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Selected Aspects of the Limnology of Zooplankton in Beaver and Degray Reservoirs, Arkansas, with Emphasis on the Development of a Method for the Estimation of Zooplankton Biomass

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INTRODUCTION

The significant role of zooplankton communities in Beaver Reservoir has been presented by way of previous reports to the United States Fish and Wildlife Service (Schmitz, 1974; Short, 1974), which leave little doubt as to the relevance of long-term studies on various aspects of zooplankton ecology. Even so, only a few of the fundamental questions which often confront limnologists can be answered reasonably through seasonal measurements of plankton densities (Short, 1974). In addition to seasonal monitoring of Beaver Reservoir, a preliminary qualitative inventory of metazoan plankton species occurring in DeGray Lake was initiated; DeGray Lake, a relatively new reservoir on the Caddo River in southern Arkansas, was impounded in 1969. This initial effort directed toward a zooplankton inventory was part of a new comprehensive fisheries production research program established by the United States Fish and Wildlife Service at DeGray Lake. In addition to continued seasonal studies of zooplankton in Beaver Reservoir, emphasis during the current period was directed toward the development of a suitable procedure for estimating the contribution of zooplankton to biomass production. The evaluation of a feasible method involved the employment of a sucrose density-gradient technique for separating zooplankton from net seston and the expression of zooplankton biomass in terms of dry weight.

We are indebted to United States Fish and Wildlife Service personnel for the field collections used in this study. Special gratitude is extended to Dr. Larry Aggus for his untiring patience, suggestions, and criticisms. The work herein reported was supported by United States Fish and Wildlife Service Contract Nos. 14-16-0008-870.

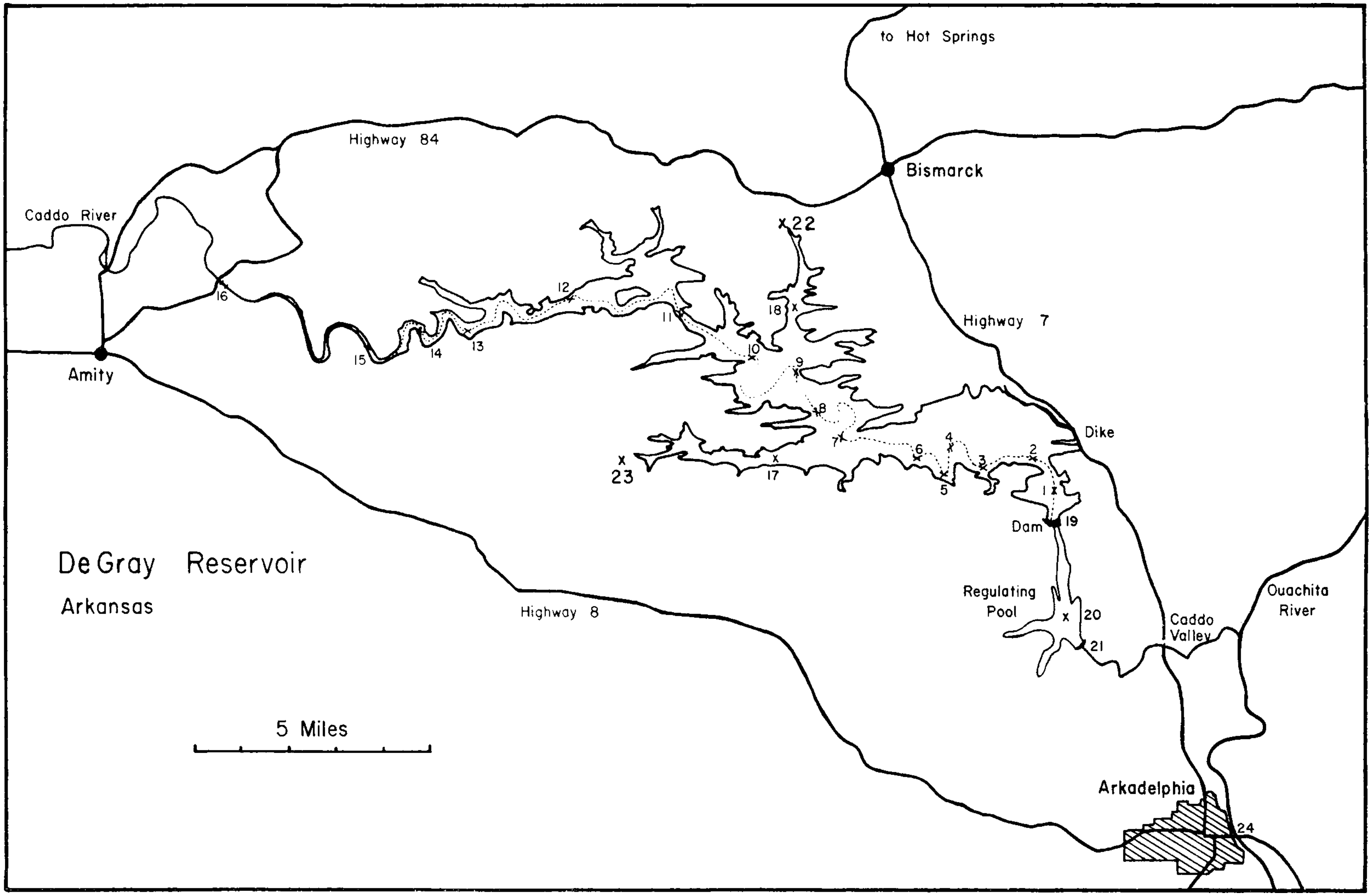
SPECIES COMPOSITION AND SEASONAL ZOOPLANKTON ABUNDANCE

DEGRAY LAKE

Zooplankton samples were taken from the deepest portion of the lake over the old Caddo River channel just above DeGray Dam. This location corresponded to Station 1 as designated by Nix, et al (1974, 1975) (Figure 1). A 50-meter vertical column was sampled weekly using a Birge-type closing net with a 29.5 cm aperture and equipped with no. 20 nylon mesh. Samples were preserved in 3% formalin and concentrated to 100 ml in the field. To assure some degree of confidence for purposes of qualitative analysis, one sample (3X) represented three composited 50-meter net hauls, while two other samples (1X) were preserved separately for semi-quantitative evaluations. In the laboratory, the 100 ml samples were concentrated to 25 ml. Two 1.0 ml subsamples from the 3X composite were examined in their entirety using a Sedgewick-Rafter chamber in conjunction with an Olympus (FHT) phase contrast microscope. When structural detail was not adequately discernible in the chamber, specimens were removed from the subsample, and a semi-permanent mount was prepared using glycerine jelly for copepod dissections and CMC-9/CMC-9AF (3:1 mixture) for Rotatoria and Cladocera. Rotatoria were identified according to Ahlstrom (1940, 1943), Edmondson (1959), and Voigt (1957). Cladocera were confirmed according to Brooks (1957, 1959), and adult copepods were diagnosed using the respectively applicable keys of Pennak (1953, 1963) and Wilson and Yeatman (1959).

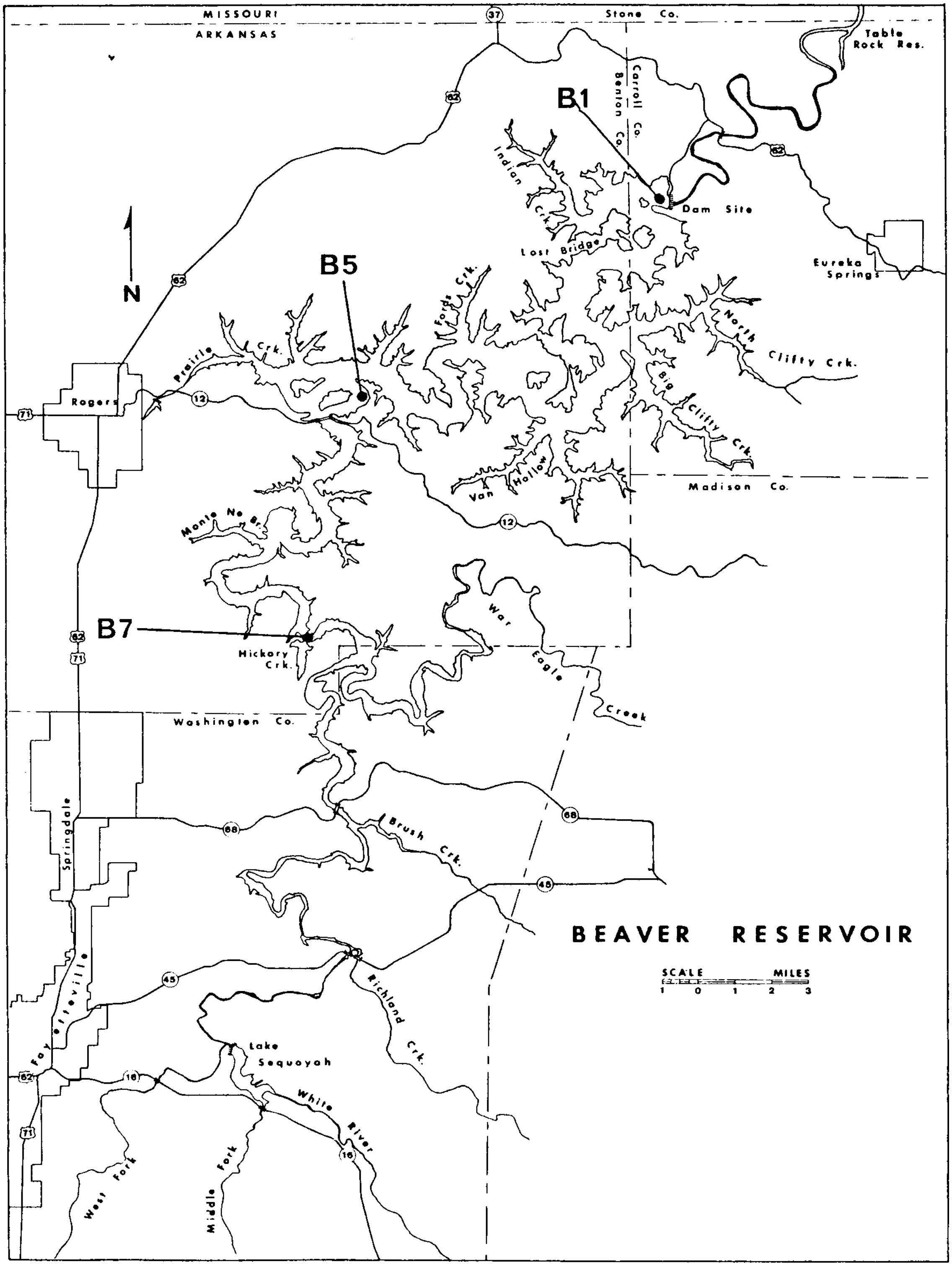
The list that follows represents an inventory of zooplankton species recorded for DeGray Lake during a period extending from August 1974 through March 1975. A total of 80 species was observed which consisted of 50 rotatorian species, 24 cladoceran species and six copepod species.

Figure 1. Map of DeGray Reservoir showing the locations of sampling stations designated by Nix, et al (1974, 1975). All collections herein reported on were taken from Station 1 (reproduced by permission from Nix, et al, 1975).



to Hot Springs
Bismarck
Highway 84
Caddo River
x22
16
12
11
18
10
9
8
7
6
4
3
2
1
5
15
14
13
Amity
Highway 7
Dike
x 23
17
Dam
19
De Gray Reservoir
Arkansas
Regulating Pool
20
21
Highway 8
Caddo Valley
Ouachita River
5 Miles
Arkadelphia
24

Figure 2. Map of Beaver Reservoir showing the locations of sampling stations designated by the United States Fish and Wildlife Service.


MISSOURI
ARKANSAS
Stone Co.
Table Rock Res.
Carroll Co.
Benton Co.
B1
Dam Site
Eureka Springs
Indian Crk.
Lost Bridge
B5
N
Prairie Crk.
Fords Crk.
North Clifty Crk.
Big Clifty Crk.
Rogers
Van Hollow
Madison Co.
Monte Ne Br.
B7
Hickory Crk.
War Eagle Creek
Washington Co.
Springdale
Brush Crk.
BEAVER RESERVOIR
SCALE MILES
1 0 1 2 3
Fayetteville
Richland Crk.
Lake Sequoyah
White River
West Fork
Middle Fork

Considering the relatively short sampling period, this inventory may not be complete, but based on weekly samples no doubt represents the great majority of metazoan zooplankters which one may expect to encounter in DeGray Lake. Each rotatorian and cladoceran species is annotated as to its relative frequency of occurrence (A = abundant; C = common; and R = rare) during the sampling period:

Rotatoria

Anureopsis fissa (Gosse)	R
Ascomorpha ecaudis Perty	R
Asplanchna priodonta Gosse	C
Brachionus plicatilis (O. F. Müller)	R
Collotheca pelagica Rousselet	R
Collotheca sp. Harring	C
Conochiloides coenobasis Skorikov	C
Conochiloides dossuarius (Hudson)	R
Conochilus unicornis Rousselet	A
Chromogaster ovalis (Bergendal)	R
Dipleuchlanis propatula (Gosse)	R
Epiphanes senta (O. F. Müller)	R
Euchlanis sp. Ehrenberg	R
Filinia longiseta (Ehrenberg)	A
Filinia terminalis (Plate)	R
Gastropus hyptopus (Ehrenberg)	R
Gastropus stylifer Imhof	C
Hexarthra mira (Hudson)	C
Kellicottia bostoniensis (Rousselet)	C

Rotatoria (continued)

