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ZOOPLANKTON COMMUNITY STRUCTURE IN DARDANELLE RESERVOIR, ARKANSAS, 1975-1982

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ABSTRACT

Zooplankton was collected at 10 stations in Dardanelle Reservoir from 1975 to 1982. Current data were compared to a five-year preoperational study phase. Rotifer taxa strongly dominated the community. Overall abundance was higher, variety about the same and diversity lower than those of comparable studies. Thermal discharges caused a dominance shift between two rotifer taxa, slightly depressed abundance and variety, did not noticeably affect diversity and elevated the phytoplankton/zooplankton ratio. Heated effluent also stimulated stronger fluctuations in abundance and variety. Other studies indicate that in upper sections of the Arkansas River drainage, microcrustaceans dominate lake habitats whereas rotifers dominate river habitats. In similar northern and eastern habitats, microcrustaceans were generally dominant.

INTRODUCTION

Much of the basic descriptive work in Arkansas with zooplankton was done under the auspices of the Water Resources Research Center (Schmitz, 1974, 1975, 1978). Sinclair and Watson (1978) conducted a five-year survey of the zooplankton community composition in Dardanelle Reservoir prior to the beginning of power generation by Arkansas Nuclear One (ANO) Unit I. Palko (1970) collected and identified zooplankton from two stations in the upper Illnois Bayou arm of Dardanelle Reservoir during the summer and autumn of 1969. Numerous reports attempting to describe and quantify the impacts of thermal discharges have come from other states (Carlson, 1974; Gehrs, 1974; Anderson and Lenat, 1978; Miller et al., 1976; Edmondson, 1965). Analysis of the structure of zooplankton communities should receive much more research effort than in the past. This report is a general examination of data collected over an eight-year period, 1975-1982, during which ANO Unit I was operative. We will attempt to describe basic community structure and relate such to thermal discharges. Main points to be addressed in this report are (1) seasonality or periodicity of community diversity, (2) which taxa are dominant and when, (3) changes in abundance and diversity related to season and location with respect to power plant discharge, and (4) evidence of long-term trends or shifts in community structure.

MATERIALS AND METHODS

Zooplankton samples were collected in January, April, July and October of the years 1975-1982 by straining 10 l. of water through a standard No. 20 Wisconsin-style plankton net. The water column was sampled by taking 2 l. of water each from near the bottom, mid-depth and 0.6 m. plus 4 l. from the surface. Ten stations were sampled quarterly and the samples preserved in Meyer's Fixative. Figure 1 is a line map of the reservoir showing the locations of the sampling stations. Close stations (1,2,3,5,10) were those affected by effluent from the power plant as determined by the thermal measurements, however not all five stations were necessarily affected at any one time. For example, a southeast wind tended to move the effluent toward Sta. 2 away from Sta. 10. Distant stations (11,14,15,16,21) were not measurably affected by the discharge.

In the lab a 1 ml. aliquot was transferred to a Sedgwick-Rafter counting cell, and quantitative evaluation was made by counting randomly-spaced strips across the counting cell until approximately 40 percent of the area was examined. Organisms were identified to genus where possible and reported as organisms per liter. Statistical procedures included calculation of the number of taxa (genera), number of individuals, mean number of individuals per taxon and community diversity at the genus level. Diversity was calculated with the Shannon Index, $d = -\Sigma(\frac{n_i}{N})\ell n(\frac{n_i}{N})$, where ni is the number of organisms in

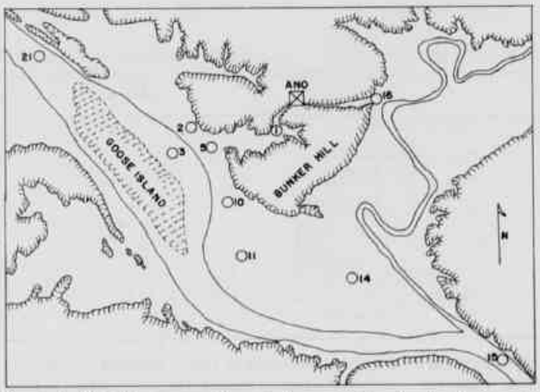

Figure 1. Plankton smampling stations on Dardanelle Reservoir, Arkansas, 1975-1982.

each taxon in turn, and N is the total number of organisms in the sample (per liter). Values are positive; the larger ones indicating greater diversity.

