THE EFFECTS OF THE FOSS DEMINERALIZATION PLANT ON THE BENTHOS OF THE WASHITA RIVER

PROJECT REPORT

OKLAHOMA WATER RESOURCES BOARD

THE EFFECTS OF THE FOSS DEMINERALIZATION PLANT ON THE BENTHOS OF THE WASHITA RIVER

STATE OF OKLAHOMA

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OKLAHOMA WATER RESOURCES BOARD

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TABLE OF CONTENTS

ACKNOLEDGMENTS

This project was initiated by the Oklahoma Water Resources Board (OWRB). It was originally proposed by D.A. Haws, W.D. Motsenbocker and R.W. Gasper. Robert Kellogg, ~~counselor, Oklahoma State Department of Health~~ and Zack Williams, ~~OG&E environmental biologist~~, collected most of the specimens and identified some of the phase I samples. Ken Morris, project supervisor, OWRB, was extremely helpful in supplying information about the early parts of the project and in suggesting revisions of this manuscript. Alan Covich, Zoology, University of Oklahoma, also helped by reviewing this manuscript. This project was funded by the OWRB.

CONCLUSIONS

1. The FDP and Foss Reservoir are in violation of state water quality standards with respect to benthic diversity.
2. The diversity in the Washita River was high prior to the FDP and Foss Reservoir releases. The decreases in diversity of one Shannon-Weaver unit is related to the increase in TDS in the river water which is due to the discharge of brine from the FDP and the increased release of Foss Reservoir water.
3. The decrease in diversity has caused a reduction of the important insect grazing community and could possibly have a major impact on the entire stream community.
4. Many dissolved salts increased in the Washita River after the FDP began operation. It is currently impossible to name any one salt or group of salts that are completely responsible. However, the source is largely from gypsum, so sulfates are probably important. High sulfate and chloride concentrations are known to have a detrimental effect on freshwater systems. There is an apparent build up of hydrogen sulfide in the stream sediments toward Clinton, Oklahoma.

RECOMMENDATIONS

1. More information is needed concerning the effect of various dissolved salts (especially sulfates and sulfides) on benthic macroinvertebrates and other organisms (e.g. fish, crayfish, etc.).
2. An effort should be made to reduce the salt concentration in the Washita River which is due to the discharge of brine from the FDP and increased discharge of water from Foss Reservoir.
3. Further study should be made to determine the magnitude of the contribution of the FDP and the Foss Reservoir to the increased salinity in the Washita River so that control methods can be apportioned correctly.
4. Continued high rates of discharge of water from Foss Reservoir may result in the long term effect of exchanging the water in the reservoir with water of lower salinity and could eventually have a beneficial effect on the reservoir and the Washita River downstream from it.
5. Careful consideration should be given to the future construction of reservoirs in the western part of the state. Increases in salinity of these shallow reservoirs due to high evaporation rates seems inevitable and will yield them unsuitable for public drinking supplies. Efforts to install demineralization plants that have high TDS brine discharges will likely have the same effect as the FDP.
6. Most benthic sampling programs allow only for the subsampling of benthic communities. Therefore, the Shannon-Weaver index should continue to be used. The Brillouin diversity index should be excluded from studies of this type and used only when the entire community is sampled.

4. Further study is needed to determine how violations of this nature should be addressed legally (i.e., when a water quality standard is violated by a combination of two entities).

LIST OF ILLUSTRATIONS

LIST OF TABLES

ABSTRACT

The Oklahoma Water Resources Board conducted a study to determine the effect of discharge of brine from the Foss Demineralization Plant (FDP) on the benthic community of the Washita River between Foss Reservoir and Clinton, Oklahoma. The study consisted of phase I (February, 1973 to January, 1974) which was before the FDP began operation and phase II (July, 1975 to January, 1976) which was after the FDP began operation. A large increase in the salinity of the Washita River occurred during phase II. This increase in salinity resulted in a decrease in benthic diversity of approximately 1.0 Shannon-Weaver unit because of the reduction of various types of grazing aquatic insects (especially mayflies). This could have a severe effect on the rest of the stream community. Further study is needed concerning the effects of various dissolved salts (especially sulfates and chlorides) on the aquatic community. The salinity in the Washita River should be reduced by decreasing the discharge of saline waters in either the FDP or Foss Reservoir or both, but this is difficult to do and still supply water to the surrounding communities.

SECTION 1

INTRODUCTION

The Oklahoma Water Resources Board (OWRB) implemented a study of the Washita River between Foss Reservoir and Clinton, Oklahoma in 1973 to determine the impact of the Foss Reservoir demineralization plant (FDP) on the river. The FDP is presently discharging waste brine into the river just downstream from the Foss Reservoir dam. The study consisted of two phases. Phase I lasted from February, 1973 to January, 1974 before the FDP began operation. Phase II lasted from July, 1975 to June, 1976 after the FDP began discharging brine into the river.

A large number of chemical and physical parameters were monitored during both phases. Only pH remained constant. Alkalinity decreased and almost all dissolved salts doubled in concentration from phase I to phase II. These include sulfates, chlorides and total dissolved solids (TDS). All of these changes were statistically significant differences. The increase in dissolved solids is due to the FDP discharge and the increased discharge of water from Foss Reservoir to augment the brine discharge. Foss Reservoir has also been increasing in salinity since 1961. Before phase II, discharge from Foss Reservoir was intermittant. The OWRB found the chemical changes in the Washita River to be within the range of the Oklahoma water standards for use as irrigation (OWRB[1]). More detailed discussions of the chemical aspects of this study are given in Madden[3], OWRB[2] and Madden and Morris[4].

The biological community was also investigated with respect to stream benthos during the two phases. This report deals with the impact of the FDP on the benthos.

SECTION 2

MATERIALS AND METHODS

Benthic samples were collected by the OWRB at ten sites in the Washita River between Foss Reservoir and Clinton, Oklahoma during phases I and II. All sites were downstream from the FDP discharge. A map of the site locations is given in Madden[3]. A description of each site is given in appendix 1. At each site, four grab samples were collected with a petit ponar dredge. Each ponar grab sample had a surface area of $0.023m^2$. The samples were preserved in 95.0% ethanol with rose bengal stain to facilitate sorting organisms from the sediments. Care was taken to sample equally all substrate microhabitats that existed at each site. Some of these preserved samples were sorted and/or identified by members of the OWRB. The remainder were processed by the author.