Keratella americana Carlin	R
Keratella cochlearis (Ehrenberg)	A
Lecane elasma Harring	R
Lecane luna (O. F. Müller)	R
Lepadella ovalis (O. F. Müller)	R
Macrochaetus longipes Myers	R
Monostyla lunaris (Ehrenberg)	R
Mytilina ventralis (Ehrenberg)	R
Philodina inopinata Milne	R
Philodina sp. Ehrenberg	R
Platyias patulas (O. F. Müller)	R
Platyias quadricornis (Ehrenberg)	R
Ploesoma hudsoni (Imhof)	C
Ploesoma truncatum (Levander)	A
Polyarthra euryptera Wierzejski	C
Polyarthra vulgaris Carlin	A
Pompholyx sulcata Hudson	C
Proales globulifera Hauer	R
Proalinopsis caudata (Collins)	R
Ptygura libera Myers	C
Rotaria neptunia (Ehrenberg)	R
Synchaeta pectinata Ehrenberg	R
Synchaeta stylata Wierzejski	A
Testudinella patina (Hermann)	R

Rotatoria (continued)

Trichocerca capucina Lucks	C
Trichocerca cylindrica (Imhof)	C
Trichocerca longiseta (Schrank)	C
Trichocerca multicrinis (Kellicott)	C
Trichocerca porcellus (Gosse)	R
Trichocerca similis (Wierzejski)	R
Trichotria tetractis (Ehrenberg)	R

Cladocera

Alona guttata Sars	R
Alona monacantha Sars	R
Alona quadrangularis (O. F. Müller)	R
Alona rectangula Sars	R
Bosmina longirostris (O. F. Müller)	A
Bosminopsis sp. Richard	R
Ceriodaphnia lacustris Birge	C
Ceriodaphnia quadrangula (O. F. Müller)	R
Ceriodaphnia reticulata (Jurine)	R
Chydorus sphaericus (O. F. Müller)	C
Daphnia ambigua Scourfield	C
Daphnia galeata mendotae Birge	A
Daphnia middendorfiana Fischer	R
Daphnia parvula Fordyce	C
Daphnia pulex Leydig	R
Daphnia schødleri Sars	R
Diaphanosoma leuchtenbergianum Fischer	C
Eurycercus lamellatus (O. F. Müller)	R

Cladocera (continued)

Ilyocryptus _spinifer_ Herrick	R
Kurzia _latissima_ (Kurz)	R
Leydigia _quadrangularis_ (Leydig)	R
Pleuroxus _hammalatus_ Birge	R
Sida _crystallina_ (O. F. Müller)	R
Simocephalus _vetulus_ Schødler	R

Copepoda

Cyclops _bicuspidatus_ _thomasi_ S. A. Forbes

Cyclops _scutifer_ Sars

Cyclops _vernalis_ Fischer

Diaptomus _pallidus_ Herrick

Mesocyclops _edax_ (S. A. Forbes)

Mesocyclops _leuckarti_ (Claus)

For semi-quantitative estimations, two 1 ml subsamples were taken from each 25 ml concentrate of a 50-meter net haul, and counted directly using a Sedgewick-Rafter chamber and 100X magnification.

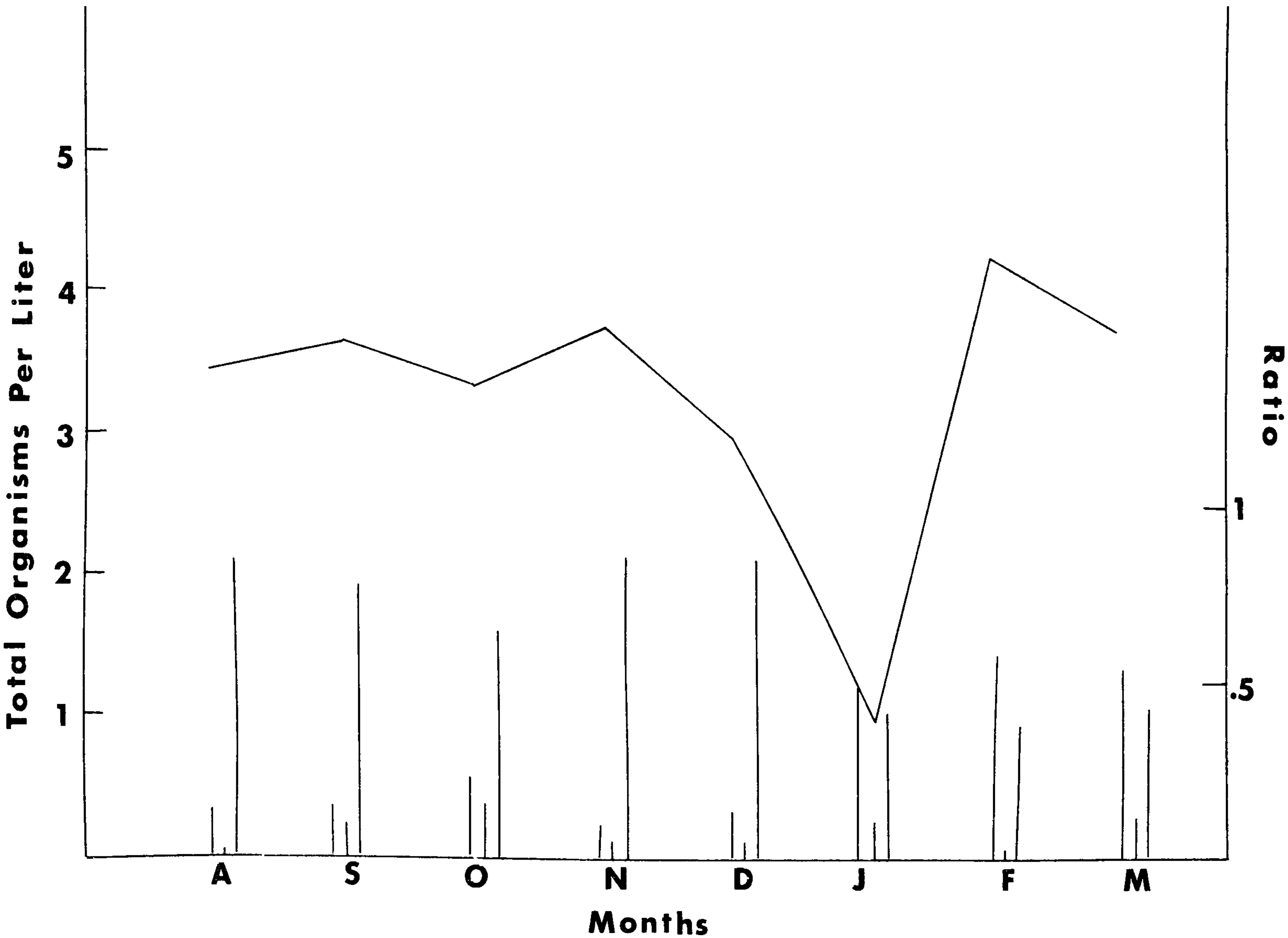
Weekly abundance data for the major metazoan groups and their totals during a period extending from August 1974 through March 1975 are given in Table 1. Mean values for each month were calculated, and comparisons with previous and simultaneous data from Nix, et al (1974, 1975) show that our data vary considerably, although somewhat consistently on a relative basis; i.e., our seasonal abundance values are extremely low, falling short of that reported by Nix, et al (1974, 1975) sometimes by more than a factor of 10. Such variance has caused us to examine critically our sampling equipment and techniques. All 50-meter vertical columns were sampled using a 29.5 cm aperture Birge closing net equipped with no. 20 nylon mesh. Nix, et al (1974, 1975), using the same piece of equipment, sampled vertically at five-meter intervals, and found a persistant stratification of zooplankters with the overwhelming majority of organisms always occurring within the 5 - 0 meter interval. Recently, Nix's group has sampled a continuous 50-meter column at the same time that the regular five-meter intervals were sampled, and discrepancies similar to those described above were observed. This situation has lead us to postulate that: (1) during a 50-meter net haul the efficiency decreases because of clogging to the extent that the upper stratum, where the majority of organisms occur, is hardly sampled—certainly not on a quantitative or even proportionate basis; and that (2) the primary causal factor is an inadequate mouth to net ratio. Calculations performed by Dr. L. Aggus (personal communication)showed the mouth to net ratio of our oversized version of the Birge closing net (aperture diameter of 29.5 cm) to be only about 1:2, whereas the desirable range should be 1:4 or 1:5. Therefore, when larger nets with small mesh are used, a mouth to net ratio, which will not permit a significant loss of straining efficiency, must be obtained.

In consideration of the foregoing, our density values as expressed in organisms per liter cannot be taken as valid. Nevertheless, ratios of major groups to the total and the overall seasonal pattern compare in a reasonable way with mean values presented by Nix et al (1975) for the same period. More specifically, the Rotatoria were distinctly dominant during the period August through December 1974. From January through March 1975 they shared subequal dominance with the Copepoda (mostly nauplii). At no time were the Cladocera significant components of the zooplankton (Table 1; Figure 3). However, density data are presented

Table 1. Densities of zooplankton organisms occurring at Station 1, DeGray Reservoir, during the period August 1974 through March 1975. Density data are expressed as organisms per liter. Percentages indicate the contribution of each major zooplankton group to total mean density for that monthly interval.

	Copepoda		Cladocera		Rotatoria		Total
8/7/74	0.42		0.06		1.67		2.15
8/21/74	0.57		0.12		3.60		4.29
8/28/74	0.25		0.08		3.63		3.96
$\bar{x}$	0.41	12%	0.09	3%	2.97	86%	3.47
9/2/74	0.77		0.16		4.75		5.68
9/11/74	0.27		0.17		1.12		1.56
9/18/74	0.48		0.30		2.36		3.14
9/25/74	0.76		0.55		3.00		4.31
$\bar{x}$	0.57	15%	0.30	8%	2.81	77%	3.67
10/2/74	1.45		0.82		2.97		5.24
10/9/74	0.84		0.49		2.14		3.47
10/23/74	0.37		0.49		2.04		2.90
10/30/74	0.13		0.22		1.57		1.92
$\bar{x}$	0.70	21%	0.51	15%	2.18	64%	3.38
11/6/74	0.22		0.18		1.99		2.39
11/13/74	0.31		0.26		3.07		3.64
11/20/74	0.29		0.16		4.95		5.40
11/27/74	0.46		0.15		3.11		3.72
$\bar{x}$	0.32	9%	0.19	5%	3.28	87%	3.79
12/4/74	0.41		0.19		2.22		2.82
12/11/74	0.21		0.10		1.14		1.72
12/18/74	0.43		0.11		2.09		2.63
12/26/74	0.46		0.10		4.43		4.99
$\bar{x}$	0.38	13%	0.13	4%	2.54	84%	3.04
1/8/75	0.25		0.15		0.47		0.87
1/15/75	0.40		0.08		0.29		0.77
1/22/75	0.60		0.12		0.31		1.03
1/29/75	0.54		0.06		0.44		1.04
$\bar{x}$	0.45	49%	0.10	11%	0.38	41%	0.92
2/5/75	1.65		0.05		0.73		2.43
2/20/75	2.97		0.06		1.89		4.92
2/26/75	2.76		0.01		2.45		5.22
$\bar{x}$	2.44	58%	0.04	1%	1.69	40%	4.19
3/5/75	2.26		0.08		2.75		5.09
3/12/75	1.40		0.05		0.87		2.32
3/26/75	2.44		0.16		1.13		3.73
$\bar{x}$	2.03	55%	0.10	3%	1.58	43%	3.71

Figure 3. Seasonal pattern of total zooplankton densities occurring at Station 1, DeGray Reservoir, during the period August 1974 through March 1975. The vertical lines represent ratios which express the proportional contribution of each major zooplankton group to total mean density for that monthly interval. The first line for each month represents Copepoda, the second Cladocera, and the third Rotatoria (cf. Table 1).



Total Organisms Per Liter
5
4
3
2
1
Ratio
1
.5
A
S
O
N
D
J
F
M
Months

for the record only, and without further elaboration.

BEAVER LAKE

Sampling and laboratory procedures followed the protocol outlined by Schmitz (1974). The same stations (B1, B5, and B7) were sampled monthly (Figure 2). Because of reductions in fuel usage imposed upon the United States Fish and Wildlife Service, collections were not authorized for the months of December (1974) and February (1975). Moreover, because of the work load and time involved in the development of biomass estimates, only those results obtained from samples taken through April 1975 are presented.

Copepoda

Copepoda occurred at each station on every sampling date. Adults consistently were observed in greater numbers than nauplii or copepodids (Tables 2, 3, 4). This pattern was remarkably similar to those described by Schmitz (1974) and Short (1974). Nauplii were observed more frequently than during the 1973-74 period, but even so, in very small densities as compared to other copepod life history stages.

Cyclopoids were the most abundant copepods, and they exhibited a recognizable bimodal pattern at B7 (Table 4); this was reflected by a peak of 4.45/liter in October 1974, being nearly equivalent to the previous spring pulse of 4.48/liter (Table 4). The pattern was less obvious at B5 where a peak of only 0.85/liter was obtained in October (Table 3). Station B1 showed no significant autumn pulse, but initiated a steady increase during March and April (Table 2).

Adult calanoids were recorded for all stations on all sampling dates with the exceptions of August and September at B7 and B5, respectively (Tables 2, 3, 4). Their seasonal distribution pattern resembles that of the two previous years, being most frequently encountered at B1; they

Table 2. Densities of zooplankton organisms occurring at Station B1, Beaver Reservoir, during the period June 1974 through April 1975. Density data are expressed as organisms per liter.

