently shown a small number of species, with the microcrustacea sometimes absent and only rotifers remaining (Bookhout et al., 1968; Crawford, 1942; Dinsmore, 1958; Gash, 1968; Heaton, 1951; Ohle, 1936; Riley, 1960; Schramm, 1973; Smith and Frey, 1971; and Stockinger and Hays, 1960). The rotifer *Brachionus urceolaris* is the most consistently occurring species in these acid lakes. It was the only species found in the lake in southern Illinois studied by Schramm (1973). We hypothesized that all acid strip-mine lakes in this area would have a plankton comprised only of *B. urceolaris*. Therefore we selected 16 acid (pH < 4) lakes and sampled the plankton qualitatively. We also sampled clumps of filamentous algae as possible habitats containing other species of rotifers.

DESCRIPTION OF THE STUDY AREA

Thirteen of the 16 bodies of water investigated are located in the NW ¼, Section 7, T. 7S., R. 1 W., of Jackson County, Illinois. Strip mining began in this area in 1944 and ended in 1952. The only attempt to reclaim the land was the aerial seeding of brome grass (*Bromus* sp.). The area is characterized by many more or less parallel mounds of spoil, some as high as 23 m. The lakes sampled are small, less than 5,000 square meters in area and at most only a few meters deep. The area of the watersheds covered by vegetation varied from about 10 percent to almost 100 percent. The vegetation consisted of brome grass, blackberry bushes (*Rubus* sp.), cottonwood (*Populus deltoides*) and sumac (*Rhus* sp.). The common cattail, *Typha latifolia*, grew emergently in all the lakes. No submersed or floating-leaved macrophytes were observed. Color of the lakes varied from blue-green to brick red. In the blue-green lakes land vegetation grew to the water's edge but in the red lakes the terrestrial vegetation submersed at high water was dead.

Of the remaining three lakes, Lake F is located 3.5 km north and 1.2 km west of the above-described area, between sections 25 and 36, T. 7S., R. 2W, and Lakes I and P are about 20 km to the east near Cambria in Williamson County. Lake I is in the E½, SE¼, SE¼, sec. 31, T. 8 S., R. 1 E, and Lake P is directly south, across the road running between them. These lakes and their watersheds are similar to the other lakes. Lakes I and P were studied by Humphrey (1970).

METHODS AND MATERIALS

Each lake was sampled one to four times between January and May. Water samples for chemical analysis were taken by dipping out a 250-ml polyethylene bottle. PH was measured with a Beckman electromate meter, conductivity with an Industrial Instruments conductivity bridge, total iron, sulfate, and orthophosphate with a Hach Chemical Analysis kit. Total acidity was measured by the Midwestern Laboratory of the Consolidated Coal company, using hot titration to an end point of 8.3.

Plankton was collected by taking at least 12 tows (standing on shore or in shallow water) with a No. 20 net (75 μm aperture size) having an opening 24 cm in diameter. About one cubic meter of water was strained through the net. Each sample was concentrated to 15 ml with a Foerst continuous centrifuge. Three Sedgwick-Rafter cells were then searched thoroughly. Rotifers were wet-mounted for identification to species. Clumps of filamentous algae were placed near a window, left for several hours, and then the top few milliliters of water were drawn off for examination. Algal filaments were also mounted and examined.

Harring and Myers (1924, 1926), Ahlstrom (1940), and Wulfert (1938) were used to identify rotifers, Kudo (1966) and Jahn (1948) to identify protozoa, and Pennak (1953) and Edmondson (1959) to identify other invertebrates.

RESULTS

The results of the chemical analyses are presented in Table 1. The pH varied from 2.40 to 3.20, a relatively narrow range of 0.80 pH units. The lakes were lettered alphabetically according to pH. Red color and higher values of iron, acidity, and phosphate were found in the lakes with lower pH values. Sulfate and conductivity were high, but variations among lakes did not correlate with pH.

Clumps of filamentous algae were seen only in lakes L through P; i.e., at pH's of 2.97 to 3.20, although in Lake F encrusting epipelic algae provided an essentially similar habitat as the algal clumps. Some algal filaments were found in lakes B, C, and D, but they were not in clumps. The algae forming the clumps were *Ulothrix*, *Mougeotia*, and *Cladophora*.

Six species of rotifers were collected, but only two were wide-spread: *Brachionus urceolaris* and *Cephalodella hoodi* (Table 2). *B. urceolaris* occurred in 11 lakes, all of which had a pH of 2.62 or more. This species was invariably planktonic. *C. hoodi* occurred in all 16 lakes and occupied both the planktonic habitat (9 lakes) and the algal clump habitat (7 lakes, including Lake F with epipelic algae); it was never present in both habitats in the same lake. In three of the lakes in which it was planktonic, algal clumps were present.

The remaining four species of rotifers were generally found associated with algal clumps, although *C. gibba* was common in the plankton of Lake K, co-occurring with *C. hoodi* and *B. urceolaris*. Lake K was the only lake to have substantial populations of more than one species of rotifer existing in the plankton at the same time; in lakes G and H the two principal species were found, but at different times, and in Lake I the populations of the two *Cephalodella* species were sparse.