The organisms were identified to genus using appropriate keys (Pennak[5], Hilsenhoff[6], Edmunds et al[7], Wiggins[8], and Mason[9]). The Oligochaeta, Nematoda and Diptera (pupae) were not identified to genus. The oligochaetes and nematodes were usually fragmented due to the methods of processing. This rendered them unidentifiable. Dipteran pupae could not be identified to genus. Therefore, these three groups were excluded from all diversity and similarity calculations. The following dates for both phases were available:

Phase I	Phase II
April, 1973	April, 1976
June, 1973	June, 1976
July, 1973	July, 1975
August, 1973	August, 1975
October, 1973	October, 1975
January, 1974	January, 1976

This comparison provided information on the benthic community over all Four seasons.

All statistical analyses were performed according to Sokal and Rohlf[10] and Barr et al[11]. Generic diversity was calulated with the Shannon-Weaver index and Brillouin's index (Wilhm[12]). The four samples at each site were added together to calculate site diversity. In a few sites during phase II, the sample sizes were < 100 for a site. This low density is a reflection of low diversity at the particular site and does not indicate an inadequate sample. In all statistical comparisons, the diversities were averaged over all sites for each month to month comparison. This procedure effectively insures that the mean sample size was > 100. The Oklahoma Water Quality Standards for 1976 state that sample sizes for calculating diversity must be > 100 (OWRB[1]). Evenness was calculated according to Pielou[13]. This method provides an equivalent measure of redundancy according to Margalef[14]. Similarity measurements for phase I to phase II comparisons were calculated using the formula in the Oklahoma Water Quality Standards for 1976 (OWRB[1]).

SECTION 3

RESULTS AND DISCUSSION

Two-way analysis of variances (ANOVA) without replication were performed on the Shannon-Weaver and Brillouin diversity values. Months during phases I and II and sites along the Washita River were used as main factors in both ANOVA's. Significant differences were found between months and between sites for both diversity indices (Table 1a&b). There are several differences between substrate, water depth and flow conditions at various sites (see Appendix 1). These are probably responsible for the differences in diversity among sites. The differences between months could be due to seasonal changes in species composition, differences in community composition between the two phases or other physical factors.

Duncan's multiple range tests were performed to help delineate the differences between months. Duncan's test on Shannon-Weaver diversities produced two main groups at the $P > 0.05$ level of significance (Table 2). The first group with higher diversities consists mostly of phase I months. It also includes October, 1975, a phase II month. The second group is of lower diversity and consists mostly of phase II months. It also includes January, 1974 which is a phase I month. Diversity values were high in both phases for October and low in both phases for January. These two months represent seasonal variation in diverstiy. However, most of the variation seems to be explained between phase I and phase II. The average diversity in phase II is approximately one Shannon-Weaver diversity unit lower than during phase I.

The results of Duncan's test on Brillouin diversity values are somewhat more complex (Table 3). Diversity values with this index are

Table 1. Results of the two way analysis of variance without replication. The main factors are months during phases I and II and sites along the Washita River.

A. ANOVA of Shannon-Weaver diversity values.

Factor	DF	F value	P > F
Month	11	7.91 ***	0.0001
Site	9	3.07 **	0.0028

B. ANOVA of Brillouin diversity values.

Factor	DF	F value	P > F
Month	11	9.85 ***	0.0001
Site	9	3.67 ***	0.0006

Mean diversity	Number of Sites	Date (Phase)
3.1846	10	August, 1973(I)
2.8819	10	October, 1973(I)
2.8282	10	July, 1973(I)
2.7956	10	April, 1973(I)
2.6546	10	October, 1975(II)
2.5828	10	June, 1973(I)
1.9196	10	July, 1975(II)
1.8919	10	January, 1974(I)
1.8688	10	August, 1975(II)
1.8207	10	April, 1976(II)
1.5872	10	June, 1976(II)
1.4652	10	January, 1976(II)

Table 2. Duncan's multiple range test with Shannon-Weaver diversity values. The continuous lines indicate significant groups at $P > 0.05$.

Mean diversity	Number of Sites	Date (Phase)
2.1075	10	August, 1973(I)
1.7429	10	October, 1973(I)
1.6893	10	July, 1973(I)
1.6585	10	April, 1973(I)
1.5857	10	October, 1975(II)
1.4158	10	June, 1973(I)
1.2266	10	January, 1974(I)
1.1162	10	April, 1976(II)
1.0395	10	August, 1975(II)
1.0001	10	July, 1975(II)
0.8937	10	January, 1976(II)
0.8335	10	June, 1976(II)

Table 3. Duncan's multible range test with Brillouin diversity values. The continuous lines indicate significant groups at $P > 0.05$.

lower overall when compared to the Shannon-Weaver diversity index. This resulted in the formation of some small overlapping groups. The months are ranked in almost the same order as with the Shannon-Weaver index. There are still two main groups consisting of phase I and phase II months respectively. Phase II months are approximately 0.7 Brillouin diversity units lower than during phase I.

Morris and Madden[22] suggest using the Brillouin index when n (sample size) < 100 and the Shannon-Weaver index when $n > 100$. By this criterion the Shannon-Weaver index should be used in this study. Brillouin's index is affected by sample size (Allan[15]). It should be used when the entire sample population can be examined (Pielou[16,17]). In this study, it was only possible to subsample the entire benthic community. The sampling was adequate to insure the inclusion of almost all species. Therefore, the Shannon-Weaver index should be used in a situation similar to this type of sampling (Pielou[16,17]). On the basis of the Shannon-Weaver index, the FDP does not meet the state's water quality standards (OWRB[1]).

Species evenness values were calculated and are given in Tables 4&5 along with a complete list of diversity values for each month and site. Generally, species evenness is high during both phases.