B1	6/74	7/74	8/74	9/74	10/74	11/74	1/75	3/75	4/75
Copepoda									
Nauplii	0.04	0.03	tr	0.01	0.03	0.01	0.08	2.11	0.20
Copepodids	0.64	0.28	0.37	0.17			0.39	3.56	1.72
Cyclopoida	2.83	1.18	1.33	0.25	0.26	0.10	0.02	0.26	1.45
Calanoida	0.28	0.28	0.12	0.03	tr	0.10	0.97	2.63	2.28
Total Copepoda	3.79	1.77	1.82	0.46	0.29	0.22	1.47	8.56	5.26
Cladocera									
Daphnia parvula		0.03	0.05			0.02	tr	0.03	0.49
D. galeata	0.68	0.06	tr		0.01		tr		
D. middendorffiana				tr		tr			
D. schødleri	0.12		tr	0.02	0.03	tr	tr		
D. rosea									
Ceriodaphnia lacustris	4.26	0.07	tr		tr				tr
Diaphanosoma leuchtenb.	0.40	0.11	0.03					tr	
Bosmina longirostris	0.80	1.60	0.48	0.04	0.26	0.17	0.65	4.30	18.92
Chydorus sphaericus									tr
Alona guttata	0.04								
A. rectangula									
A. monacantha									
Leydigia quadrangularis			tr	tr				tr	
Moina micura									
Simocephalus expinosus									
Total Cladocera	6.38	1.87	0.56	0.06	0.30	0.19	0.65	4.33	19.41
Rotatoria									
Asplanchna priodonta	tr	0.09	0.15	0.19	0.05	0.01	tr	7.74	7.34
Total Rotatoria	tr	0.09	0.15	0.19	0.05	0.01	tr	7.74	7.34
Chaoborus punctipennis	0.01	tr	tr	tr	tr		tr	tr	
Total Organisms	10.18	3.73	2.53	0.71	0.64	0.42	2.12	20.63	32.01

---

tr = trace quantities; i.e., organism densities less than 0.01/liter.

Table 3. Densities of zooplankton organisms occurring at Station B5, Beaver Reservoir, during the period June 1974 through April 1975. Density data are expressed as organisms per liter.

B5	6/74	7/74	8/74	9/74	10/74	11/74	1/75	3/75	4/75
Copepoda									
Nauplii				0.03	1.05		0.06	2.70	0.14
Copepodids	0.40	0.09	0.01	0.21	0.69	0.08	0.12	1.45	0.63
Cyclopoida	1.40	0.40	0.23	0.14	0.85	0.05	0.51	1.31	0.71
Calanoida	0.74	0.23	0.01		0.19	0.16	0.33	0.12	0.09
Total Copepoda	2.54	0.72	0.25	0.38	2.78	0.29	1.01	5.58	1.57
Cladocera									
Daphnia parvula	0.88	0.07	0.01		2.74	0.07	0.07	0.08	0.24
D. galeata									
D. middendorffiana				0.01					
D. schødleri	0.03				0.01				
D. retrocurva									
D. rosea	0.14								
Ceriodaphnia lacustris	3.39	0.08		tr	0.06				
Bosmina longirostris	2.25	0.34	0.08	0.38	0.63	0.11	1.00	0.89	1.28
Chydorus sphaericus	0.03								
Alona guttata									
A. rectangula				tr			tr		tr
A. monacantha									
Leydigia quadrangularis							0.01	0.01	
Moina micura		tr		0.01					
Simocephalus expinosus									
Total Cladocera	6.81	0.51	0.13	0.52	3.46	0.18	1.09	0.98	1.52
Rotatoria									
Asplanchna priodonta	0.06	0.15	0.16	0.06	0.50	0.01	tr	0.07	0.17
Total Rotatoria	0.06	0.15	0.16	0.06	0.50	0.01	tr	0.07	0.17
Chaoborus punctipennis	0.04	0.04	0.06	0.04	tr	tr	tr	0.01	0.01
Total Organisms	9.45	1.42	0.60	1.00	6.74	0.48	2.10	6.64	3.27

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tr = trace quantities; i.e., organism densities less than 0.01/liter.

Table 4. Densities of zooplankton organisms occurring at Station B7, Beaver Reservoir, during the period June 1974 through April 1975. Density data are expressed as organisms per liter.

B7	6/74	7/74	8/74	9/74	10/74	11/74	1/75	3/75	4/75
Copepoda									
Nauplii	0.12	0.04		0.57	2.12		0.07	0.02	0.01
Copepodids	0.37	0.21	0.11	1.35	3.06	0.03	0.24	0.09	0.17
Cyclopoida	4.48	0.94	0.27	0.84	4.45	0.15	1.31	0.15	0.40
Calanoida	3.68	0.44		0.06	0.20	0.04	0.03	0.01	0.06
Total Copepoda	8.67	1.63	0.38	2.82	10.53	0.22	1.65	0.27	0.64
Cladocera									
Daphnia parvula	1.43	0.09		0.82	2.62	0.07	0.03	0.05	0.07
D. galeata									
D. middendorffiana									
D. schødleri									
D. retrocurva	0.74								
D. rosea									
Ceriodaphnia lacustris	2.39	0.40	0.01	0.19	0.01				
Diaphanosoma leuchtenb.	1.17	0.10	0.55	0.44					
Bosmina longirostris	4.48	0.55	0.07	0.10	0.48	0.06	0.27	0.12	0.17
Chydorus sphaericus						0.02			
Alona guttata					0.01	0.01			
A. rectangula						0.01	0.02	0.02	
A. monacantha								0.01	
Leydigia quadrangularis						0.01			
Moina micura				0.68					
Simocephalus expinosus						0.01			
Total Cladocera	10.22	1.14	0.63	2.23	3.12	0.19	0.32	0.20	0.24
Rotatoria									
Asplanchna priodonta	0.17	0.18		0.21	0.11	0.02	0.09	0.03	0.08
Total Rotatoria	0.17	0.18		0.21	0.11	0.02	0.09	0.03	0.08
Chaoborus punctipennis	0.10	0.16	0.16	0.04	0.01			0.04	tr
Total Organisms	19.16	3.11	1.17	5.30	13.77	0.43	2.06	0.54	0.96

tr = trace quantities; i.e., organism densities less than 0.01/liter.

tended toward a unimodal pattern, unlike the bimodal pattern reported by Short (1974). However, it is noteworthy that December (omitted in 1974) was the period during which Short (1974) recorded a second pulse. Although the calanoids occurred more frequently in 1974-75, their total abundance was lower. The mean density of calanoids during 1974-75 was 30% less than 1972-73 (see Schmitz, 1974) and 50% less than for 1973-74 (see Short, 1974).

Nauplii were observed on all dates at B1, but were absent approximately 38% of the time from B5 and B7 (Tables 3, 4). They occurred in relatively small densities, but a tendency toward a bimodal seasonal distribution could be discerned; pulses of 1.05/liter (October) and 2.70/liter (March) were observed. On the other hand, single pulses occurred at B1 and B7 in March and October, respectively (Tables 2, 4). The apparent lack of consistency in seasonal abundance and distribution of copepods within the reservoir would seem to strengthen the contention of Schmitz (1974) that monthly sampling intervals are inadequate where the vicissitudes of their life histories are considered.

Cladocera

Some 16 species of Cladocera were recorded during the period June 1974 through April 1975. Daphnia parvula Fordyce was the most frequently encountered daphnid at all stations. This species exhibited bimodal patterns at B5 and B7; autumn peaks of 2.74/liter at B5 and 2.62/liter at B7 were noted in October (Tables 3, 4). Spring peaks of 0.88/liter at B5 and 1.43/liter at B7 were recorded for June 1974. D. parvula appeared again to pulse with increases noted for B1 and B5 in April (Tables 2, 3).

As previously reported by Schmitz (1974), Bosmina longirostris (O. F. Müller) was the most ubiquitous cladoceran occurring in Beaver Lake. During 1974-75, this species again seemed to reflect a trend toward a trimodal seasonal abundance pattern. Such a pattern was evident at B1 with a late pulse peaking at 1.60/liter in July 1974, a weaker October pulse (0.26/liter), and a relatively high peak (18.92/liter) in April Table 2). B5 and B7 also revealed pulses during autumn and winter, but these were not of the relative magnitude observed at B1. Peaks of 0.63/liter (October) and 0.10/liter (January) were produced at B5. Similar values were recorded in October (0.48/liter) and January (0.27/liter) at B7 (Tables 3, 4).

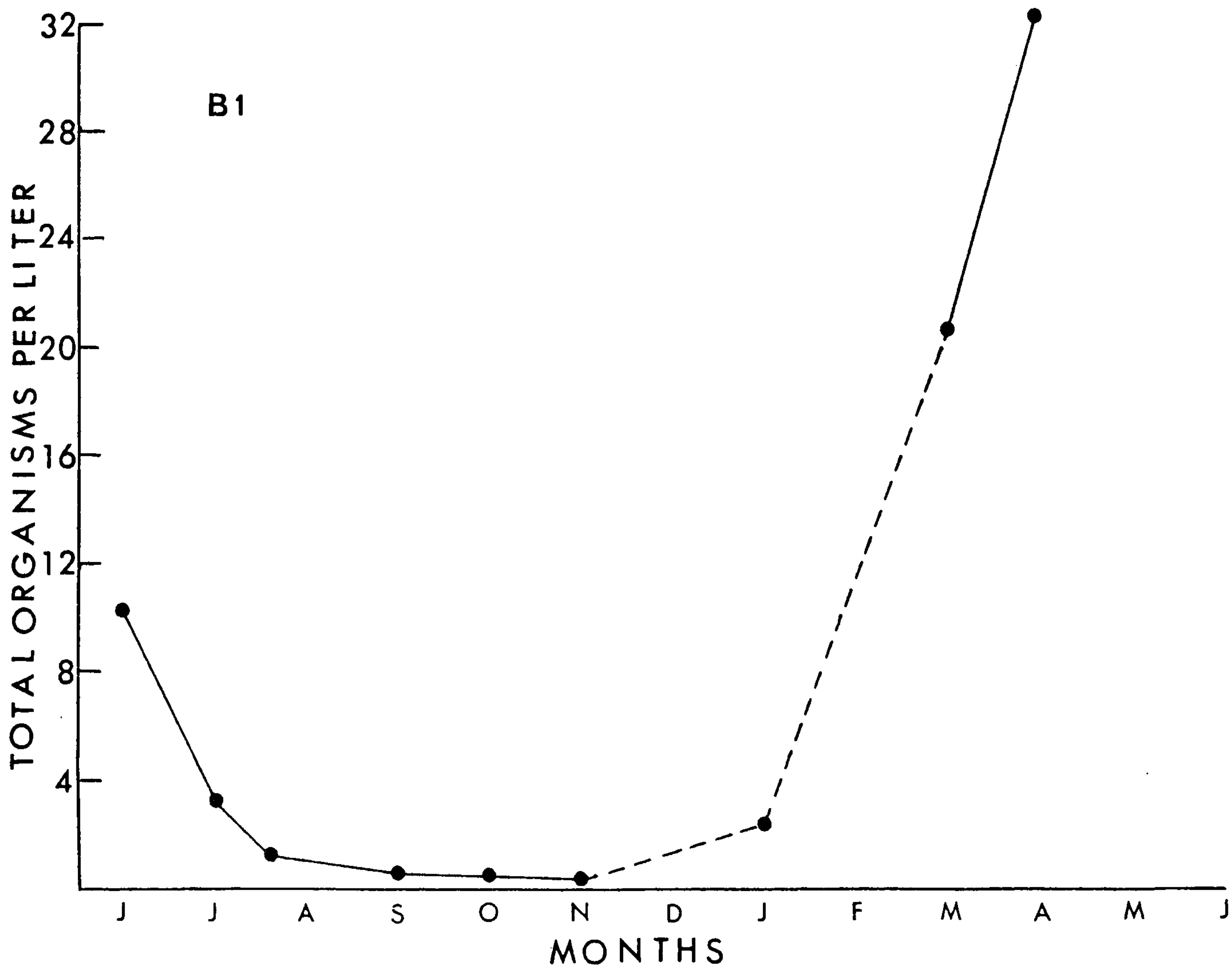
Daphnia galeata mendotae Birge was frequently present at B1, as during past years (Schmitz, 1974; Short, 1974). Also noteworthy was the fact that *Ceriodaphnia lacustris* Birge appeared only sporadically and in small numbers at all stations following its initial peak in June (Tables 2, 3, 4).

The occurrence of three cladoceran species were recorded for the 1974-75 period which were not observed during 1972-73 or 1973-74; these were *Alona rectangula* Sars, *A. monacantha* Sars, and *Simocephalus expinosus* (Koch), none of which occurred frequently or in large numbers. The same sporadic cladocerans that were observed earlier (cf. Schmitz, 1974; Short, 1974) also were recorded for the 1974-75 period, with the exceptions of *Daphnia catawba* Coker, *Ceriodaphnia quadrangula* (O. F. Müller), *Holopedium amazonicum* Stringelin, and *Sida crystallina* (O. F. Müller).