RESULTS AND DISCUSSION

Table 1 lists the genera of zooplankton collected during the study period (excluding unidentified specimens, nauplii and eggs). Quite often the nauplii and/or eggs counted comprised a significant proportion of the sample. Twenty-six genera representing 22 families in three phyla were identified. Rotatoria contained 46.2 percent of the genera and 40.9 percent of the families. Wilhm et al. (1977) collected 27 genera in the Arkansas River near Ponca City, Oklahoma (excluding unidentified taxa). They obtained three genera of Protozoa, seven of Rotatoria and four of microcrustacea not obtained in our study, whereas our study obtained eight genera of Protozoa, three of Rotatoria and two of microcrustacea not obtained in theirs. Palko (1970) reported three genera of Protozoa (all Ciliata), one genus of Cladocera *(Diaphanosoma)* and 11 genera of rotifers not recorded in this study.

Table 2 contains mean numbers of organisms and taxa, number per taxon and diversity values grouped by season. Although there was considerable fluctuation from year to year within a given season, the means show the greatest overall abundance occurred in July and the lowest in October. That close stations had more organisms than distant stations in January and April was probably due to the heated water which elevated metabolism allowing them to take greater advantage of available

Table 1. Taxonomy of zooplankton in Dardanelle Reservoir, Arkansas, 1975-1982. (Protozoa after Kudo, 1966, modified; others after Edmondson, 1959).

- Phylum Protozoa
  - Class Sarcodina
    - Family Actinophryidae
      - 1. Actinosphaerium
    - Family Difflugidae
      - 2. Difflugia
  - Class Ciliata
    - Family Didiniidae
      - 3. Didinium
    - Family Epistylidae
      - 4. Epistylis
      - 5. Opercularia
    - Family Halteridae
      - 6. Strombidium
    - Family Vorticellidae
      - 7. Vorticella
  - Class Suctoria
    - Family Podophryidae
      - 8. Podophrya
- Phylum Rotatoria
  - Class Monogononta
    - Family Asplanchnidae
      - 9. Asplanchna
    - Family Brachionidae
      - 10. Brachionus
      - 11. Kellicottia
      - 12. Keratella
      - 13. Notholca
    - Family Lecanidae
      - 14. Monostyla
    - Family Notommatidae
      - 15. Enteroplea
    - Family Synchaetidae
      - 15. Polyarthra
    - Family Trichoceridae
      - 17. Trichocera
    - Family Flosculariidae
      - 18. Lacinularia
    - Family Hexarthridae
      - 19. Hexarthra
    - Family Testudinellidae
      - 20. Filinia
- Phylum Arthropoda
  - Class Crustacea
    - Family Bosminidae
      - 21. Bosmina
    - Family Daphnidae
      - 22. Daphnia
    - Family Holopedidae
      - 23. Holopedium
    - Family Polyphemidae
      - 24. Polyphemus
    - Family Cyclopidae
      - 25. Cyclops
    - Family Diaptomidae
      - 26. Diaptomus

phytoplankton food sources. Wilhm et al. (1977) obtained considerably fewer organisms, but their maximum density was also observed in summer. Smith et al. (1979) obtained maximum biomass in June and July in a small pond in northcentral Texas. Kochsiek et al. (1971) obtained up to 267 organisms per liter in Keystone Reservoir, Oklahoma; a value closer to the numbers obtained in our study.

The greatest fluctuation (31-fold) over the entire study period occurred in January, whereas the slighest fluctuation of 2.7x occurred in October. Figure 2 shows mean numbers of organisms in chronological sequence. The peaks of abundance were not closely correlated with season, but four peaks at close stations occurred in January, two in April and one in July. At the distant stations six peaks occurred in July and three in January. Distant stations had greater abundance 19 times of 32 possible and were greater by an average of 64 organisms. When close stations showed greater abundance, they were greater by an average of 115 organisms. Fluctuations can sometimes be partially explained by normal patchiness of distribution (Bowles and Wilhm, 1977). In Dardanelle Reservoir the heated effluent apparently stimulated stronger fluctuations perhaps by increasing the patchiness of the distribution which could result from the mixing of the heated effluent with reservoir water. The effluent also caused a slight depression of numbers of organisms in July and October.