Species similarities between phase I and II months are given in Table 6. These are low and are due to a decrease in the number of genera in phase II collections. Almost all insect groups changed in generic composition during phase II. Among the Ephemeroptera (mayflies), Caenis, Baetis and Tricorythodes were abundant during phase I (Fig. 1&2), but decreased significantly in phase II. The Trichoptera (caddisflies) were not very common in either phase (Fig. 3), but Cheumatopsyche showed decreased

Table 4. Shannon-Weaver diversity values (H') and evenness values (J) for each month and site during phases I and II.

Date	Site	H'	J
April 1973	1	3.028	0.688
	2	3.321	1.037
	3	1.459	0.946
	4	2.846	0.718
	5	4.191	0.966
	6	3.938	1.024
	7	2.781	0.838
	8	1.912	0.647
	9	2.284	0.936
	10	2.281	0.965
June 1973	1	2.707	1.030
	2	2.015	0.725
	3	2.964	1.005
	4	3.126	1.094
	5	2.452	0.957
	6	2.311	0.801
	7	3.368	1.044
	8	2.633	0.959
	9	2.054	0.772
	10	2.198	1.027
July 1973	1	2.754	0.987
	2	2.644	0.839
	3	3.177	0.936
	4	3.344	0.996
	5	2.836	0.913
	6	2.064	0.544
	7	3.484	0.942
	8	2.525	0.815
	9	2.932	0.909
	10	2.522	0.666
August 1973	1	2.776	0.937
	2	3.669	0.834
	3	2.675	0.680
	4	3.026	0.784
	5	3.549	0.875
	6	3.775	0.863
	7	3.602	0.921
	8	3.405	0.809
	9	3.097	0.854
	10	2.272	0.871

Table 4. Continued.

Date	Site	H'	J
October 1973	1	3.690	1.149
	2	2.430	0.578
	3	3.614	0.928
	4	3.114	0.871
	5	3.526	0.844
	6	2.746	0.831
	7	1.985	0.692
	8	2.355	0.833
	9	2.770	0.818
	10	2.588	0.921
January 1974	1	2.495	0.646
	2	2.543	0.624
	3	1.259	0.325
	4	1.149	0.316
	5	2.322	0.584
	6	2.493	0.549
	7	2.494	0.657
	8	1.785	0.942
	9	1.327	0.509
	10	1.052	0.678
July 1975	1	3.141	0.748
	2	0.918	0.898
	3	0.918	0.871
	4	1.919	1.018
	5	2.914	0.771
	6	2.804	0.818
	7	2.156	1.021
	8	2.976	1.060
	9	0.794	0.545
	10	0.656	0.389
August 1975	1	3.053	0.996
	2	0.000	0.000
	3	1.585	0.992
	4	2.632	0.770
	5	2.398	0.811
	6	2.189	1.008
	7	3.028	0.906
	8	1.352	0.756
	9	2.036	0.742
	10	0.414	0.449

Table 4. Continued.

Date	Site	H'	J
October 1975	1	1.360	0.605
	2	2.661	0.880
	3	3.683	0.374
	4	3.267	0.878
	5	3.460	0.850
	6	2.477	0.852
	7	2.145	0.888
	8	2.694	0.695
	9	2.843	0.976
	10	2.451	1.092
January 1976	1	0.511	0.176
	2	1.997	0.652
	3	0.900	0.425
	4	1.095	0.397
	5	1.194	0.338
	6	2.687	0.737
	7	2.436	0.872
	8	1.015	0.536
	9	1.677	0.903
	10	1.140	0.766
April 1976	1	2.810	0.785
	2	1.884	0.555
	3	2.453	0.757
	4	0.707	0.268
	5	1.744	0.572
	6	1.128	0.364
	7	2.077	0.920
	8	1.768	0.730
	9	2.279	0.885
	10	1.357	0.775
June 1976	1	0.000	0.000
	2	1.334	0.658
	3	1.500	0.964
	4	2.376	0.931
	5	2.764	0.965
	6	2.275	0.783
	7	1.646	0.871
	8	1.371	0.907
	9	1.371	0.907
	10	1.235	0.811

Table 5. Brillouin diversity values (H") for each month and site during phases I and II.

Date	Site	H"	Date	Site	H"
April 1973	1	1.990	June 1973	1	1.390
	2	1.819		2	1.226
	3	0.682		3	1.633
	4	1.841		4	1.588
	5	2.605		5	1.353
	6	2.325		6	1.369
	7	1.620		7	1.860
	8	1.139		8	1.498
	9	1.344		9	1.172
	10	1.221		10	1.069
July 1973	1	1.485	August 1973	1	1.508
	2	1.592		2	2.443
	3	1.980		3	1.772
	4	1.902		4	1.946
	5	1.585		5	2.342
	6	1.336		6	2.504
	7	2.095		7	2.331
	8	1.479		8	2.239
	9	1.792		9	1.936
	10	1.647		10	2.054
October 1973	1	1.911	January 1974	1	1.656
	2	1.602		2	1.717
	3	2.231		3	0.837
	4	1.956		4	0.766
	5	2.268		5	1.544
	6	1.582		6	1.667
	7	1.215		7	1.634
	8	1.358		8	0.944
	9	1.768		9	0.835
	10	1.538		10	0.666
July 1975	1	1.301	August 1975	1	1.701
	2	0.451		2	0.000
	3	0.366		3	0.597
	4	0.866		4	1.638
	5	1.878		5	1.385
	6	1.739		6	1.136
	7	1.015		7	1.856
	8	1.569		8	0.697
	9	0.450		9	1.145
	10	0.367		10	0.234

Table 5. Continued.

Date	Site	H"	Date	Site	H"
October 1975	1	1.281	January 1976	1	0.330
	2	2.105		2	1.244
	3	0.890		3	0.547
	4	1.740		4	0.686
	5	1.815		5	0.776
	6	1.753		6	1.765
	7	2.202		7	1.462
	8	1.476		8	0.648
	9	1.256		9	0.867
	10	1.339		10	0.612
April 1976	1	1.799	June 1976	1	0.000
	2	1.219		2	0.728
	3	1.551		3	0.621
	4	0.441		4	1.211
	5	1.073		5	1.566
	6	0.733		6	1.371
	7	1.297		7	0.919
	8	1.084		8	0.599
	9	1.307		9	0.599
	10	0.658		10	0.722

Table 6. Similarity index values for phase I to phase II comparison months.