Rotatoria

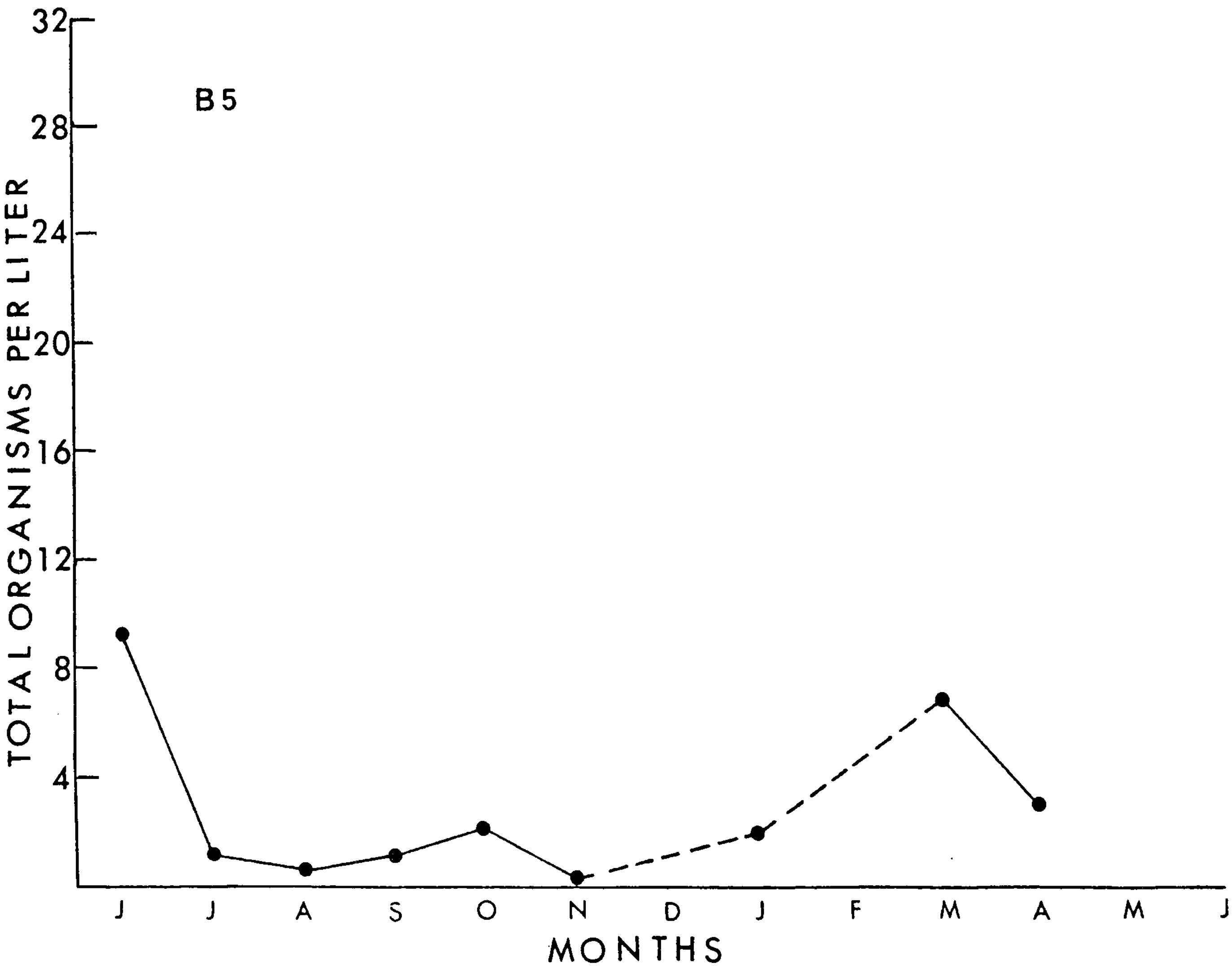
The large rotifer, *Asplanchna priodonta* Gosse, which exhibited a unimodal seasonal pattern, attained a peak of 7.74/liter in March 1975 at B1 (Table 2). There were small but noticeable peaks of 0.50/liter in October at B5 and 0.21/liter in September at B7 (Tables 3, 4). Other rotifers were not enumerated since a no. 10 mesh was used in conjunction with the Miller sampler.

Figure 4. Seasonal pattern of total zooplankton densities occurring at Station B1, Beaver Reservoir, during the period June 1974 through April 1975. Note that samples were not taken during December 1974 or February 1975.



B1
TOTAL ORGANISMS PER LITER
32
28
24
20
16
12
8
4
J
J
A
S
O
N
D
J
F
M
A
M
J
MONTHS

Figure 5. Seasonal pattern of total zooplankton densities occurring at Station B5, Beaver Reservoir, during the period June 1974 through April 1975. Note that samples were not taken during December 1974 or February 1975.



B5
TOTAL ORGANISMS PER LITER
32
28
24
20
16
12
8
4
J
J
A
S
O
N
D
J
F
M
A
M
J
MONTHS

Figure 6. Seasonal pattern of total zooplankton densities occurring at Station B7, Beaver Reservoir, during the period June 1974 through April 1975. Note that samples were not taken during December 1974 or February 1975.

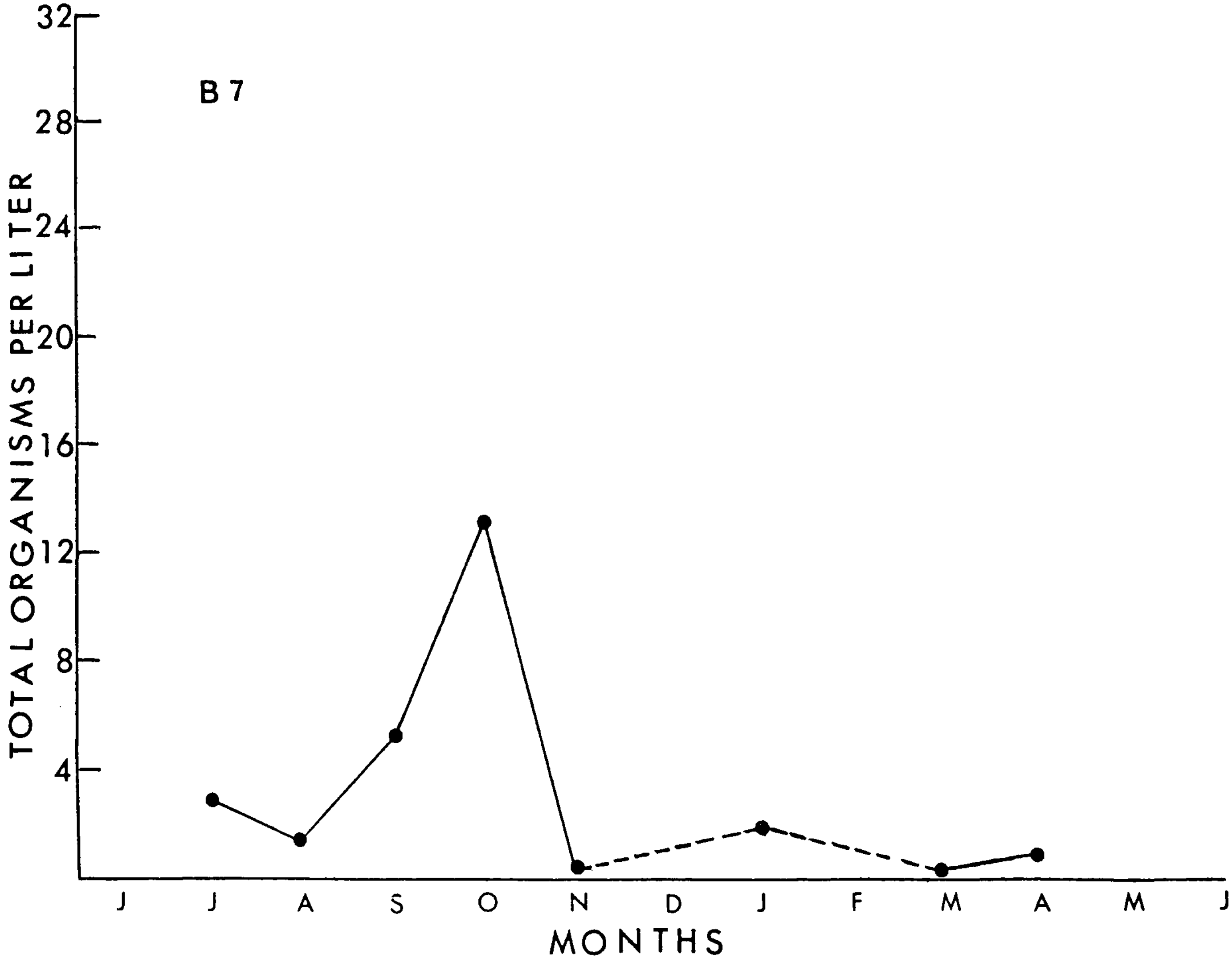
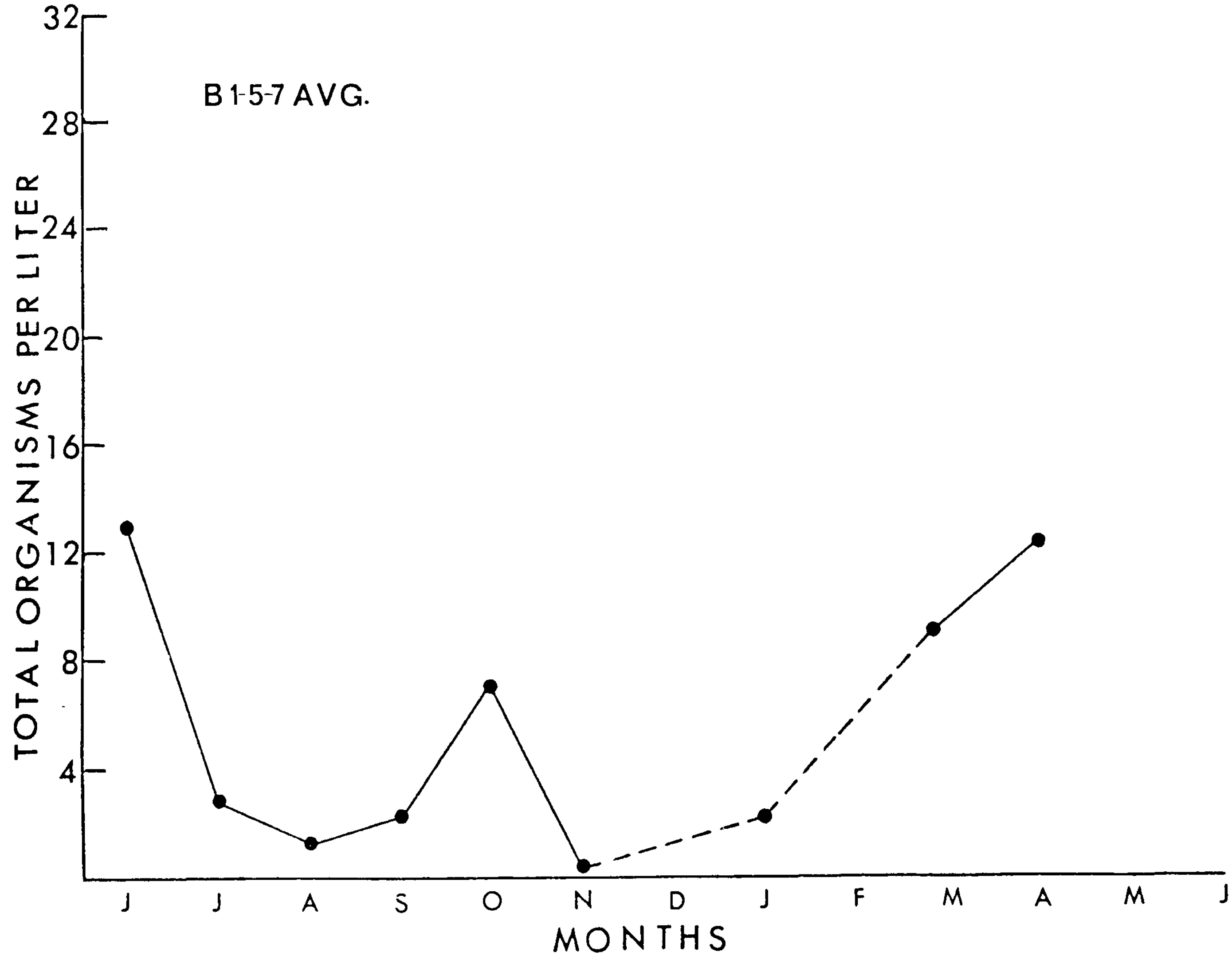

B 7
32
28
24
20
16
12
8
4
TOTAL ORGANISMS PER LITER
J J A S O N D J F M A M J
MONTHS

Figure 7. Mean seasonal pattern of total zooplankton densities occurring in Beaver Reservoir during the period June 1974 through April 1975. Note that samples were not taken during December 1974 or February 1975.



B 1-5-7 AVG.
TOTAL ORGANISMS PER LITER
32
28
24
20
16
12
8
4
J
J
A
S
O
N
D
J
F
M
A
M
J
MONTHS

Diptera

Chaoborus punctipennis occurred frequently at all stations (Tables 2, 3, 4). However, densities were so low that cyclic abundance patterns, if such existed, were not clearly discernible. Such an apparent lack of patterns was to be expected inasmuch as all sampling was conducted during daylight hours; Chaoborus sp. typically is benthic by day and planktonic at night in most lakes (see Hutchinson, 1967).

General

Data taken during 1974-75 indicate that Beaver Reservoir reflects a bimodal seasonal abundance pattern similar to those reported for 1972-73 and 1973-74 by Schmitz (1974) and Short (1974), respectively. When considered from the standpoint of mean densities, the autumn pulse emerged as a distinct pattern (Figure 7; cf. Figures 4, 5, 6). Autumnal densities observed at B5 and B7 during 1973-74 and 1974-75 represent a continuous and collective three-fold increase over those recorded for 1972-73 (cf. with Schmitz, 1974 and Short, 1974) (Figures 5, 6). Such a consistent increase in the magnitude of the autumn pulse appears to contradict the hypothesis that Beaver Lake is passing from a bimodal seasonal abundance pattern to one that is unimodal and thus more mature (see Applegate and Mullan, 1967, 1968, 1969; Damico, 1972). Accordingly, Short (1974) stated that "...abnormal conditions undoubtedly may effect irregularities during the stabilization process...." Considering this, it is quite possible that inconsistencies in seasonal abundance patterns were in fact "irregularities" during stabilization. Thus, the enormous array of inherent limnological variables should make it obvious that further elucidation of overall patterns involved in the life histories of reservoirs is possible only with the expenditure of more intensive and long-term efforts.

