SOME ECOLOGY
OF BENTHIC INSECTS IN GLADFELTER POND

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by

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Abstract approved: John D. Ransom

Benthic and emerging fauna were investigated at Gladfelter Pond from September, 1972, through September, 1973. Species diversity analyses were made on the benthic community by using the equation of Shannon Weaver (1949). Relationships between benthic fauna and emerging fauna were established.

A total of 15,419 benthic organisms representing 33 taxa were collected. Eighty-two percent of the total individuals collected were represented by the phantom midge larva, Chaoborus punctipennis Say. Six percent were represented by the fingernail clam, Sphaerium sp. Hexagenia sp. composed 3 % of the total benthic fauna collected, although no adults were caught in the emergence traps.

The majority of the benthic organisms collected was from the 3 m and 4 m depths, 34 % and 49 % respectively.

A total of 775 emerged insects was collected. Seventy-four percent of all emerged insects collected belonged to the family Chironomidae. By comparison, only 26 % of the benthic fauna collected were Chironomidae. There were no

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significant differences among the numbers of individuals caught in the three traps. The two major families emerging, Culicidae and Chironomidae, had peak emergence periods only two weeks apart.

There were no significant differences found in annual diversity ($\bar{d}$) by depth, but there were significant differences in monthly diversity when all depths were combined.

Approved for Major Department

Approved for Graduate Council

ACKNOWLEDGMENT

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Several studies have been made on Gladfelter Pond at the Emporia State University Ross Natural History Reservation (Griffith, 1961; Kingsbury, 1963; Osborne, 1968; Perez, 1970). To date, no attempt has been made to relate the benthic community to emerging insects from this impoundment. A few studies similar to this research have been conducted in other areas of the world, but most were concerned with the biology of certain families or species of aquatic insects, or with certain conditions affecting emergence rates (Morgan and Waddell, 1961; Buckley and Sublette, 1964; Hilsenhoff, 1966; Hilsenhoff and Narf, 1968; Nebeker, 1971).

The benthic macroinvertebrates are defined by location and size, but not by their position in the trophic structure since they occupy virtually all trophic levels. Species composition, distribution, and abundance of aquatic macroinvertebrates may be subject to wide seasonal variations (Funk, 1973). The distribution of aquatic macroinvertebrates is affected partially by the type of substrate and depth (Ransom and Dorris, 1972; Funk, 1973). Seasonal variations are particularly important in freshwater habitats dominated by insects having several life stages, not all of which are aquatic. Aquatic macroinvertebrates are important members of the food web, especially to higher forms such as fish. Some, such as mosquitoes, black flies, and biting midges, are of considerable public health significance and some are simply pests. Many forms are important for digestion of organic material and recycling nutrients (Weber, 1973).

Much of what is known about aquatic insect populations has been learned from bottom faunal studies using conventional bottom samplers. Quantitative and qualitative data have been secured in this manner, but investigators have experienced difficulty in making positive identification of collected immature forms (Buckley and Sublette, 1964). Because of the scarcity of studies on lakes in the Midwest, this research was undertaken to secure quantitative and qualitative data on the larval benthic organisms from collections made by conventional methods and from samples of adults taken by floating emergence traps.

DESCRIPTION OF THE STUDY AREA

Gladfelter Pond is located on the F. B. and Rena G. Ross Natural History Reservation. The Reservation is primarily rolling bluestem prairie, broken by several shallow ridges and limestone outcrops. A small intermittent creek and several other drainages cross the area. The 420 ha area is located 22 km northwest of Emporia, Kansas, and was made available to Emporia State University in 1958 for research and field study.

One drainage on the Ross Natural History Reservation forms the watershed for Gladfelter Pond. There is a spring above the pond which could provide some spring-fed discharge into it, but most of the pond water comes from rainfall run-off from the native prairie grass watershed. Cottonwood (*Populus* sp.) and willow (*Salix* sp.) trees were in the early stages of growth around the upper edges of the pond at the time of this study. The banks were eroded to a depth of about 0.3 m, which defined the outline of the pond when the water level was at the top of the vertical overflow tube. The water level dropped during the dry summer of this study, exposing a gradual shoreline composed of clay and small chips of limestone. Beyond the 1 m depth, the substrate was silt material. Gladfelter Pond was in a gradual silting-in stage with most of the silt settling out in the shallower areas of the pond. The soft-bodied, burrowing macroinvertebrates were found in both the silty and the deep areas of the pond.

METHODS AND MATERIALS

This study extended from September, 1972, through September, 1973. The seasonal abundance of benthic organisms along a transect in the pond was studied intensively. Collections were made with a 15 cm Ekman Dredge. Bottom samples were taken monthly at 1 m depth intervals from the shore to a maximum depth of 4 m by use of the Ekman Dredge. Two dredge hauls were combined into a single sample and duplicate samples were taken at each depth. Samples were washed in a field screen at the pond and preserved in 10 % formalin. In the laboratory, the samples were washed in a United States Series Size Number 45 sieve, then sorted, counted, and stored in 70 % alcohol.