Months compared	Number of Genera (I)	Number of Genera (II)	Genera in Common	S
April 1973-1976	44	26	19	0.543
June 1973-1976	26	21	10	0.426
July 1973-1975	41	26	18	0.537
August 1973-1975	44	25	14	0.406
October 1973-1975	42	36	27	0.692
January 1974-1976	34	24	17	0.586

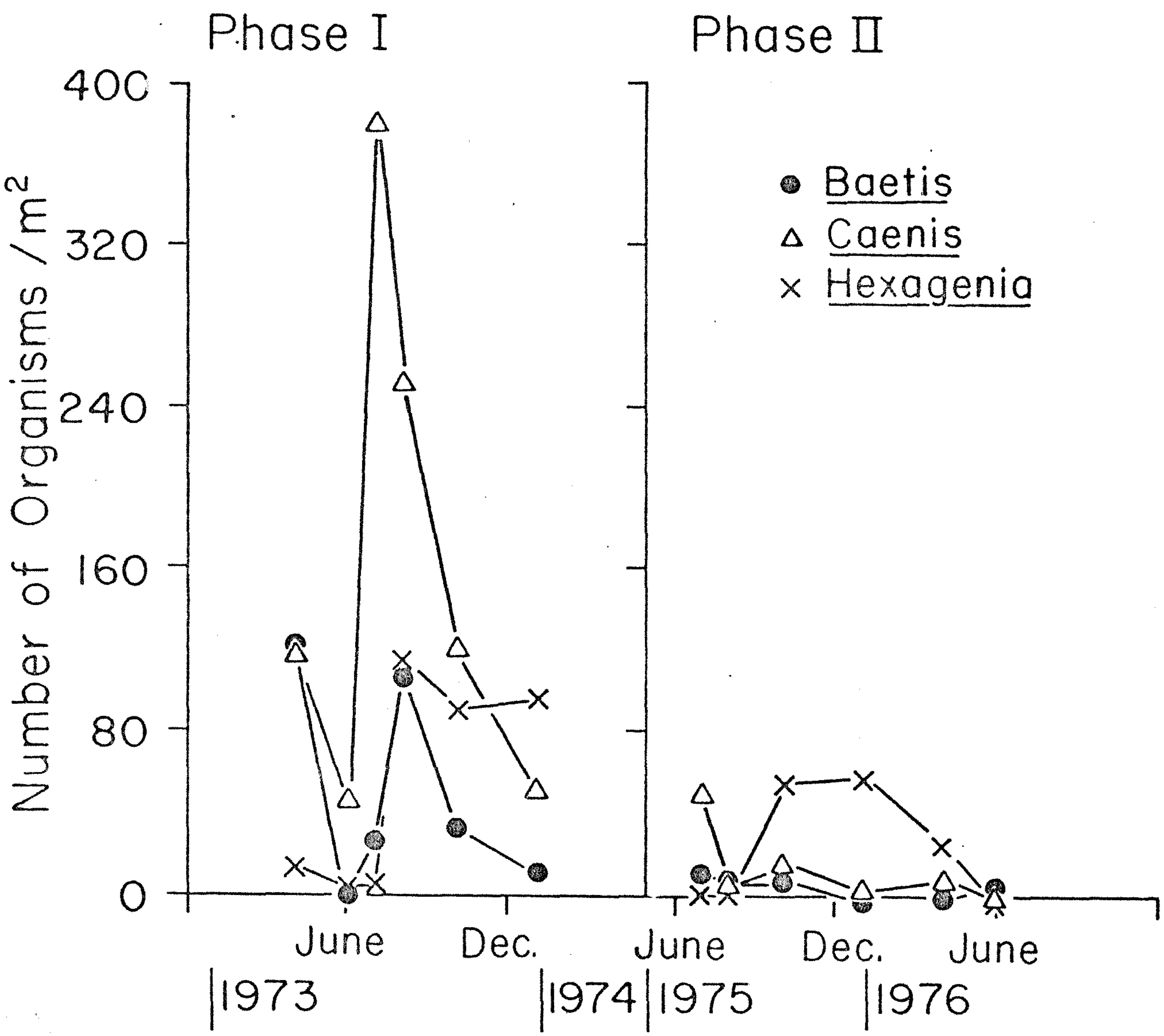

Figure 1. Densities of some Ephemeroptera in the Washita River during phases I and II.