Figure 3 shows the variety (mean number of taxa) of zooplankton in chronological order. At close stations six of 10 peaks occurred in July, two in January and one each in April and October, whereas at distance stations four peaks were in July, two in October and one each in January and April. Distant stations had greater variety 19 times. Figure 4 shows the mean number of individuals per taxon. Four of eight peaks occurred in January at close stations whereas four of nine peaks were in January at distant stations. Distant stations were greater than close stations 20 times out of 32, but were greater by only 8.6. When close stations were greater, the difference was 21.8. Again their is in-

Table 2. Summary of zooplankton abundance, variety, number per taxon and community diversity, Dardanelle Reservoir, Arkansas, 1975-1982.

JANUARY Year	Stations	Number of Organisms	Number of taxa	Number per taxon	Diversity Value
1975	Close	32	5.3	5.4	1.246
	Distant	78	4.5	18	1.058
1976	Close	429	9.4	47	1.711
	Distant	389	9.6	41	1.633
1977	Close	831	7.0	125	0.832
	Distant	596	6.0	99	0.785
1978	Close	297	7.2	43	1.118
	Distant	338	7.2	48	1.022
1979	Close	346	8.5	38	1.484
	Distant	250	9.3	27	1.651
1980	Close	500	4.8	107	0.869
	Distant	538	5.2	109	1.097
1981	Close	1004	7.6	137	1.426
	Distant	915	7.0	136	1.141
1982	Close	421	4.0	108	1.121
	Distant	400	4.8	84	1.318
Mean	Close	482	6.7	76	1.226
	Distant	438	6.7	70	1.213
APRIL					
1975	Close	234	8.4	29	1.413
	Distant	316	9.8	34	1.491
1976	Close	391	9.0	44	1.724
	Distant	386	9.6	40	1.734
1977	Close	762	9.4	83	1.736
	Distant	624	9.8	62	1.790
1978	Close	527	10.2	53	1.590
	Distant	538	10.0	57	1.623
1979	Close	163	11.6	14	1.427
	Distant	248	10.6	24	1.268
1980	Close	334	4.0	81	0.848
	Distant	78	4.6	22	0.711
1981	Close	559	6.4	94	1.476
	Distant	233	5.4	48	1.071
1982	Close	984	7.0	150	1.688
	Distant	1004	6.2	165	1.663
Mean	Close	494	8.2	68	1.488
	Distant	428	8.2	56	1.419

JULY Year	Stations	Number of Organisms	Number of taxa	Number per taxon	Diversity Value
1975	Close	756	12.3	59	1.523
	Distant	840	11.5	74	1.745
1976	Close	186	6.8	26	1.178
	Distant	159	7.0	22	1.188
1977	Close	491	9.6	53	1.171
	Distant	689	9.6	71	1.463
1978	Close	422	11.4	39	1.781
	Distant	505	11.4	43	1.529
1979	Close	232	9.8	23	1.757
	Distant	313	10.6	29	1.703
1980	Close	264	5.4	43	1.055
	Distant	170	5.0	33	1.093
1981	Close	464	6.8	68	1.468
	Distant	535	7.6	72	1.263
1982	Close	962	7.6	128	1.821
	Distant	1022	7.0	145	1.785
Mean	Close	472	8.7	55	1.469
	Distant	529	8.7	61	1.471
OCTOBER					
1975	Close	441	9.2	48	1.542
	Distant	368	11.6	32	1.644
1976	Close	371	9.2	39	1.556
	Distant	434	10.2	43	1.779
1977	Close	311	8.6	34	1.570
	Distant	407	9.2	44	1.578
1978	Close	250	8.6	30	1.562
	Distant	295	8.6	32	1.446
1979	Close	235	7.4	32	1.557
	Distant	270	7.6	37	1.424
1980	Close	177	4.8	41	1.242
	Distant	326	6.1	52	1.370
1981	Close	237	5.8	43	1.461
	Distant	239	5.2	47	1.079
1982	Close	476	4.4	112	1.311
	Distant	303	5.2	59	1.598
Mean	Close	312	7.2	47	1.475
	Distant	330	8.0	43	1.490