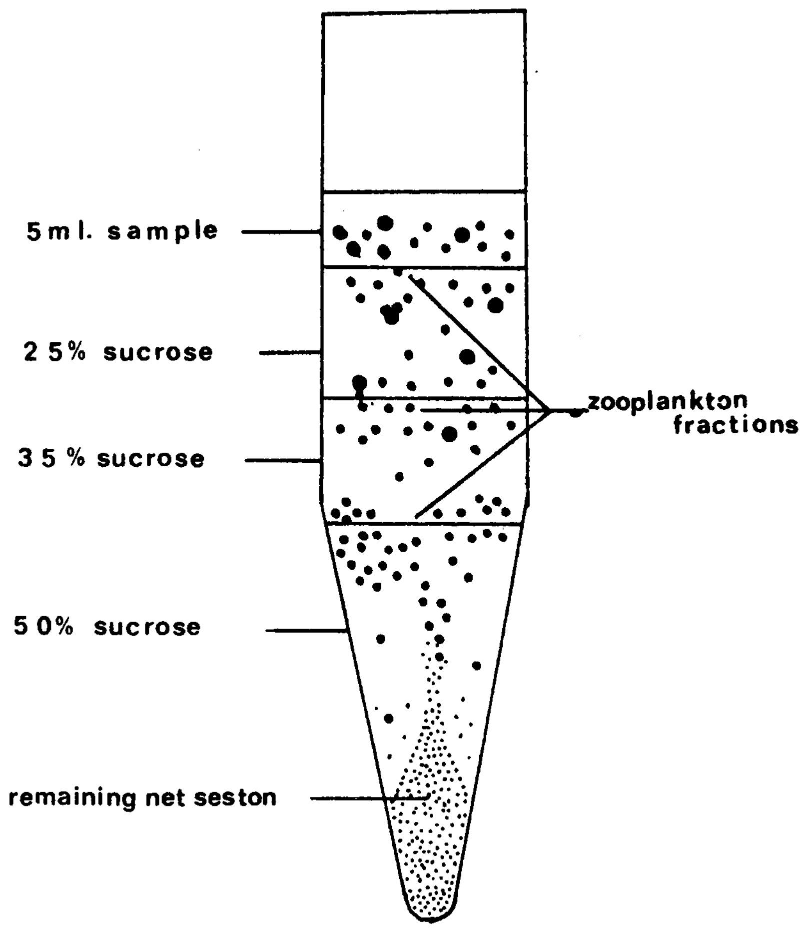
METHOD FOR THE ESTIMATION OF TOTAL ZOOPLANKTON BIOMASS

Estimates of the contribution of zooplankton to total biomass, in addition to seasonal abundance estimates, form a useful adjunct toward furthering our knowledge of the life histories of reservoirs. There are, however, various problems associated with the determination of zooplankton biomass. One of the primary obstacles is the separation of zooplankton from other seston (in this case, net seston) within a plankton sample. Density-gradient techniques were utilized by Lammers (1962) to separate plankton and clay particles from river water, and by Lammers (1963) to separate organic and inorganic particulate matter. Baker, Martin, and Schmitz (1971) applied a modification of these methods to the separation of identifiable organisms from detritus occurring in the stomach contents of shad. The results of preliminary attempts to adapt sucrose density-gradient procedures to the separation of zooplankton from seston and the subsequent determination of dry weights are described below.

The evolution of our method essentially involved manipulation of three variables: (1) the combination of sucrose concentrations; (2) the centrifuge speed; and (3) the length of time samples were centrifuged. An appropriate combination of variables was obtained through a trial and error approach. It may be noted here that this approach entailed innumerable man hours of effort; in fact, it is safe to say that the development of the method outlined below accounted for well over 70% of the total time that could be allotted to the entire project during the period herein reported on.

Three solutions of sucrose with concentrations of 25%, 35%, and 50% were selected and prepared by weight; e.g., 25% sucrose solutions were

Figure 8. Diagram of a 50 ml centrifuge tube showing separation of total net seston following sucrose density-gradient centrifugation. Note that the zooplankton component generally separates into three fractions.



5ml. sample
25% sucrose
35 % sucrose
50% sucrose
remaining net seston
zooplankton fractions

prepared by adding 75 ml of distilled water to 25 gm of sucrose. A few drops of methylene blue were added to the 35% sucrose solution to identify any mixing with the 25% or 50% solutions during the process of pipetting these respective gradient solutions into the centrifuge tubes. Eleven ml of the 50%, 35%, and 25% solutions were pipetted into each of two 50 ml centrifuge tubes so that the 35% solution was above the 50% and below the 25% solution.

Zooplankton samples were suspended in 3% formalin and concentrated to 20 ml. Two 5 ml aliquots were pipetted into each of the two centrifuge tubes prepared with sucrose gradients as described above. These preparations were spun in an IEC Clinical Centrifuge (Model CL) at 148.8 X g for 30 seconds, 516.8 X g for 30 seconds, 650 X g for 11 minutes, followed by 148.8 X g for 60 seconds. The zooplankton fractions (Figure 8) were removed immediately with a 10 ml pipette and washed in 70% ethanol. The subsequent procedure consisted of three separate washings; the first in running tap water, and the next two in 70% ethanol. The zooplankton fractions from the two centrifuge tubes were pooled and stored in 30 ml of 70% ethanol for a minimum of 24 hours. These washed samples then were filtered using pre-weighed 4.5 cm diameter glass fiber filter discs at 20 cm Hg vacuum. Each filter disc was pre-combusted at 650 C for 20 minutes, placed in a dessicator and the tare weight determined to the nearest 0.1 mg. Tared discs were placed in aluminum scale pans and stored in a dessicator to await filtration. Filtered zooplankton fractions were dried in an oven maintained at 60 C for 24 hours, returned to the dessicator, and weighed immediately. The net dry weights of zooplankton thus obtained were converted to mg/liter. The samples used for these determinations were the same samples as those utilized for seasonal abundance data by Schmitz (1974), Short (1974), Nix, et al (1974), and those from which the seasonal abundance data for Beaver Reservoir were obtained for purposes of this report.

Although most samples contained relatively small proportions of other seston as compared to zooplankton, the separation of the two were readily apparent in those processed samples taken during substantial algal pulses (Figure 8). Separation of most of the Entomostraca was clearly visible in all samples[1]. However, a margin of error in the separation of rotifers and copepods was readily recognized; i.e., a sample too heavily concentrated resulted in the entanglement of adult copepods and these inevitably were spun to the bottom of the tube. This problem can be controlled by diluting the sample, although caution must be exercised not to dilute a sample excessively thus obtaining a dry weight too small to be significantly measured. Another source of error was observed in the process of removing the zooplankton from the centrifuge tubes. A considerable number of organisms were found between each definable fraction, and some of these occurred at the interface of the gradient solutions. When removing zooplankton fractions, the point(s) of pipette draw-off must be left to the best judgement of the investigator, and it is recognized that this represents many possibilities for individual variation. Moreover, unless one is extremely cautious, the use of a pipette in the removal of fractions may result in additional particulate material being drawn into the pipette from adjacent fractions. Finally, it is readily apparent that 100% of zooplankton organisms are not retained in the zooplankton fractions but are spun to the bottom of the tube with other seston. This occurs most

[1] Initial efforts involved careful microscopic examination of all fractions obtained by centrifugation, as well as direct density counts using a Sedgewick-Rafter cell in conjunction with 100X magnification.

frequently on the part of smaller and less dense organisms; e.g., rotifers and nauplii. Although the densities of some of these smaller zooplankters may be relatively high withing their size classes, their contribution to the total zooplankton biomass was considered negligible.

Zooplankton Biomass in Beaver Reservoir

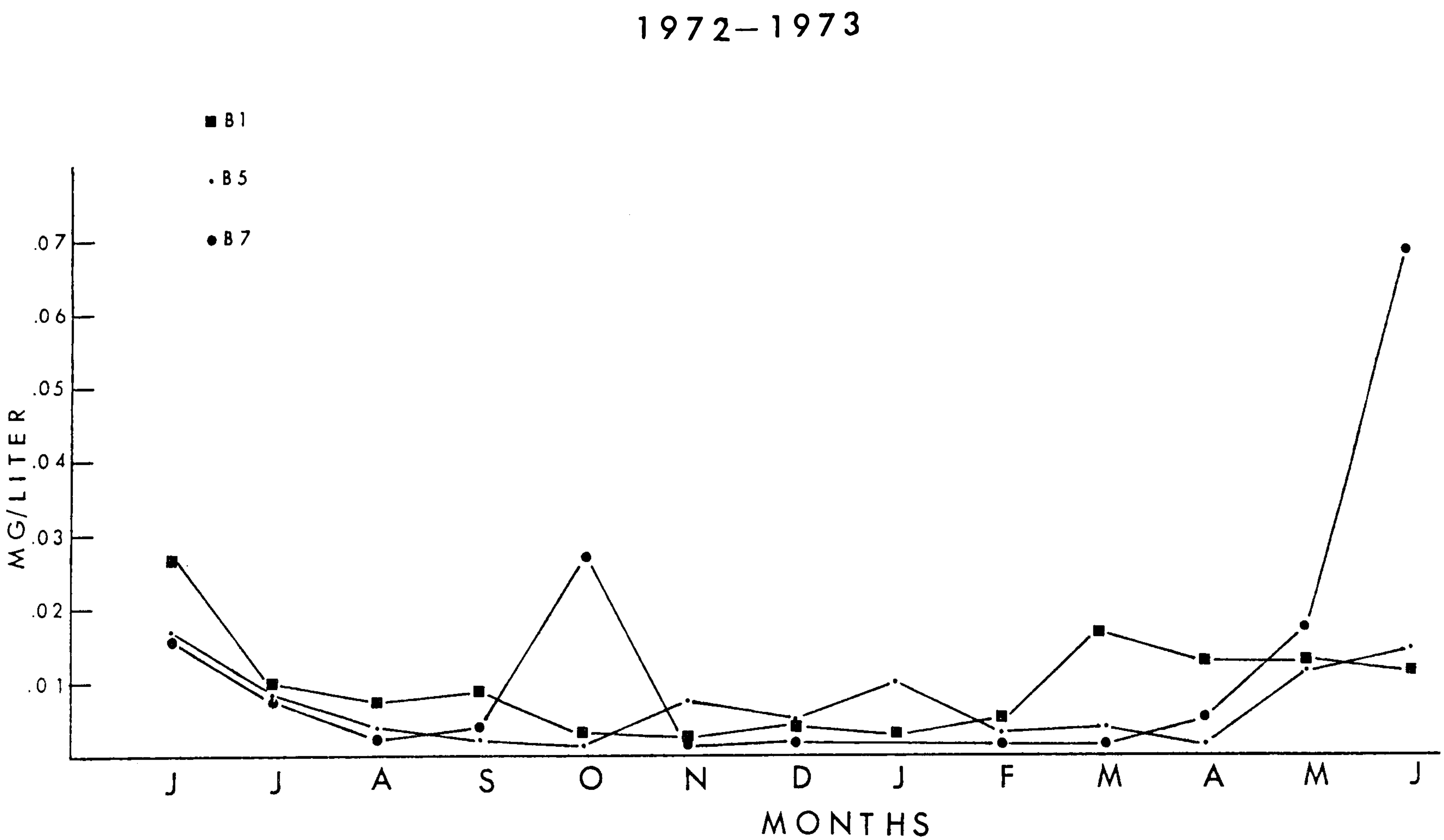
Dry weights from Beaver Reservoir ranged from z maximum of 0.0687 mg/liter in June 1973 at B7 to a minimum of 0.0004 mg/liter in November 1974 at B5 (Table 5). Mean dry weights calculated for all three Beaver stations revealed two peaks per year (Figures 9, 10, 11); i.e., a smaller peak occurred in the autumn (usually around October), and a more pronounced pulse was observed in the spring (usually May or June). In both instances, sharp declines followed each peak during the subsequent month. The maximum peak was noted for June 1973 when the mean for the three stations reached 0.0313 mg/liter (Table 5). This maximum was followed by a sharp decline, but in October 1973 again peaked out at 0.0158 mg/liter. Therefore, 1973-74 appeared to be the most productive period, as reflected in terms of zooplankton biomass for the three sampling period considered. These results parallel total zooplankton organism densities observed by Schmitz (1974), Short (1974), and abundance data presented in this report; i.e., the bimodal pattern of biomass distribution reflects that of seasonal abundance (cf. Figure 12 with 13). The peaks of maximum mean densities are influenced mostly by concentrations of organisms at B7. B5 produced less zooplankton biomass than B1, which in turn produced less than B7, a pattern that seems to hold true for all three sampling periods (Figures 9, 10, 11).

It is interesting to note the effect on dry weight estimates that different species of zooplankton impose. For example, there was a rather

Table 5. Zooplankton biomass in Beaver Reservoir for the period June 1972 through April 1975 expressed as mg/liter dry weight. Blank spaces represent intervals for which samples were not available.