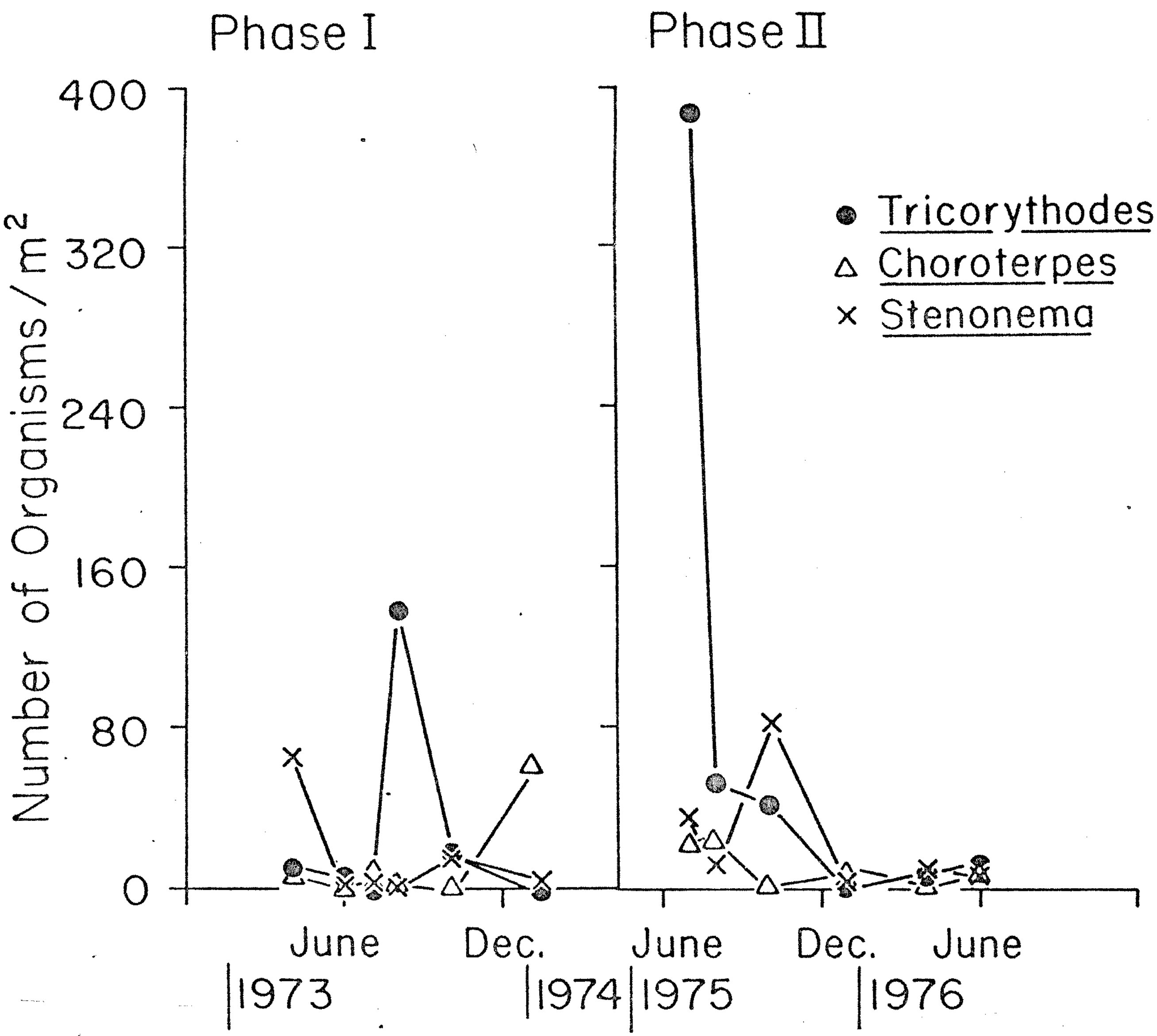

Figure 2. Densities of some Ephemeroptera in the Washita River during phases I and II.

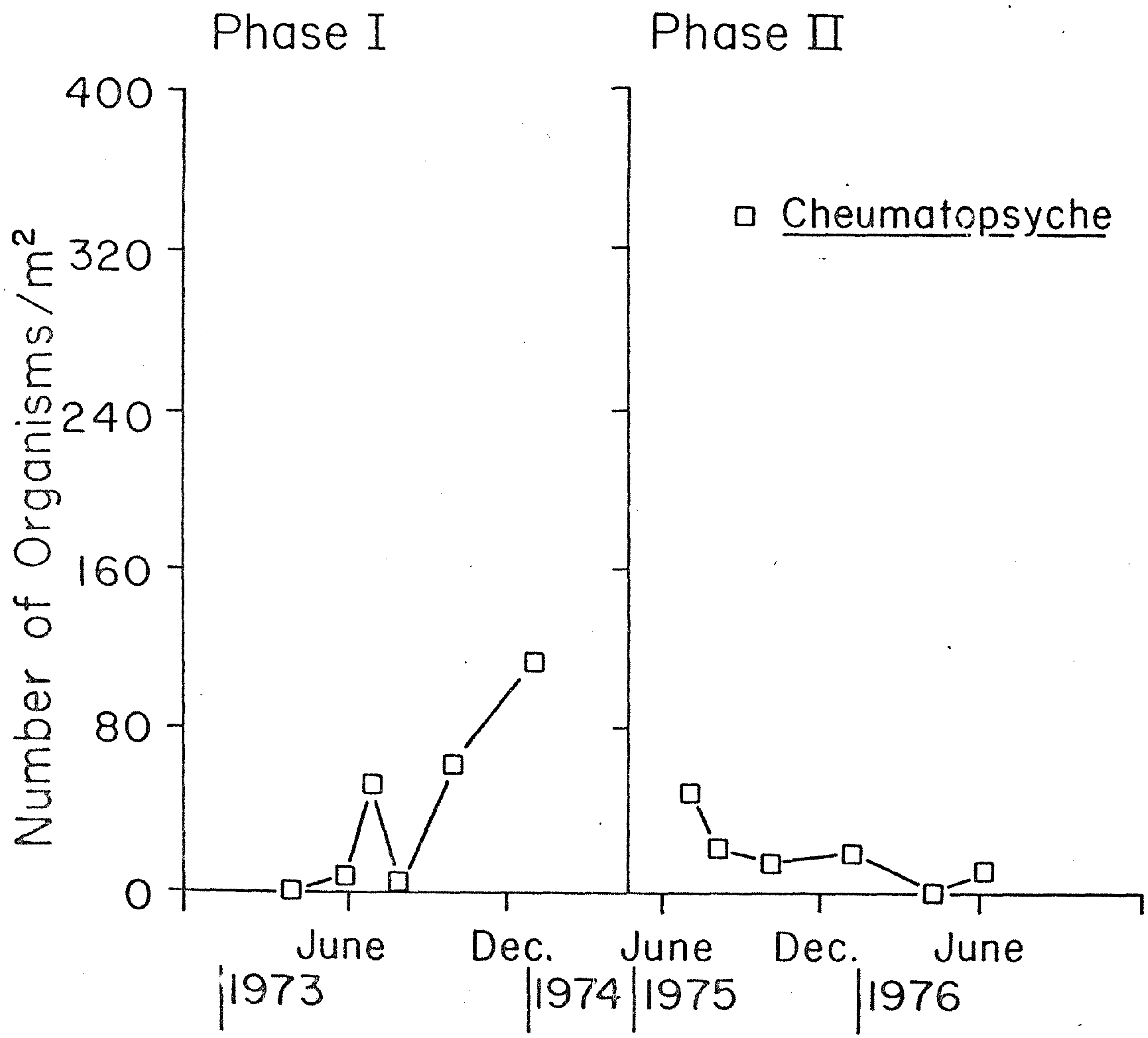

Figure 3. Densities of some Trichoptera in the Washita River during phases I and II.

numbers in phase II samples. It was abundant on sticks and snags during visits to the Washita River in 1979. These substrates extend into the open water. The Coleoptera also showed decreases, especially in Dubiraphia (Fig. 4). Diptera remained abundant, but changed generic composition. Cricotopus decreased but was still quite abundant (Fig. 5). Palpomyia, Cryptochironomus and Polypedilum also decreased. Stictochironomus, Chironomus and Rheotanytarsus increased during phase II (Fig. 6). Chironomus species have been found to be common in saline waters (Topping[18] and Lauer[19]).