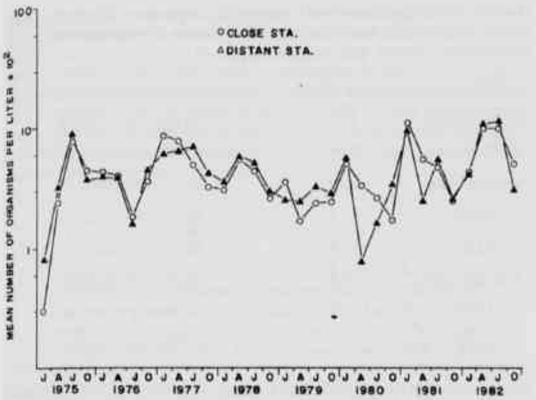

Figure 2. Mean number of zooplankton organisms for close vs. distant stations in chronological sequence in Dardanelle Reservoir, Arkansas, 1975-1982.

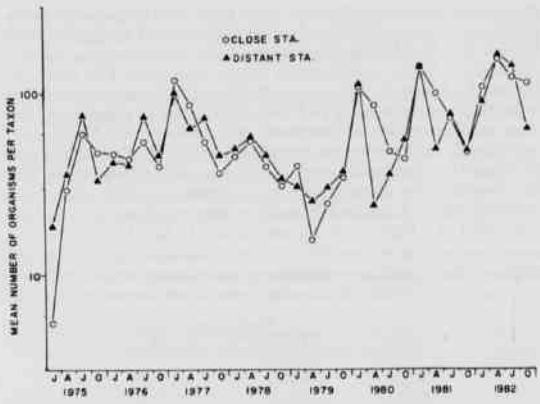

Figure 4. Mean number of zooplankton organisms per taxon for close vs. distant stations in chronological sequence in Dardanelle Reservoir, Arkansas, 1975-1982.

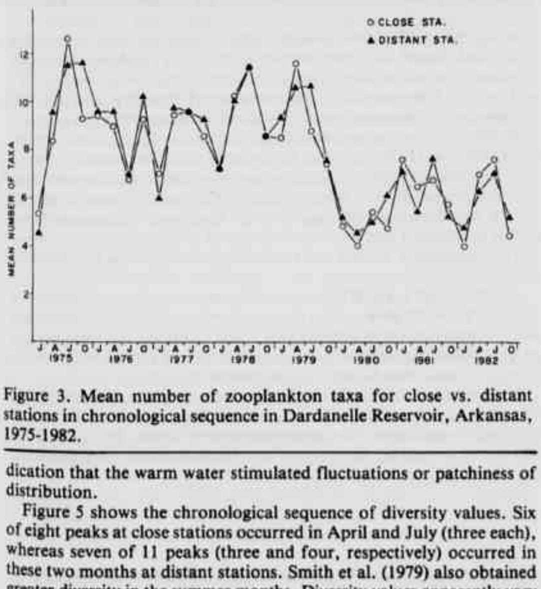

Figure 3. Mean number of zooplankton taxa for close vs. distant stations in chronological sequence in Dardanelle Reservoir, Arkansas, 1975-1982.

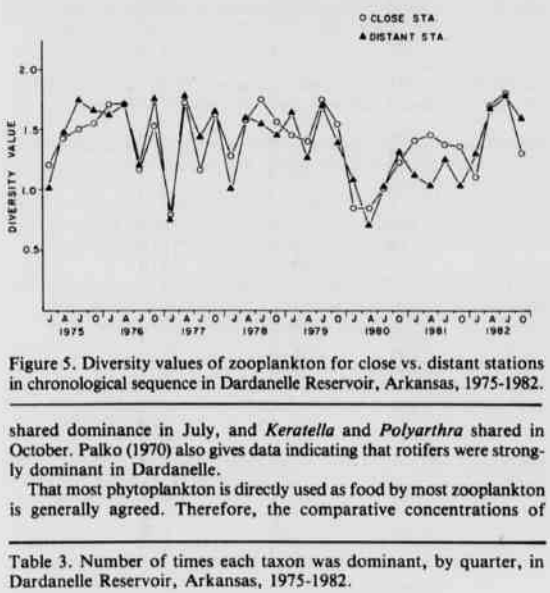

Figure 5. Diversity values of zooplankton for close vs. distant stations in chronological sequence in Dardanelle Reservoir, Arkansas, 1975-1982.

dication that the warm water stimulated fluctuations or patchiness of distribution.