	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May
						1972-73						
B1	0.0280	0.0150	0.0080	0.0092	0.0038	0.0006	0.0036	0.0040	0.0050	0.0164	0.0138	0.0132
B5	0.0166	0.0076	0.0034	0.0029	0.0020	0.0080	0.0030	0.0110	0.0042	0.0040	0.0012	0.0122
B7	0.0152	0.0075	0.0020	0.0040	0.0270	0.0012	0.0012	0.0012		0.0006	0.0044	0.0170
$\bar{x}$	0.0199	0.0100	0.0045	0.0054	0.0109	0.0033	0.0026	0.0054	0.0046	0.0070	0.0065	0.0141
						1973-74						
B1	0.0112	0.0056	0.0050	0.0140	0.0014	0.0048	0.0052	0.0024	0.0044		0.0330	0.0138
B5	0.0141	0.0162	0.0096	0.0108	0.0263	0.0050	0.0058	0.0028	0.0014	0.0072	0.0196	0.0138
B7	0.0687		0.0124	0.0252	0.0146	0.0234	0.0014	0.0012	0.0028	0.0042	0.0148	0.0250
$\bar{x}$	0.0313	0.0109	0.0090	0.0167	0.-141	0.0111	0.0041	0.0021	0.0029	0.0057	0.0225	0.0175
						1974-75						
B1	0.0082	0.0014	0.0053	0.0014	0.0010	0.0012		0.0024		0.0062	0.0185	
B5	0.0092	0.0059	0.0039	0.0024	0.0094	0.0004		0.0021		0.0030	0.0045	
B7	0.0200	0.0080	0.0065	0.0128	0.0351	0.0010		0.0064		0.0090	0.0030	
$\bar{x}$	0.0125	0.0051	0.0052	0.0055	0.0152	0.0009		0.0036		0.0061	0.0087	

Figure 9. Seasonal zooplankton biomass patterns in Beaver Reservoir during the period June 1972 through June 1973.



1972–1973
B1
B5
B7
.07
.06
.05
.04
.03
.02
.01
MG/LITER
J
J
A
S
O
N
D
J
F
M
A
M
J
MONTHS

Figure 10. Seasonal zooplankton biomass patterns in Beaver Reservoir during the period June 1973 through June 1974.

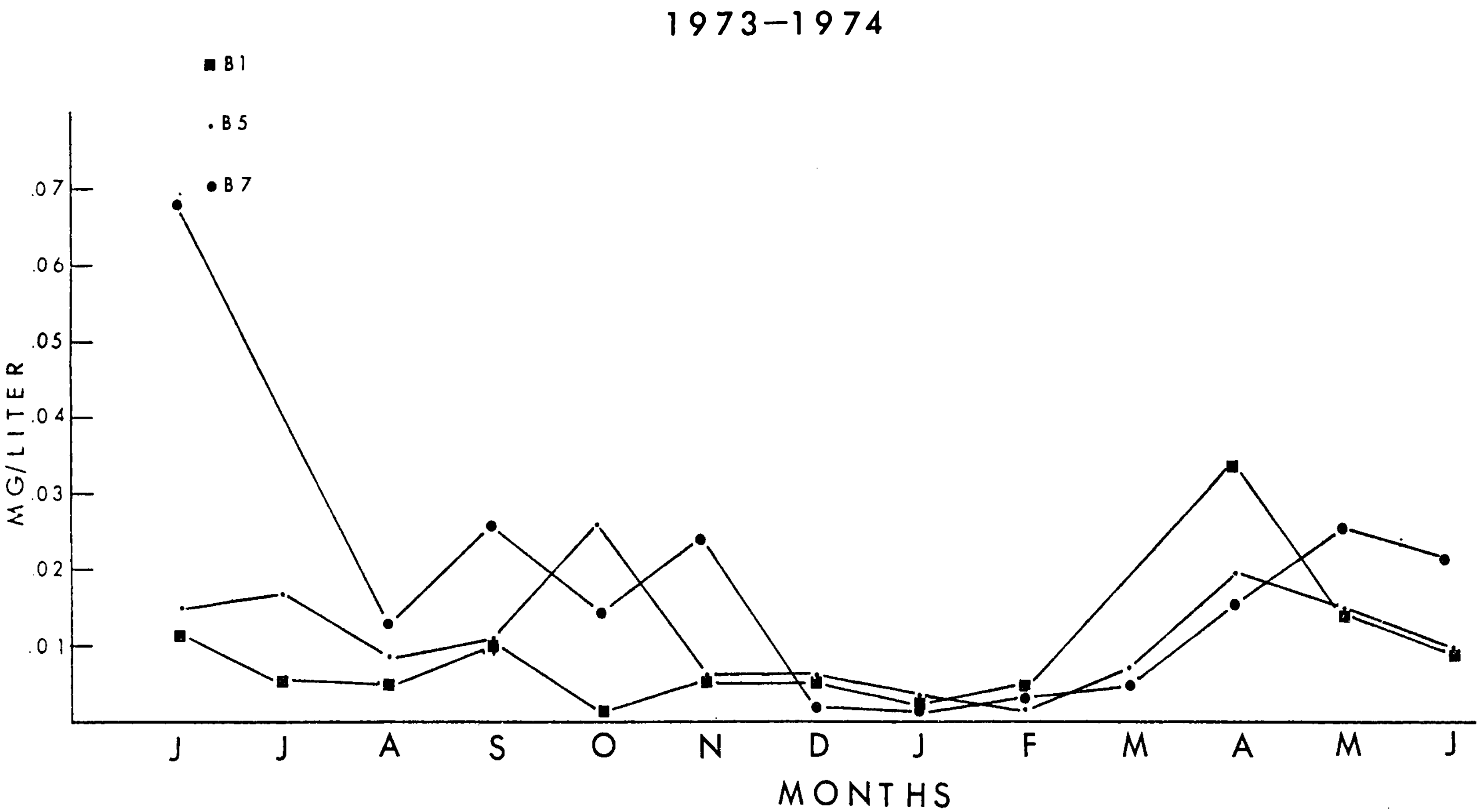

1973–1974
B1
B5
B7
MG/LITER
.07
.06
.05
.04
.03
.02
.01
J
J
A
S
O
N
D
J
F
M
A
M
J
MONTHS

Figure 11. Seasonal zooplankton biomass patterns in Beaver Reservoir during the period June 1974 through April 1975.

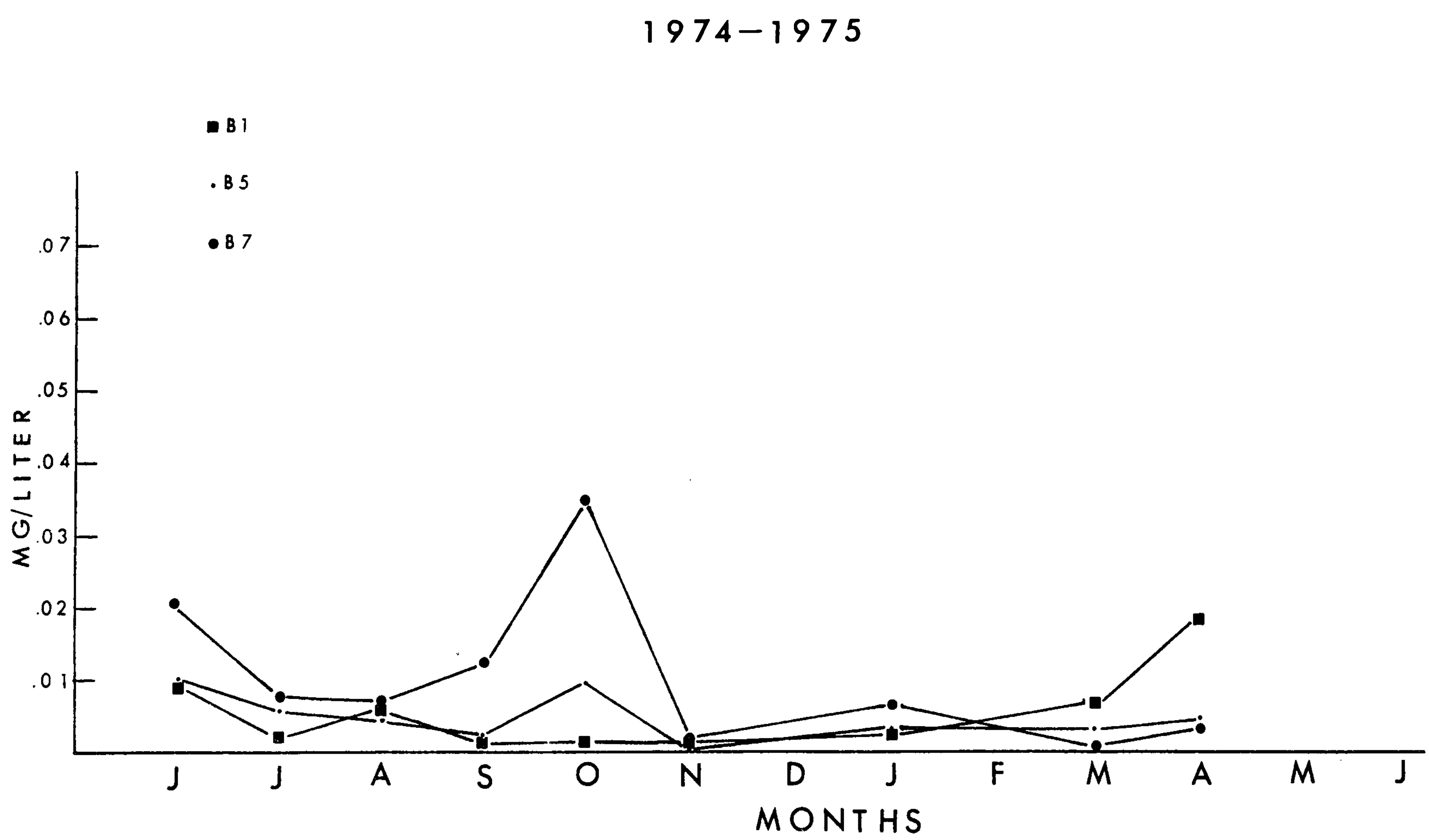

1974—1975
B1
B5
B7
MG/LITER
.07
.06
.05
.04
.03
.02
.01
J
J
A
S
O
N
D
J
F
M
A
M
J
MONTHS

Figure 12. Mean seasonal zooplankton biomass patterns in Beaver Reservoir during the period June 1972 through April 1975.

B 1-5-7 AVG.

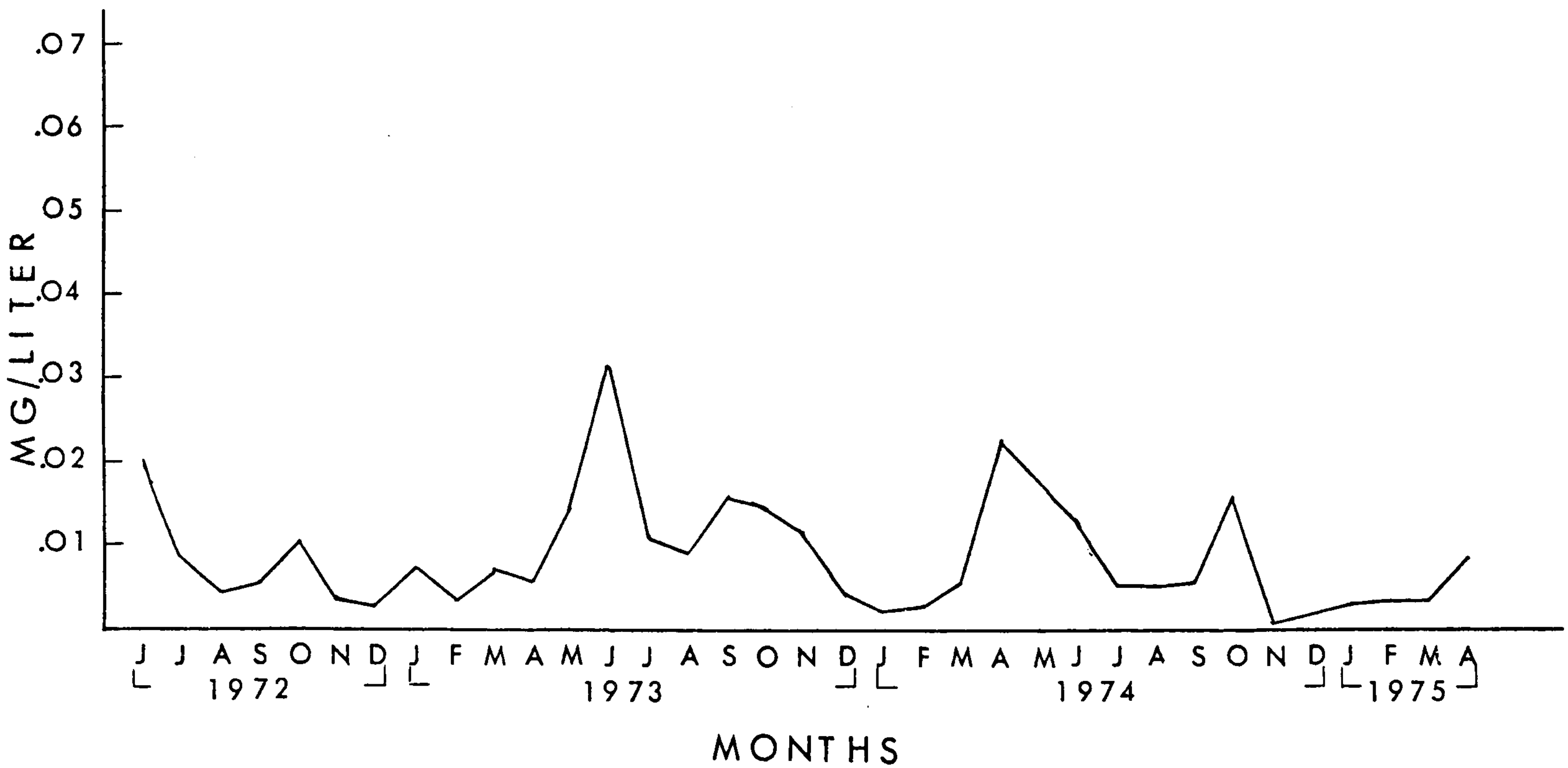
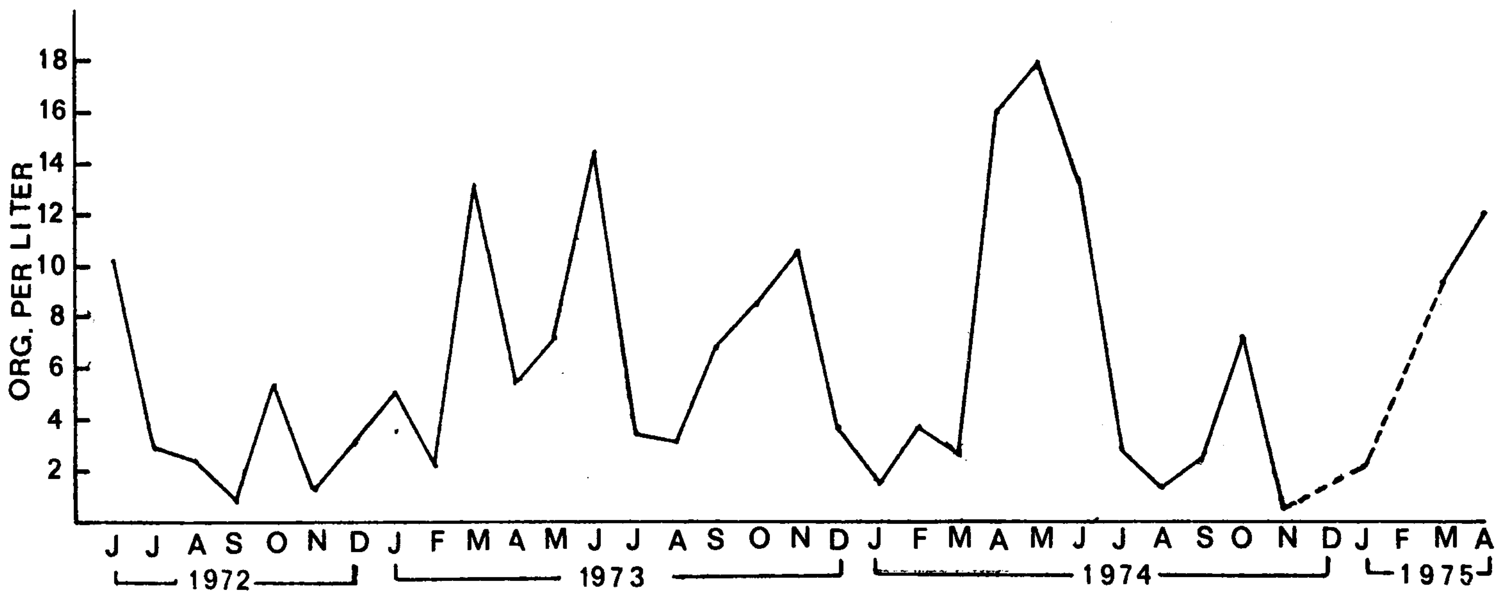