Streams in the southwest U.S. are probably autotrophic systems with periphyton responsible for most of the production (Minshall[20]). Wiggins and Mackay[21] give supporting evidence for this and show that grazing insects are more abundant in western streams than in eastern streams, and ~~They also state that~~ the generic level of identification should be indicative of an ecological type because it implies certain differences in structural morphology between genera. The mayflies are mostly grazers, feeding on periphyton and detritus. The chironomids (Diptera) are also feeders of periphyton and detritus. The Coleoptera present were mostly elmids, ~~These are~~ usually associated with detritus. Cheumatopsyche (Trichoptera) are collectors and feed mostly by netting food particles in the water. The decrease in density of grazing genera, especially mayflies, indicates that the benthic community may not be able to process periphyton as it did during phase I. This reduction in benthic grazers could have a major impact on the entire stream community. The decrease in the number of genera during phase II results in a decrease in the number of ecological niches being used, and ~~This decrease also~~ means that not as many forms of periphyton and detritus can be processed as in phase I.

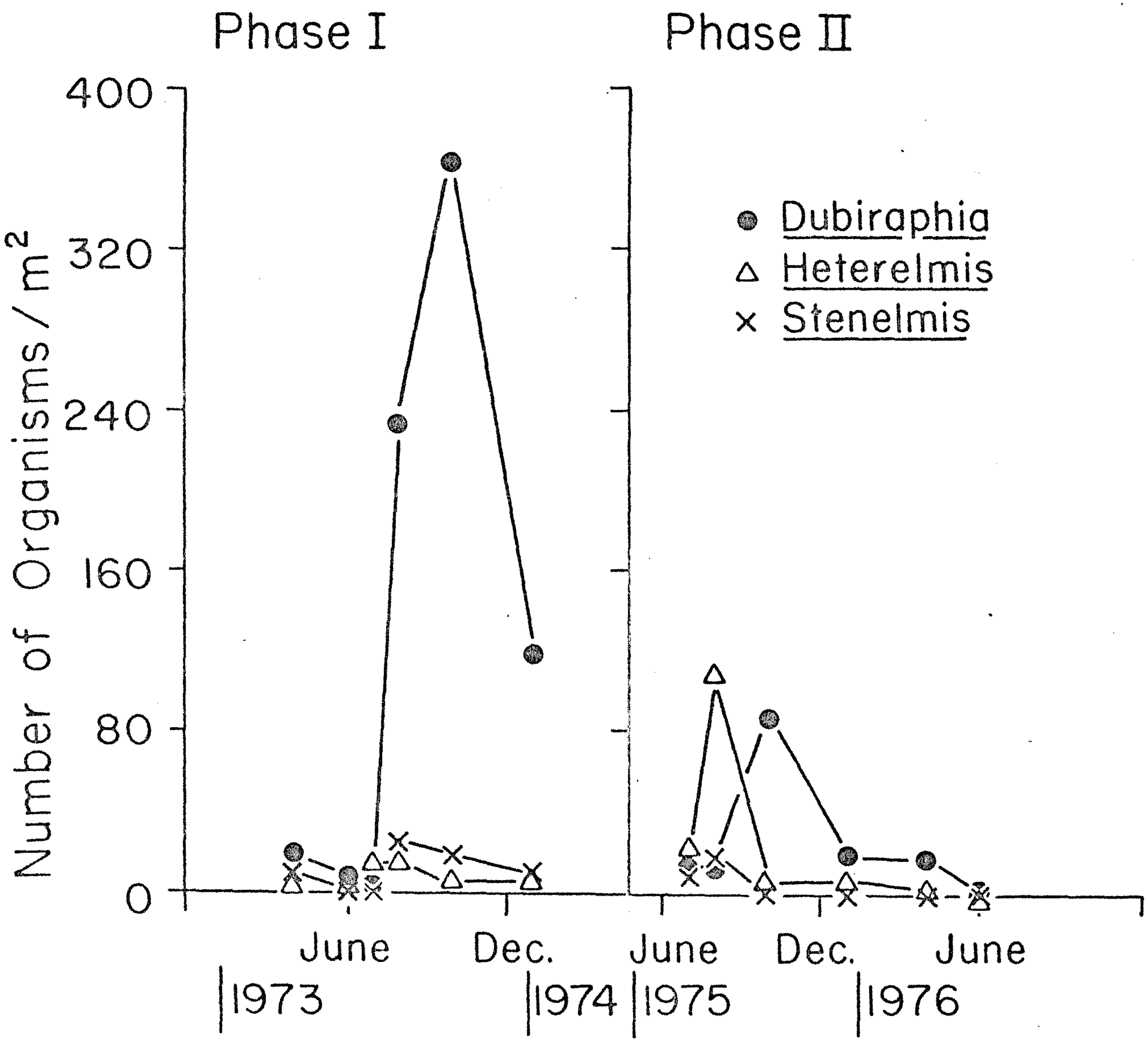

Figure 4. Densities of Coleoptera in the Washita River during phases I and II.