A ciliate protozoan, *Chilodonella caudata* (Stokes), was found in the plankton of Lake D and among the algal clumps of Lake L. Seven other genera of protozoa were found, but only among algal clumps and only in one or two lakes: *Amoeba* (O), *Actinophrys* (M, P), *Euplotes* (L), *Oxytricha* (L and M), *Stylonychia* (O), *Uroleptus* (L), and *Vorticella* (N, O). A gastrotrich, *Chaetonotus*, was abundant among the algal clumps of lakes M and N.

DISCUSSION

The majority of rotifers are associated with a substrate (Ruttner-Kolisko, 1972) and that substrate is frequently submersed macrophytes. Acid strip-mine lakes usually lack submersed macrophytes (Bell, 1956) but clumps of filamentous algae offer a similar habitat. It seems that formation of clumps is correlated with the pH, and does not occur below a pH of about 2.6. We cannot think of a reason for this.

The total number of rotifer species in these acid lakes is low compared to circumneutral lakes, and compares with the number found in other acid strip-mine lakes; e.g., Smith and Frey (1971) found three species in their most acid lake (pH 2.5-3.2), five species in the next most acid lake (pH 3.0-3.4), and up to 15 species in the lakes having a higher pH. Both acid lakes contained *Brachionus urceolaris*, as well as an unidentified species of *Monostyla*. In our lakes *Monostyla bulla* was common in only two lakes with a pH of 3.00 and 3.20, and it was found only among the algal clumps. The other species found in the lakes studied by Smith and Frey (1971) were different than the ones we found. Indeed, the only report of *Cephalodella* is from one acid (pH 3.2 to 4.5) pond in Ohio (Bookhout et al., 1968). Ruttner-Kolisko (1972) points out that this is a littoral genus, with individuals occurring in the plankton only as strays. Our identifications of the two species must be regarded as provisional in view of the pressing need of a taxonomic version of this genus (Ruttner-Kolisko, 1972).

More intensive studies, lasting an entire year, would be desirable. PH and other chemical characteristics vary during the year (e.g., Schramm, 1973; Smith

and Frey, 1971), as do the population densities of rotifers. Schramm (1973) reported that *B. urceolaris* varied from 4 to 4,000 individuals per liter in Bradley's Acid Pit during the year. In ponds G and H the presence of *C. hoodi* early in the year and of *B. urceolaris* later also illustrates seasonal change.

Lake K is a puzzle because of the co-occurrence in the plankton in substantial numbers of three species. Moreover algal clumps in that lake did not have any rotifers associated with them. We cannot think of any reasonable explanations for these observations.

This study has shown that acid strip-mine lakes have a simplified ecosystem that provides opportunities for studies of tolerance limits and choice of habitat that are not feasible in other lakes.

LITERATURE CITED

AHLSTROM, E. H., 1940. A revision of the rotatorian genera *Brachionus* and *Platyias* with descriptions of one new species and two new varieties. Bull. Am. Mus. Nat. Hist. 77: 143-184.

BELL, R., 1956. Aquatic and marginal vegetation of strip mine waters in southern Illinois. Trans. Ill. State Acad. Sci. 48: 85-91.

BOOKHOUT, T. A., C. P. STONE, J. D. BITTNER, R. A. TUBB, S. H. TAUB, and R. E. DEIS, 1968. Potential of a strip-mined area for fish and wildlife reclamation. Ohio State University Research Foundation, Final Report, RF Project 2296. 84 pp.

CAMPBELL, R. S., and O. T. LIND, 1969. Water quality and aging of strip-mine lakes. J. Water Pollut. Control Fed. 41: 1943-1955.

CRAWFORD, B. T., 1942. Ecological succession in a series of strip mine lakes in central Missouri. M. A. thesis. University of Missouri, Columbia. 134 pp.

DINSMORE, B. H., 1958. Ecological studies of twelve strip mine ponds in Clarion County, Pennsylvania. Ph.D. thesis. University of Pittsburgh, 118 pp. University Microfilms, Ann Arbor, Mich. (Diss. Abstr. 19: 1479.)

EDMONDSON, W. T., ed. 1959. Freshwater Biology. John Wiley and Sons, New York, 1248 pp.

GASH, S. L., 1968. Limnology and fisheries productivity of acid and alkaline strip-mine lakes. M. S. thesis. University of Maryland. College Park.

HARRING, H. K., and F. J. MYERS, 1924. The rotifer fauna of Wisconsin II. A revision of the notommatid rotifers exclusive of the Dicranophorinae. Trans. Wis. Acad. Sci. Arts Lett. 21: 415-423.

HARRING, H. K., and F. J. MYERS, 1926. The rofiter fauna of Wisconsin III. A revision of the genera *Lecane* and *Monostyla*. Trans. Wis. Acad. Sci. Arts Lett. 22: 315-423.

HAYNES, R. J., and W. D. KLIMSTRA, 1975. Illinois lands surface mined for coal. Report. Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale. 201 pp.