MG/LITER
.07
.06
.05
.04
.03
.02
.01
J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A
1972
1973
1974
1975
MONTHS

Figure 13. Mean seasonal zooplankton abundance patterns in Beaver Reservoir during the period June 1972 through April 1975.

B 1-5-7 AVG.


ORG. PER LITER
18
16
14
12
10
8
6
4
2
J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A
1972
1973
1974
1975

sharp increase in the biomass of organisms at B7 in October 1973, as compared to September and November of the same year (Figure 10). Total densities revealed 5.93 organisms/liter in September, 14.67/liter in October, and 22.69/liter in November (Short, 1974). On this basis, one might expect a continuous increase in biomass over the three-month period. Closer observation reveals that the lower density in September was overshadowed by the presence of nearly four times as many large *Diaphanosoma leuchtenbergianum* than occurred in October. In October, the increase in numbers was dependent on a noteworthy increase in densities of small rotifers--this is a general observation which was clearly apparent in the case of such small forms as *Conochilus unicornis*, but for which abundance data could not be cited in this report, since a no. 10 net was used in sampling procedures. Likewise, during November the increase in densities was reflective of an increase in the samll cladoceran *Bosmina longirostris*, while the greater total dry weight probably was influenced by adult calanoids and *Daphnia parvula* (Table 5).

Biomass in DeGray Lake

Preliminary biomass values from DeGray Lake for the period 27 June 1974 through 7 February 1975 must be approached with extreme caution (cf. Figure 14 and Table 6 with Figures 1, 2, 3, 4 in Nix, et al, 1975). These data presented an apparent error that could not be isolated; i.e., the maximum zooplankton biomass recorded for 8 August was not reconcilable with the 11 September maximum in terms of abundance. If one reasons that relatively smaller densities of Entomostraca make greater contributions to biomass than higher densities of Rotatoria, it should be noted that the period from 27 June to 11 September is characterized by a decline in Copepoda, the Cladocera remaining insignificant.

Table 6. Zooplankton biomass in DeGray Reservoir during the period June 1974 through February 1975 expressed as mg/liter dry weight.

Station	Date	Depth Interval (M)	Zooplankton Dry Weight (gm)	Mg/Liter	* $\bar{x}$
1	6/27/74	53 - 0	0.0012	0.0006	
10	6/27/74	24 - 0	0.0031	0.0038	
12	6/27/74	15 - 5	0.0014	0.0040	0.0028
20	6/27/74	5 - 0	0.0003	0.0018	
1	8/8/74	50 - 0	0.0094	0.0054	
4	8/8/74	20 - 0	0.0063	0.0092	
9	8/8/74	20 - 10	0.0090	0.0264	
10	8/8/74	23 - 0	0.0059	0.0074	
12	8/8/74	15 - 5	0.0100	0.0292	
13	8/8/74	10 - 0	0.0080	0.0234	0.0168
1	9/11/74	50 - 0	0.0006	0.0004	
10	9/11/74	25 - 0	0.0006	0.0008	
12	9/11/74	14 - 0	0.0008	0.0016	0.0010
20	9/12/74	5 - 0	NO DATA		
1	10/16/74	55 - 0	0.0229	0.0122	
4	10/16/74	20 - 0	0.0005	0.0008	
9	10/16/74	20 - 0	0.0044	0.0064	
10	10/16/74	25 - 0	0.0044	0.0052	
12	10/16/74	13 - 0	0.0003	0.0006	
13	10/16/74	10 - 0	0.0018	0.0052	0.0050
20	10/16/74	5 - 0	0.0007	0.0040	
1	11/15/74	53 - 0	0.0095	0.0052	
4	11/15/74	20 - 0	0.0003	0.0004	
9	11/15/74	20 - 0	0.0004	0.0006	
10	11/15/74	24 - 0	0.0002	0.0002	
12	11/15/74	14 - 0	0.0004	0.0008	
13	11/15/74	9 - 0	0.0007	0.0022	0.0016
20	11/15/74	5 - 0	0.0003	0.0018	
1	12/26/74	50 - 0	0.0003	0.0002	
10	12/26/74	5 - 0	0.0010	0.0058	
12	12/26/74	5 - 0	NO DATA		
13	12/26/74	5 - 0	0.0005	0.0030	0.0030
20	12/30/74	5 - 0	0.0001	0.0006	
1	2/7/75	52 - 0	0.0007	0.0004	
9	2/7/75	20 - 0	0.0017	0.0024	
10	2/7/75	22 - 0	0.0010	0.0014	
12	2/7/75	14 - 0	0.0001	0.0002	0.0012
20	2/7/75	5 - 0	0.0004	0.0024	

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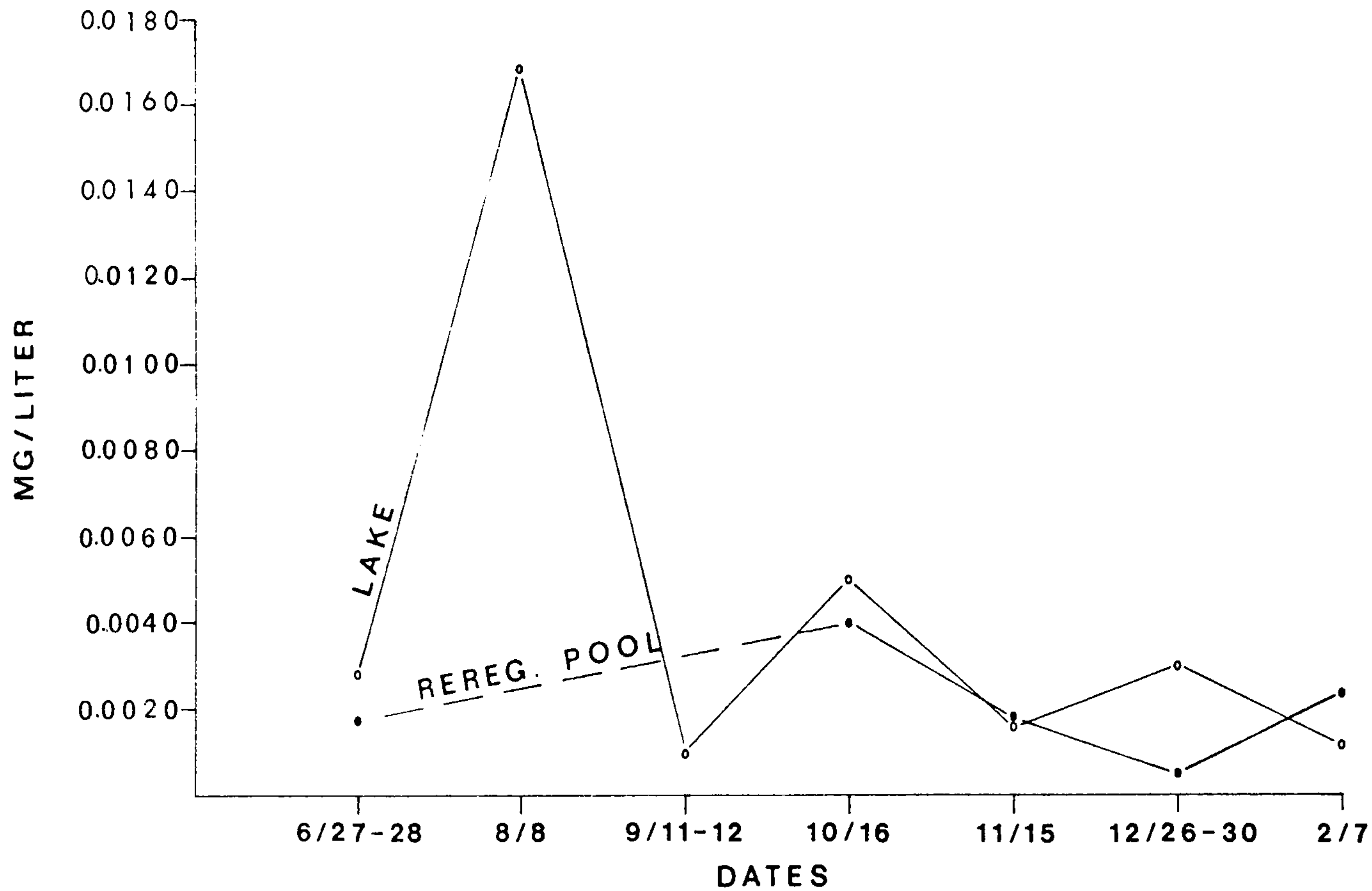
*Mean values for each sampling interval do not include Station 20 (re-regulating pool).

Figure 14. Seasonal zooplankton biomass patterns in DeGray Reservoir and the re-regulating pool during the period June 1974 through February 1975.



0.0180
0.0160
0.0140
0.0120
0.0100
0.0080
0.0060
0.0040
0.0020
MG/LITER
LAKE
REREG. POOL
6/27-28
8/8
9/11-12
10/16
11/15
12/26-30
2/7
DATES

Table 7. Total (T) and zooplankton biomass (F) data for DeGray Reservoir during the period 7 March 1975 through 10 June 1975. Note that total biomass is represented by total net seston. (This phase of the work was conducted under U. S. Army Corps of Engineers Contract No. DACW 39-75-C-0025).

	Date	Station & Depth	Vol. of Conc. Sample (ml)	Vol. of Subsample (ml)	Zooplankton Dry Weight (gm)	Mg/Liter
T	3/7/75	1-52-0	60	10	0.0083	0.0028
F	3/7/75	1-52-0	60	10	0.0013	0.0004
T	3/7/75	10-24-0	60	10	0.0077	0.0056
F	3/7/75	10-24-0	60	10	0.0025	0.0018
T	3/7/75	12-14-0	120	10	0.0020	0.0050
F	3/7/75	12-14-0	120	10	0.0017	0.0042
T	4/11/75	1-52-0	80	10	0.0193	0.0087
F	4/11/75	1-52-0	80	10	0.0066	0.0030
T	4/11/75	10-23-0	80	10	0.0367	0.0374
F	4/11/75	10-23-0	80	10	0.0083	0.0085
T	4/11/75	12-13-0	140	10	0.0108	0.0341
F	4/11/75	12-13-0	140	10	0.0052	0.0164
T	5/15/75	1-52-0	50	10	0.0089	0.0125
F	5/15/75	1-52-0	50	10	0.0048	0.0068
T	5/15/75	10-25-0	50	10	0.0015	0.0044
F	5/15/75	10-25-0	50	10	0.0034	0.0100
T	5/15/75	12-14-0	60	10	0.0096	0.0301
F	5/15/75	12-14-0	60	10	0.0074	0.0232
T	6/10/75	1-50-0	140	10	0.0073	0.0060
F	6/10/75	1-50-0	140	10	0.0043	0.0035
T	6/10/75	10-25-0	140	10	0.0078	0.0128
F	6/10/75	10-25-0	140	10	0.0030	0.0049
T	6/10/75	12-14-0	140	10	0.0091	0.0266
F	6/10/75	12-14-0	140	10	0.0048	0.0141

Figure 15. Seasonal pattern of mean zooplankton densities occurring in DeGray Reservoir during the period 7 March 1975 through 10 June 1975. (This phase of the work was conducted under U. S. Army Corps of Engineers Contract No. DACW 39-75-C-0025).