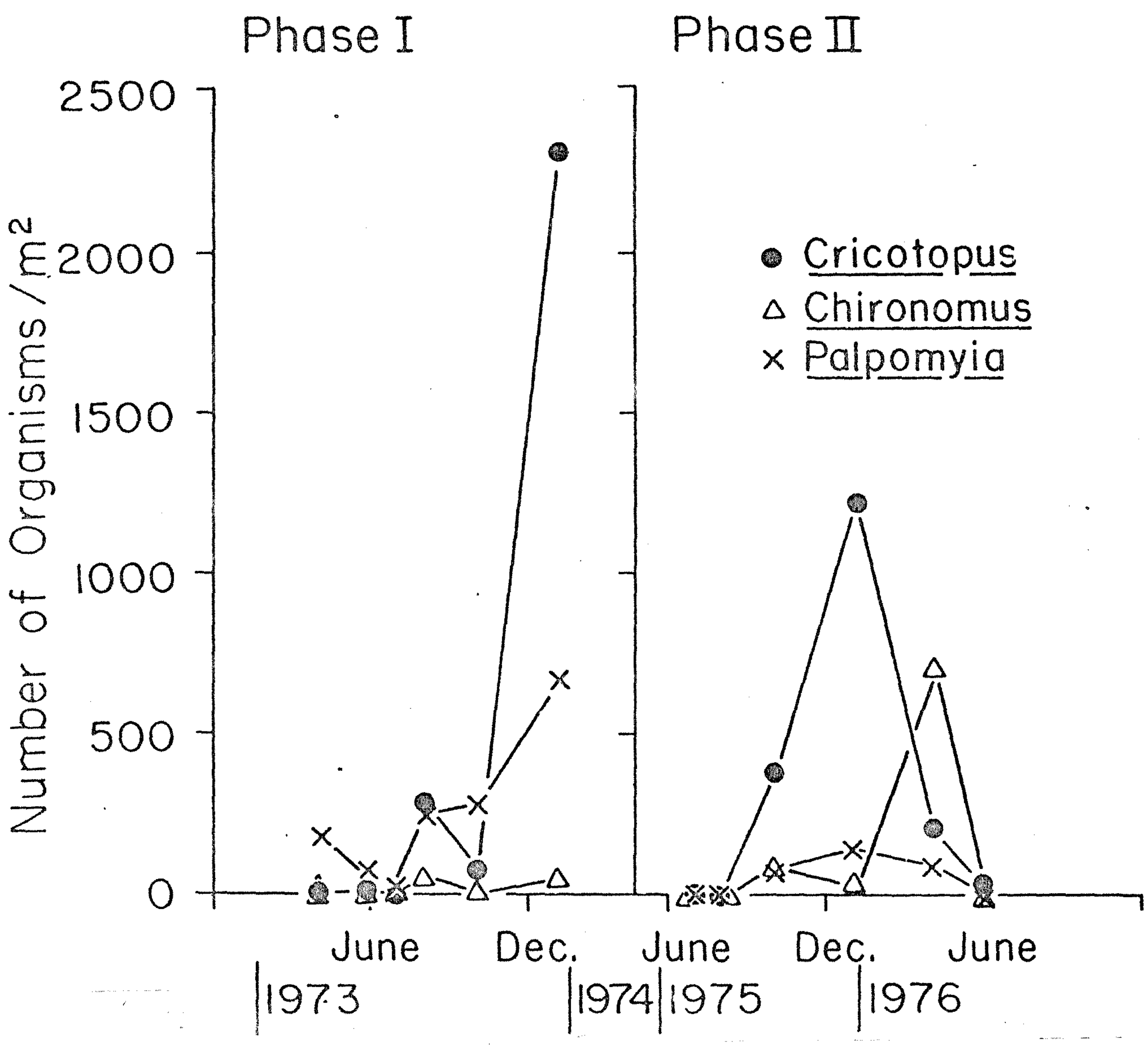

Figure 5. Densities of some Diptera in the Washita River during phases I and II.