Figure 5 shows the chronological sequence of diversity values. Six of eight peaks at close stations occurred in April and July (three each), whereas seven of 11 peaks (three and four, respectively) occurred in these two months at distant stations. Smith et al. (1979) also obtained greater diversity in the summer months. Diversity values apparently vary more in rivers than in riverine reservoirs (Wilhm et al., 1977). Kochsiek et al. (1971) obtained values from 2.45 to 2.61 near the dam in Keystone Reservoir, Oklahoma, and Prather and Prophet (1969) obtained values from 2.19 to 3.02. Dardanelle zooplankton diversity ranged from 0.71 to 1.82.

In the upper Arkansas drainage apparently rotifers dominate river zooplankton but microcrustaceans dominate in lakes (Hynes, 1972; Kochsiek et al., 1971; Yacovino, 1970). In the Arkansas River within Arkansas, rotifers are dominante in lakes as well as the river sections (Williams, 1963). In Dardanelle Reservoir, rotifers were strongly dominant. Considering individual sampling stations quarterly during the study period, *Polyarthra* was dominant 105 times, *Keratella* 70, *Brachionus* 66 and *Asplanchna* 24 (Table 3). *Polyarthra* was strongly dominant in January, *Keratella* was dominant in April, *Brachionus* and *Polyarthra* shared dominance in July, and *Keratella* and *Polyarthra* shared in October. Palko (1970) also gives data indicating that rotifers were strongly dominant in Dardanelle.

That most phytoplankton is directly used as food by most zooplankton is generally agreed. Therefore, the comparative concentrations of

Table 3. Number of times each taxon was dominant, by quarter, in Dardanelle Reservoir, Arkansas, 1975-1982.

Taxon	Number of times dominant in: January	April	July	October	Total
Polyarthra	48	7	28	22	105
Keratella	10	32	1	27	70
Brachionus	7	13	33	13	66
Asplanchna	5	8	2	9	24
Rotifer sp.	0	9	3	3	15
Miscellaneous (includes other rotifer genera)	6	22	15	21	64

phytoplankton and zooplankton (P/Z ratio) could be used as an indicator of community quality or stability. O'Brien and deNoyelles (1974) showed that the filtering rate of *Ceriodaphnia reticulata* was directly proportional to the concentration of phytoplankton. P/Z ratios for Dardanelle Reservoir are given in Table 4. Close stations had larger ratios than distant stations 19.5 times (one tie) of 32 possibilities. For close and distant stations combined, most peaks occurred in January and July. In general close stations showed higher P/Z ratios. A sharp downward fluctuation occurred in October 1980 through April 1981 as a result of the drought during the summer of 1980 when fewer nutrients were being added from the watershed. The phytoplankton rebounded to a higher than normal density in July 1981.

Table 4. Phytoplankton/zooplankton ratios (using mean abundance) in chronological order, Dardanelle Reservoir, Arkansas, 1975-1982.

	Stations	
Date	Close	Distant
1/75	40.9	15.6
4/75	21.4	17.3
7/75	5.0	4.8
10/75	6.7	6.8
1/76	12.3	15.3
4/76	6.3	6.3
7/76	9.5	15.8
10/76	5.4	3.6
1/77	6.1	11.8
4/77	3.7	6.1
7/77	9.7	7.1
10/77	9.9	7.5
1/78	11.2	7.8
4/78	10.7	10.1
7/78	29.7	18.1
10/78	7.3	5.9
1/79	3.9	4.8
4/79	18.9	13.4
7/79	14.2	12.8
10/79	11.4	8.7
1/80	9.3	8.3
4/80	2.5	10.0
7/80	16.3	14.5
10/80	1.6	0.71
1/81	0.08	0.10
4/81	0.63	1.4
7/81	25.0	23.3
10/81	7.2	8.9
1/82	10.4	8.2
4/82	3.7	3.2
7/82	5.4	5.8
10/82	5.3	8.6
Mean	10.3	9.1