HEATON, J. R., 1951. The ecology and succession of a group of acid and alkaline strip mine lakes in central Missouri. M. A. thesis. University of Missouri, Columbia. 143 pp.

HUMPHREY, S. A., 1970. A qualitative survey of the macroinvertebrates from three acid-polluted strip-mine lakes. M. S. research report. Southern Illinois University, Carbondale. 31 pp.

JAHN, T. L., 1949. How to know the Protozoa. Wm. C. Brown, Dubuque. 234 pp.

KUDO, R. R., 1966. Protozoology. Charles C. Thomas, Springfield, Illinois. 1174 pp.

OHLE, W., 1936. Der schwefelsaure Tonteich bei Reinbek. Arch. Hydrobiol. 30: 604-662.

PENNAK, R. W., 1953. Fresh-water invertebrates of the United States. Ronald Press, New York. 769 pp.

RILEY, C. V., 1960. The ecology of water areas associated with coal strip mined lakes in Ohio. Ohio J. Sci. 60: 106-121.

RUTTNER-KOLISKO, A. 1972. Rotatoria. Binnengewässer. 26: 99-234.

SCHRAMM, H. L., Jr. 1973. The population dynamics of *Brachionus urceolaris* O. F. Müller (Rotifera) in an acid strip-pit lake. M. A. thesis. Southern Illinois University, Carbondale. 68 pp.

SMITH, R. W., and D. G. FREY, 1971. Acid mine pollution effects on lake biology. Water Pollution Control Research Series 18050 EEC 12/71.

STOCKINGER, N. E, and H. A. HAYS, 1960. Plankton, benthos, and fish in three strip mine lakes with varying pH values. Trans. Kans. Acad. Sci. 63: 1-11.

THIENEMANN, A., 1954. Ein drittes biozönotisches Grundprinzip. Arch. Hydrobiol. 49: 421-422.

WULFERT, K., 1938. Die Rädertiergattung *Cephalodella* Bory de St. Vincent. Arch. Naturgeschichte 7: 137-152.

Lake	Sampling Dates	pH	Color	Total Iron (mg/l)	Acidity (mg/l $CaCo_3$)	Phosphate (mg/l)	Sulfate (mg/l)	Conductivity (μhos, 25° C)
A	17 Feb	2.40	red	112	150	5	1550	3020
B	2 Apr	2.45	very red	195	200	20	2200	2200
C	2 May	2.47	very red	168	200	16	1700	2700
D	18 Apr	2.50	red	145	200	15	1300	2500
E	30 Apr	2.62	red	60	—	0	2200	2460
F	17 Apr	2.62	red	59	—	0	950	1928
G	27 Jan 21 Mar	2.65	red	120	200	0	2350	3130
H	27 Jan 25 Apr	2.65	red	84	150	0	3100	2980
I	3 May	2.65	red	82	—	0	2800	3590
J	26 Apr	2.75	red-brown	36	100	0	1150	1960
K	2 Apr	2.82	red-brown	28	50	0	1100	2080
L	3 Mar	2.97	red	34	100	0	2950	2850
M	27 Jan 10 Mar	3.00	blue-green	12	50	0	1750	2480
N	21 Mar	3.10	blue-green	5	50	0	1650	2460
O	17 Feb 3 Mar	3.20	blue-green	9	0	0	550	1350
P	8 May	3.20	blue-green	5	—	0	1400	2190

Table 1. Chemical data from 16 acid strip-mine lakes.

Lake		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Sampling	Jan							27	27					27			
date (month-day)	Feb	17														17	
	Mar	3,10						21	21				3	10	21	3,26	
	Apr		2,17		18	30	17,23		25		19,26	2,19	2			6	
	May			2		23		25		3			21		21		8
Species																	
Brachionus	pl	-	-	-	-	-	va	va[1]	c[3]	va	c	a	c	a	va	a	va
urceolaris (Müller)	al	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cephalodella	pl	c	c	c	c	r	-	c[2]	c[2]	r	-	c	-	-	-	-	r
hoodi (Gosse)	al	-	-	-	-	-	c**	-	-	-	c	-	c	c	c	r	-
Cephalodella	pl	-	-	r	-	-	-	-	-	r	-	a	-	-	-	-	r
gibba (Ehrenberg)	al	-	-	-	-	-	-	-	-	-	-	-	-	c	c	c	-
Monostyla	pl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
bulla (Gosse)	al	-	-	-	-	-	-	-	-	-	-	-	-	c	-	c	-
Philodina	pl	-	-	-	vr	-	-	-	-	-	-	-	-	-	-	-	-
sp. A	al	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Philodina	pl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
sp. B	al	-	-	-	-	-	c**	-	-	-	-	-	-	-	-	-	-

Table 2. Rotifers in plankton and among algal clumps in 16 acid strip-mine lakes.
va = very abundant; a = abundant; c = common; r = rare; vr = very rare; x = present pl = in plankton; al = among algal clumps

**among epipelic algae
[1]on 25 May only [2]on 27 Jan. 21 Mar only [3]on 25 Apr only