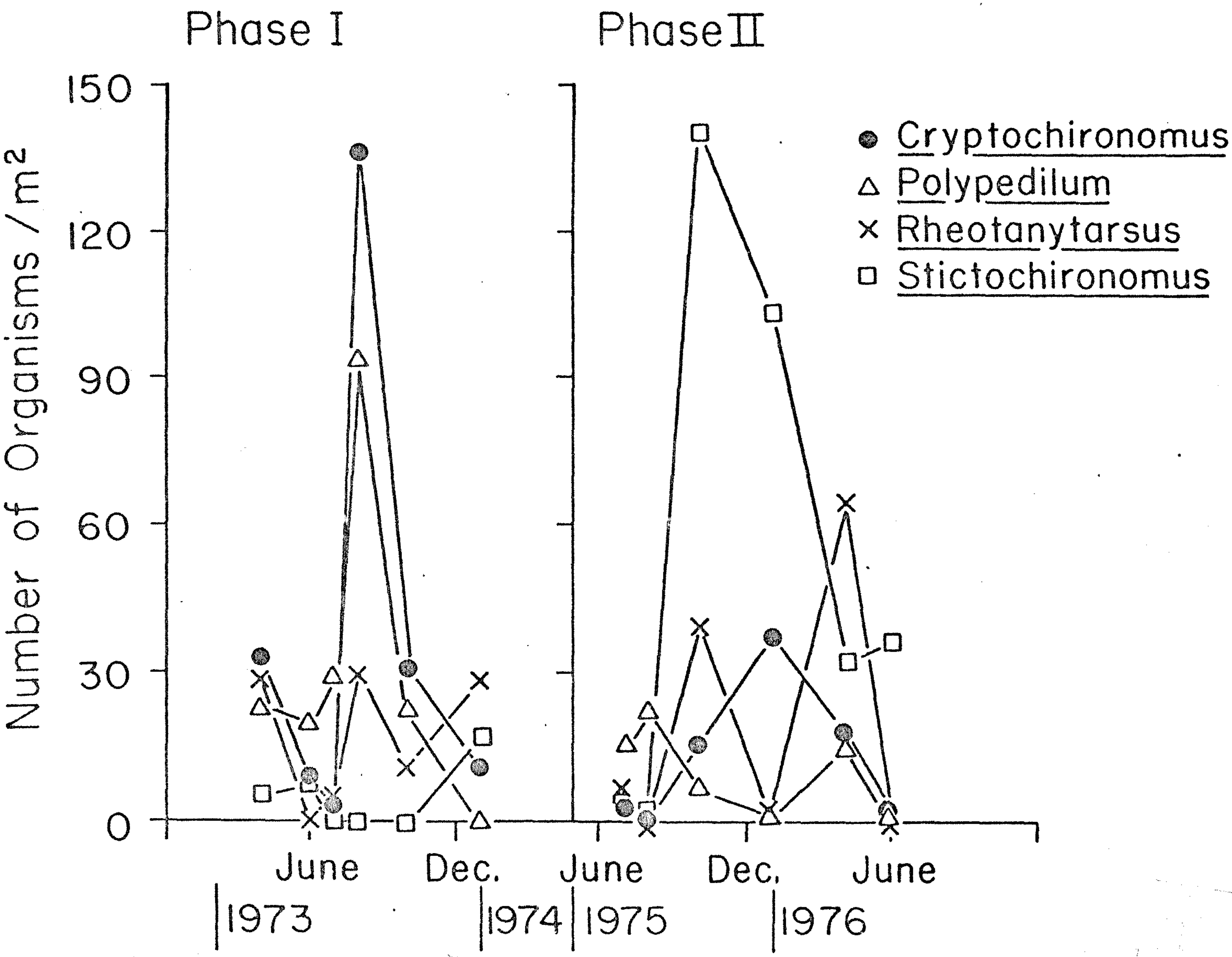

Figure 6. Densities of some Diptera in the Washita River during phases I and II.

Predatory insects, such as the odonates (dragonflies) were common in low densities during both phases. Oligochaets could not be counted, but were common in high densities during both phases.

Mean total dissolved solids (TDS) increased from 843mg/l (phase I) to 1394mg/l (phase II) in the Washita River. Mean chloride concentration increased from 17mg/l to 41mg/l and mean sulfate concentration from 360mg/l to 616mg/l (Madden and Morris[4]). These increases correlate with the decreases in diversity, number of genera and density of the benthic community. There is a buildup of hydrogen sulfide in the stream sediments (especially downstream near Clinton, Oklahoma). This buildup was apparent during an October, 1979 visit to the sites. Conditions during phase I are unknown. However, sulfates have greatly increased in phase II and could be responsible for an increase in hydrogen sulfide in the sediments, possibly rendering them toxic. This factor could be largely responsible for the decrease in diversity. Other dissolved salts, such as chlorides, probably have a synergistic effect. Some organisms, such as Cheumatopsyche, Dubiraphia, Heterelmis and Baetis, are currently abundant on wood snags in the stream although not in the sediments. These snags extend into the open water and may provide a refuge microhabitat for the organisms. Snags are common in the stream but do not constitute a major habitat. Rainfall, pH and dissolved oxygen were not significantly different between phases I and II. Therefore, these should not have affected the species composition between the two phases.

The increase in salts in the Washita River is due to the brine discharge from the FDP and the release of water from Foss Reservoir. Currently, the salt concentration in the river is equivalent to that in the reservoir. Before the FDP began operation the river water was less saline than Foss Reservoir. Prior to the FDP, water release from Foss was irregular. Salt concentration has been increasing in Foss Reservoir since 1961. This increase is related to a low outflow and high evaporation rate in the reservoir (Madden and Morris[4]). The salinity of the reservoir is probably higher than the river originally was before Foss was constructed. Release of the saline water from the reservoir is probably equally responsible with the FDP for the decline in the benthic community. Both are degrading the quality of the river downstream of Foss Reservoir.

The FDP is in violation of state water standards with respect to biological diversity. This violation relates to the increase of certain salts, especially sulfates and chlorides. An effort should be made to reduce the concentration of these salts in the FDP discharge, but economic considerations may complicate this issue. Extreme caution should be exercised in considering the future construction of reservoir and demineralization plants in western Oklahoma. High evaporation rates in shallow western reservoirs will certainly lead to increases in TDS. This increase in salinity will require use of demineralization plants if the reservoirs are to be used for public drinking supplies. Plants of the same design as the FDP will likely have severe biological impact. If demineralization technologies are developed that do not produce high TDS brine discharges, then demineralization may become a feasible alternative.

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APPENDIX 1

Notes on substrate types at each site in the Washita River.

Site 1: The bottom is patchy, consisting of sand, gravel and mud. Snags are abundant. Water depth is about 1.0-1.5m.

Site 2: Sand and gravel bottom. Water depth is 1m.

Site 3: Shallow water, 10-20cm. Fine sand and silty mud.

Site 4: As in site 3.

Site 5: As in site 3.

Site 6: Shallow water, but pools are present. Sand and silt bottom, muddier in the pools.

Site 7: Hardpan clay bottom.

Site 8: Sand and mud bottom. H_2S in mud. Trash present in stream. About 20cm deep.

Site 9: Mud and sand bottom. As in site 8 but without trash.

Site 10: Sand bottom. H_2S noticeable in the sediments.

APPENDIX 2

Listing of the genera found in this study by order.

Order	Genus
Amphipoda	
	Hyalella
Ephemeroptera	
	Baetis
	Caenis
	Choroterpes
	Cloeon
	Hexagenia
	Stenonema
	Tricorythodes
Coleoptera	
	Agabus
	Berosus
	Cyphon
	Dineutus
	Dubiraphia
	Heterelmis
	Hydrovatus
	Stenelmis
	Tropisternus
Diptera	
	Atherix
	Chironomus
	Cricotopus
	Cryptochironomus
	Dicrotendipes
	Diplocladius
	Endochironomus
	Erioptera
	Euparyphus
	Glyptotendipes
	Kiefferulus
	Menetus
	Microspectra
	Orthocladius
	Palpomyia
	Parachironomus
	Paralauterborniella
	Paratendipes
	Polypedilum
	Procladius
	Psectrocladius
	Psectrotanypus
	Pseudochironomus

Order	Genus
Diptera	
	Rheotanytarsus
	Simulium
	Stenochironomus
	Stictochironomus
	Tanypus
	Tanytarsus
	Trissocladius
	Xenochironomus
Gastropoda	
	Ferrissia
	Helisoma
	Physa
Hemiptera	
	Cymatia
Megaloptera	
	Dysmicohermes
Nematoda	
	Unidentified
Odonata	
	Dromogomphus
	Enallagma
	Gomphus
	Ophiogomphus
	Progomphus
Oligocaeta	
	Unidentified
Pelecypoda	
	Spaerium
Trichoptera	
	Athripsodes
	Cheumatopsyche
	Hydropsyche
	Leptocercus
	Oecetis