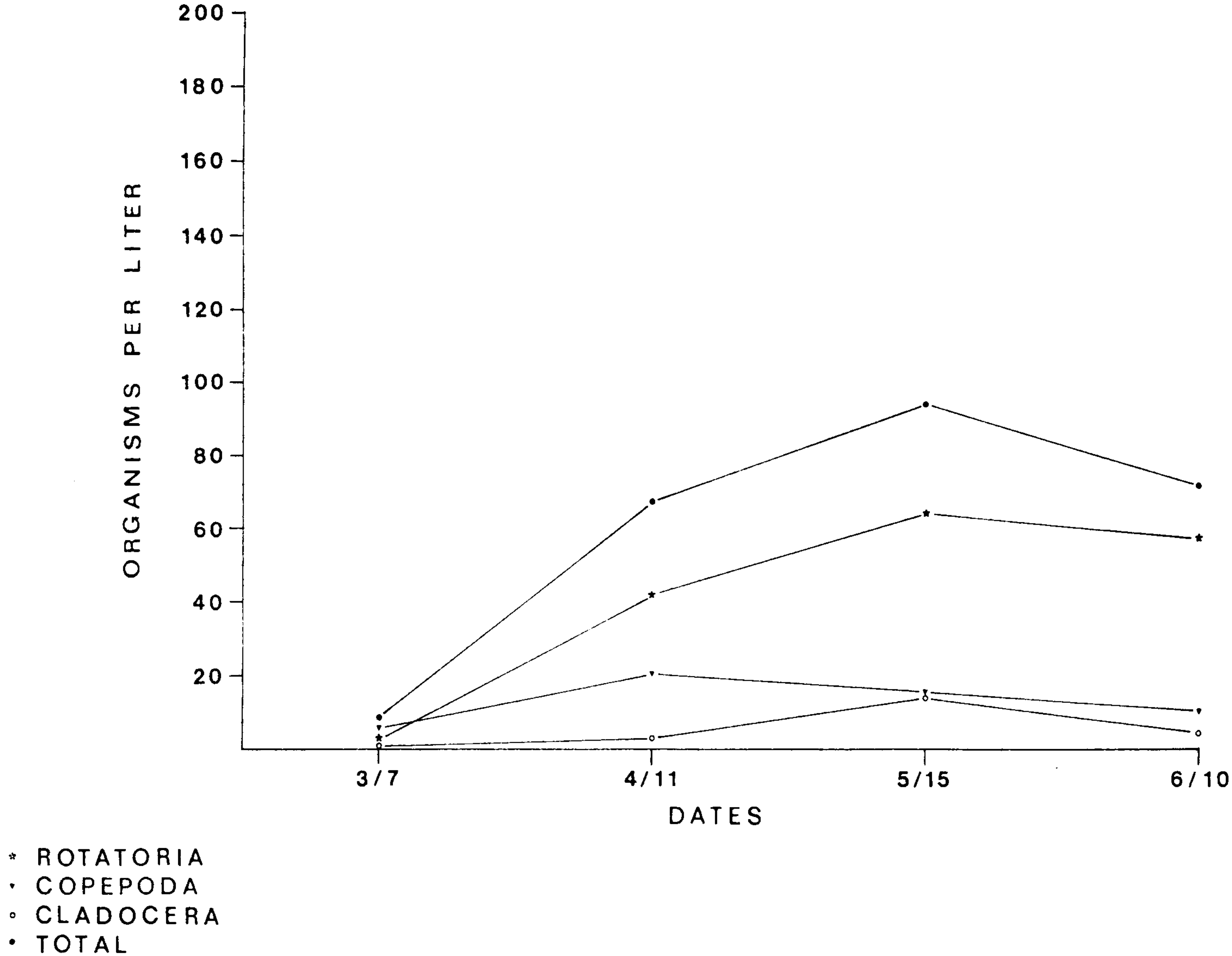
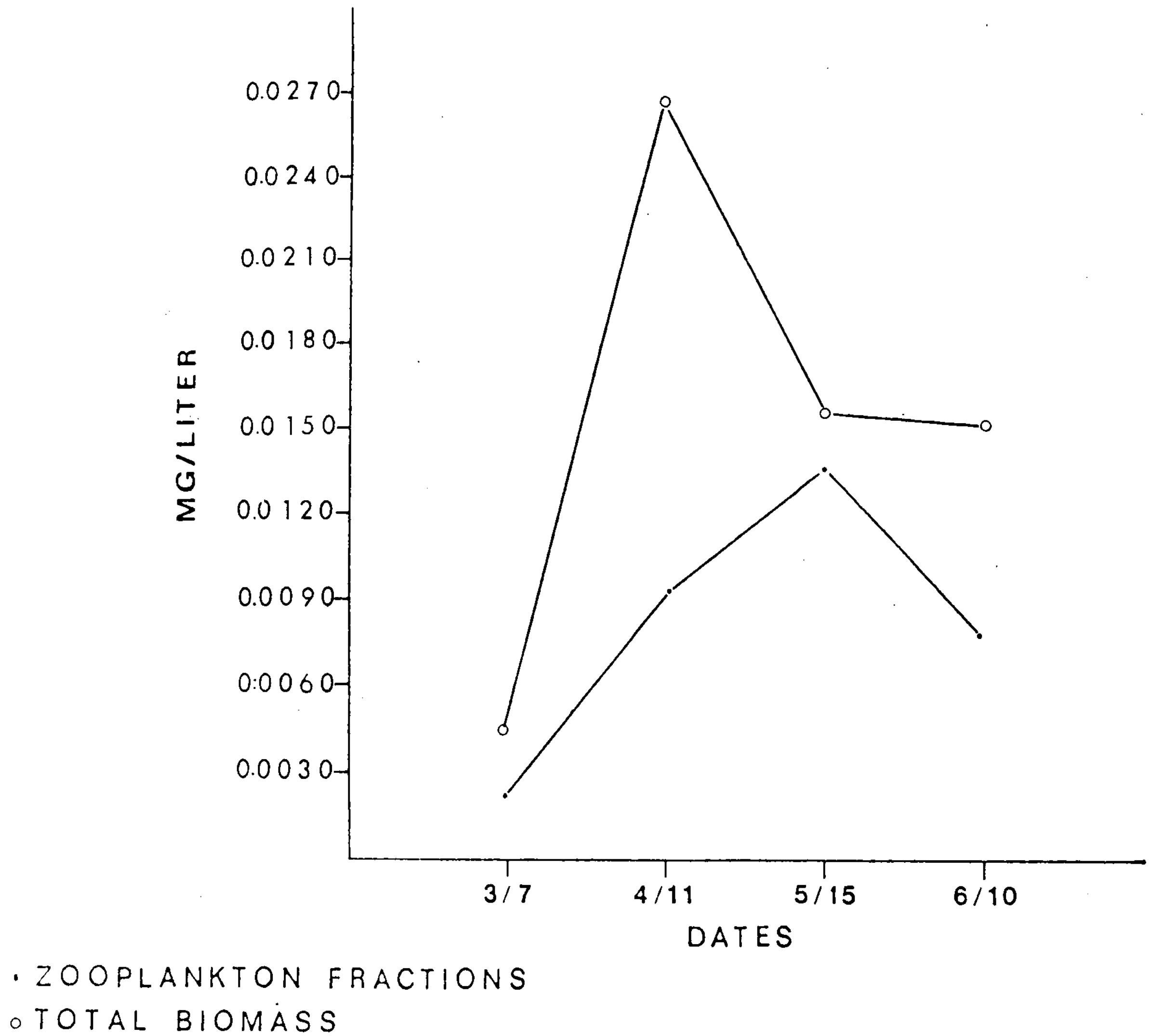

ORGANISMS PER LITER
200
180
160
140
120
100
80
60
40
20
3/7
4/11
5/15
6/10
DATES
* ROTATORIA
▾ COPEPODA
∘ CLADOCERA
• TOTAL

Figure 16. Seasonal mean biomass estimates for DeGray Reservoir during the period 7 March 1975 through 10 June 1975 expressed as mg/liter dry weight. (This phase of the work was conducted under U. S. Army Corps of Engineers Contract No. DACW 39-75-C-0025).


MG/LITER
0.0270
0.0240
0.0210
0.0180
0.0150
0.0120
0.0090
0:0060
0.0030
3/7
4/11
5/15
6/10
DATES
· ZOOPLANKTON FRACTIONS
○ TOTAL BIOMASS

We have a good deal more confidence in the data taken for the period 7 March through 10 June 1975, this assertion being based upon the following: (1) special large-volume samples (five continuous net hauls from two meters off of the bottom to the surface were composited) were taken for biomass estimations, which enabled us to have an adequate mass of dried zooplankton to weigh within the capabilities of our available gravimetric techniques; (2) replications with different subsamples yielded reasonably consistent results; and (3) seasonal biomass patterns tended to parallel those of the spring pulse as measured in terms of organism densities—this seemed particularly to be the case where larger Entomostraca appeared in significant densities, even when rotifers dominated, as was the usual pattern during this sampling interval.

For the DeGray work, dry weights of total net seston were used as "controls." Thus, both "total" biomass and zooplankton biomass (centrifuged fraction) were plotted (see Figure 16 and Table 7). From these data, it is easily observed that zooplankton biomass peaked (the most conspicuous peak at Station 12) in May, therefore paralleling organism density patterns for each station, as well as the mean density pattern (cf. Figure 15 with 16). The total biomass peak at Station 10 in April is ascribed mostly to a high density of filamentous algae and diatoms, which were separated from the zooplankton fractions.

Finally, it should be noted that the zooplankton fractions have been consistently "clean" in a microscopic sense using our present procedure. However, an ever present problem has been the estimation of zooplankton loss to the remaining seston fractions. Microscopic analyses involving density counts of the latter have lead us to assert that such loss amounts to no more than 20%—in most cases, probably less than 10%. Moreover, those zooplankton forms which are "spun out" usually are smaller forms (e.g., nauplii and rotifers). Presumably, such forms would not contribute significantly to overall zooplankton biomass.

SUMMARY

A 50-meter column was sampled weekly for zooplankton from the deepest portion of DeGray Lake (Station 1) over the old Caddo River channel just above the dam. A preliminary qualitative inventory of metazoan plankton species occurring in DeGray Lake enumerated a total of 80 species which consisted of 50 rotatorians, 24 cladocerans, and six copepods. Weekly abundance data for the period August 1974 through March 1975 showed rotatorians to be the dominant group August through December, and rotatorians and copepods to be co-dominant groups January through March; cladocerans were never a significant component of the zooplankton associations. However, weekly density values were extremely low as compared to data for the same period as reported by Nix, et al (1974, 1975). Evaluation of field equipment and techniques lead to the hypothesis that the mouth to net ratio of the 29.5 cm aperture Birge closing net was inadequate for sampling a 50-meter vertical column with maximum straining efficiency.

Beaver Lake Stations B1, B5, and B7 were monitored monthly during the period June 1974 through April 1975, with the exceptions of December and February. Cyclopoids were the most abundant copepods and they reflected a recognizable bimodal pattern. Adult calanoids tended toward a unimodal pattern, although their total densities were lower than those reported for 1972-73 and 1973-74. Nauplii occurred in relatively small numbers, but a tendency toward a bimodal seasonal pattern could be discerned at B5. Sixteen cladoceran species were recorded. *Daphnia parvula* was the most frequently encountered daphnid and this species exhibited a bimodal pattern at B5 and B7.

Bosmina longirostris demonstrated a tendency toward a trimodal pattern at B1 and was the most ubiquitous cladoceran observed in the lake during the entire sampling period. *D. galeata mendotae* occurred frequently with *D. parvula* at B1, but *Ceriodaphnia lacustris* generally was sporadic throughout the lake. *Alona rectangula*, *A. monacantha*, and *Simocephalus expinosus* were observed infrequently and in low numbers, but these species were not recorded for 1972-73 and 1973-74. The large rotatorian, *Asplanchna priodonta*, reflected a unimodal pattern. Smaller rotatorians could not be evaluated quantitatively because of the sampling equipment used. Although occurring frequently, negligible densities of *Chaoborus punctipennis* precluded any attempt to discern seasonal patterns. Beaver Lake reflected an overall bimodal seasonal pattern with the autumn pulse emerging as a distinct pattern. Such appears to contradict the hypothesis that the lake is evolving from a bimodal to a more mature unimodal pattern.

The major expenditure of effort was directed toward the development of a suitable method for estimating the contribution of zooplankton to total biomass. Sucrose density-gradient centrifugation techniques were adapted to separate zooplankton from other net seston in preserved samples. A suitable combination of variables was obtained by manipulating the combination of sucrose concentrations, centrifuge speed, and centrifuge time at various speeds. Zooplankton fractions were washed, filtered using pre-combusted, pre-weighed glass fiber filter discs, dried, weighed, and recorded as mg/liter.

Mean dry weight patterns obtained from preserved Beaver samples, representing three sampling periods within the 1972-1975 interval, parallel total zooplankton organism densities to the extent that the bimodal pattern of biomass distribution reflects that of seasonal abundance. Some effects of various species on biomass estimates are discussed.

For DeGray Lake, dry weights of total net seston were used as "controls." Total and zooplankton values for the June 1974 through February 1975 period could not be reconciled with seasonal abundance values. However, determinations using special large-volume samples taken during the March through June 1975 period yielded zooplankton biomass values which were reflective of seasonal abundance patterns, particularly where the influence of individual group densities were considered.

Sources of error and precautions in the use of the method are discussed. Zooplankton fractions are consistently "clean" even from samples representing periods during which significant algal pulses occurred. Microscopic analyses suggest that loss of zooplankters to the remaining seston fraction probably is less than 10% and that such loss includes smaller forms which would not contribute significantly to total zooplankton biomass.

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