THERMAL IMPACT

Eight genera of zooplankton, including five of rotifers, were considered to be a major taxa in Dardanelle Reservoir by Sinclair and Watson (1978) during five pre-operational years. They ranked each taxon with respect to its annual abundance and listed the month when its peak abundance occurred. We calculated a mean rank for each taxon and listed the months of peak abundances (Table 5). During the eight years of operation, *Polyarthra* replaced *Brachionus* as the most frequently dominant taxon, *Keratella* remained second, and microcrustaceans were virtually eliminated as dominant taxa. There was no significant difference between close and distant stations. Drenner et al. (1981) studied a similar situation in northeast Kansas. The normal July maximum total abundant shifted to May and April after start-up (1973 and 1974, respectively). The overall community abundance increased somewhat, but the heat-tolerant *Bosmina longirostris* exhibited a very strong peak in April 1974. In their study rotifers were unimportant as dominant zooplankton taxa.

Table 5. Mean abundance rank and timing of peak abundances of eight major zooplankton taxa, Dardanelle Reservoir, Arkansas, 1970-1974. (Data from Sinclair and Watson 1978).

Taxon	Mean Rank	Month(s) of Peak Abundance
Brachionus	1.4	MayMayJunJulSep
Keratella	2.4	MarAprMayJulSepOct
Polyarthra	4.6	JunJulSepSepDec
Cyclops	4.6	AprAprAprJulSep
Bosmina	4.8	MarAprAprMayJun
Asplanchna	7.2	MayMayMayJunOct
Filinia	8.4	MarMarAprJulAug
Daphnia	9.2	MayMayJulJulAug

Miller et al. (1976) studied the discharge of a power plant on the Ohio River and found the zooplankton community declined from 200 organisms per liter to 10 per liter in a discharge canal with average ΔT's of 7 to 8 °C. Part was due to natural seasonal mortality, and part was due to elevated temperatures. This mortality was also taxon selective affecting large cladocerans most. Under experimental conditions in New York, Carlson (1974) obtained increases in microcrustacean diversity with temperatures up to 5 °C above ambient, but a marked reduction was observed at 13.5 °C above ambient. The most successful species overall was *Ceriodaphnia quadrangula*. In eastern Tennessee, Gehrs (1974) determined that heated water caused deeper vertical migration of two species of *Daphnia*. This action might contribute to decreased productivity.

Anderson and Lenat (1978) noticed an increase in overall density of *Hexarthra* and *Ptygura* and an increase in winter density of *Polyarthra* due to heated effluent in Belews Lake, North Carolina. They also noticed greater spatial and seasonal homogeneity in heated surface water which may have been due, in part, to the forced circulation.

A noteworthy concern has been the effects of plant shutdown once the aquatic community has become adjusted to the thermal discharge. Although a sudden decline in temperature narcotizes threadfin shad *(Dorosoma petenense)*, fluctuations in the zooplankton community were not attributable to the same.

CONCLUSIONS

A major difficulty of this type of study is the scarcity of comparable data. Most projects of this nature have occurred in the northeastern part of the United States where microcrustacean taxa seem to be routinely dominant. In the Arkansas River drainage microcrustaceans trade off with rotifers. From northeast Oklahoma upstream, rotifers dominate truly riverine sections, whereas microcrustaceans dominate lakes. However, within Arkansas (and possibly part of Oklahoma) rotifers seem to dominate in both major habitats.

In general the annual abundance peak occurred in July in Dardanelle Reservoir, but it wasn't particularly strong. Variety was also greatest in July. Community diversity was lowest in January and about constant the rest of the year. P/Z ratios were highly variable exhibiting peaks in January and July (except the uncommonly steep slump in January 1981).

Plant start-up and thermal discharge caused a dominance shift between the rotifer genera *Brachionus* and *Polyarthra* (the latter moved from third to first). Heated effluent also slightly suppressed overall abundance and variety but had no obvious effect on diversity. Other studies have shown that slight temperature increases stimulated zooplankton, but they dealt with communities in which microcrustaceans were dominant. Similar data on rotifer-dominated communities were unavailable. In Dardanelle Reservoir the P/Z ratios were generally greater at close stations indicating the phytoplankton was stimulated or zooplankton was depressed or both. The phytoplankton data indicated both phenomena occurred.

ACKNOWLEDGMENTS

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LITERATURE CITED

ANDERSON, T. P., and D. R. LENAT. 1978. Effects of power-plant operation on the zooplankton community of Belews Lake, North Carolina. *In* Energy and Environmental Stress in Aquatic Systems, ed. by J. H. Thorp and J. W. Gibbons, DOE Conf. No. 771114, pp. 618-641.

BOWLES, L. G., and J. WILHM. 1977. Effects of patchiness on estimates of concentration and species diversity of pelagic net plankton. Southw. Nat., 21(4):463-468.

CARLSON, D. M. 1974. Responses of planktonic cladocerans to heated waters. *In* Thermal Ecology, I, ed. by J. W. Gibbons and R. R. Sharitz, AEC Symposium Series, pp. 186-206.

DRENNER, R. W., G. L. VINEYARD, W. J. O'BRIEN, J. R. TRIPLETT, and J. WAGNER. 1981. The zooplankton community of LaCygne Lake: a cooling pond in Kansas. Southw. Nat., 26(3):243-249.

EDMONDSON, W. T. 1965. Reproductive rate of planktonic rotifers as related to food and temperature in nature. Ecol. Monogr., 35:61-110.

EDMONDSON, W. T. 1969. Freshwater Biology. John Wiley & Sons, New York, 1248 pp.

GEHRS, C. W. 1974. Vertical movement of zooplankton in response to heated water. *In* Thermal Ecology, I, ed. by J. W. Gibbons and R. R. Sharitz, AEC Symposium Series, pp. 285-290.

HYNES, H. B. N. 1972. Ecology of running waters. Univ. of Toronto Press, Toronto, 555 pp.

KOCHSIEK, K. A., J. L. WILHM, and R. MORRISON. 1971. Species diversity of net zooplankton and physico-chemical conditions in Keystone Reservoir, Oklahoma. Ecology, 53:1119-1125.

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

MILLER, M. C., G. R. HATER, T. W. FEDERLE, and J. P. REED. 1976. Effects of power-plant operation on the biota of a thermal discharge channel. *In* Thermal Ecology, II, ed. by G. W. Esch and R. W. McFarlane, ERDA Symposium Series 40, pp. 251-258.

O'BRIEN, J. W., and F. DENOYELLES, JR. 1974. Filtering rate of *Ceriodaphnia reticulata* in pond waters of varying phytoplankton concentration. Amer. Midl. Nat., 91(2):509-512.

PALKO, T. N. 1970. A preliminary study of zooplankton over a six month period on Lake Dardanelle. Proc. Ark. Acad. Sci., XXIV: 55-61.

PRATHER, J. E., and C. W. PROPHET. 1969. Zooplankton species diversity in John Redmond, Marion and Council Grove Reservoirs, Kansas, Summer 1968. Emporia St. Res. Stud., 18(1):1-16.

SCHMITZ, E. H. 1974. Limnetic zooplankton dynamics in Beaver Reservoir including an inventory of copepod species and an evaluation of vertical sampling methods. Ark. Water Res. Res. Center, Publ. No. 20.

SCHMITZ, E. H. 1975. Zooplankton limnology of Beaver and DeGray Reservoirs in Arkansas. Ark. Water Res. Res. Center. Publ. No. 40.

SCHMITZ, E. H. 1978. Zooplankton limnology of Beaver and DeGray Reservoirs in Arkansas. Ark. Water Res. Res. Center, Publ. No. 55.

SINCLAIR, C. B., and R. L. WATSON. 1978. A primary ecological survey of Dardanelle Reservoir prior to nuclear facility effluent discharge. Ark. Water Res. Res. Center, Publ. No. 60, 45 pp.

SMITH, G. A., L. C. FITZPATRICK, and W. D. PEARSON. 1979. Structure and dynamics of a zooplankton community in a small northcentral Texas pond ecosystem. Southw. Nat., 24(1):1-16.

WILHM, J., T. DORRIS, J. R. SEYFER, and N. MCCLINTOCK. 1977. Seasonal variation in plankton populations in the Arkansas River near the confluence of Red Rock Creek. Southw. Nat., 22(4):1411-420.

WILLIAMS, L. G. 1963. Plankton population dynamics. Nat. Water Qual. Network, Publ. Health Serv., U.S. Dept. HEW, Cincinnati, 90 pp.

YACOVINO, J. T. 1970. Distribution and abundance of the zooplankton of Canton Reservoir, Oklahoma. Proc. Okla. Acad. Sci., 50:87-90.