The emergence of adults at three sites was studied by use of pyramid-shaped floating emergence traps constructed from 1.5 cm thick plywood. The traps were 0.7 m on each side and were 0.5 m high for a total surface area covered of 0.5 m^2. Attached to the outside of the trap was a copper skirting which extended into the water. The traps were floated by means of 10 cm by 10 cm square styrofoam collar which was attached around the trap. The traps were anchored in place with 1 cm nylon ski rope attached to eye bolts on the floating traps and to anchors on the bottom of the pond. A quart, Kerr canning jar was used to collect the emerged insects. Brass screen was soldered to the lid and a small slot

(5 mm x 12 mm) was cut in the screen to allow entrance of insects from the trap into the jar. The jar-lid combination was then inverted on top of the trap and held in place by a triangular-shaped rubber strap cut from a tire inner tube. Collected insects were taken by removing the jar and any insects clinging to the screen and the sides were washed out with 80 % alcohol. The adult insects were then transfered to a labeled vial for later identification.

The traps were located over water depths of 0.5 m, 3.0 m and 4.0 m when the pond level was at the top of the vertical overflow tube. During the summer the water level dropped and by the middle of July, the 0.5 m trap was resting on the bottom. Emergence traps were checked at three to four day intervals from March to June, 1973, and weekly from July to October 1, 1973.

Estimates of diversity per individual ($\bar{d}$) were determined by the Shannon-Weaver (1949) equation

$$\bar{d} = -\sum_{i}^{a} \left[(n_i/n) \log_2 (n_i/n) \right]$$ where n is the total

number of individuals and n_i is the number of individuals of species i. Numbers of emerged insects and $\bar{d}$'s were compared by use of a Student t-test at $p = .05$ level of significance.

RESULTS AND DISCUSSION

Type of substrate and water levels are among the important controlling factors in the distribution of benthic communities (Funk, 1973). The substrate around the perimeter of Gladfelter Pond was clay-rock particles up to 2 cm in size with some larger granules of top soil washed in during runoff. The Ekman Dredge did not penetrate deeply into this substrate. In the deeper areas of the pond, the substrate was finer silt and ooze. The dredge had little difficulty digging into the bottom in these areas.

Fluctuation of the water level during the study may have had some influence on the position of the benthic samples taken. When the water level was at the top of the vertical overflow tube, the 1 m depth sample was taken closer to the defined shore line. In the fall, the water level was down approximately 0.5 m, so the 1 m and 2 m sampling sites were further from the shore. During the winter and after the spring rains, the water level was at the top of the overflow tube and these same sampling depths were closer to the shore.

Distribution and abundance of benthic taxa collected

A total of 15,419 individuals representing 33 taxa was collected during the study (Table I). Thirty-one of the 33 taxa collected were in the Class Insecta, and 18 of those taxa were represented by three families, Ceratopogonidae, Chirono-

TABLE I. Abundance of Selected Benthic Macroinvertebrates by Month

Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
					Individuals/m^2							
CRUSTACEA												
AMPHIPODA												
TALITRIDAE												
Hyalella azteca	167	45	233	89	667	100	111	177	156	11	256	0
INSECTA												
EPHEMEROPTERA												
EPHEMERIDAE												
Hexagenia sp.	267	1500	1522	1022	1011	289	267	500	167	44	11	11
BAETIDAE												
Caenis sp.	0	11	33	22	22	0	0	11	34	0	0	78
ODONATA												
LIBELLULIDAE												
Libellula sp.	0	0	0	11	0	0	0	11	0	0	11	0
Tetragoneuria sp.	0	0	0	0	0	0	0	0	0	0	0	11
COENAGRIONIDAE												
Enallagma sp.	0	0	0	0	0	0	0	11	0	0	0	0
Ischnura sp.	0	0	0	0	0	0	0	0	0	0	11	22
Lestis sp.	0	0	0	0	0	0	0	0	0	0	11	0
DIPTERA												
CERATOPOGONIDAE												
Palpomyia sp.	0	56	0	0	256	111	122	300	356	233	0	0

TABLE I. Continued.

Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
					Individuals/m^2							
CHIRONOMIDAE												
<u>Procladius</u> sp.	11	644	467	178	967	111	656	467	211	56	0	88
<u>Coelotanypus</u> sp.	45	100	22	11	278	144	100	67	222	22	0	11
<u>Ablabesmysis</u> sp.	22	22	56	34	665	22	22	89	34	0	0	0
<u>Clinotanypus</u> sp.	0	0	0	0	0	11	11	0	0	11	0	11
<u>Chironomus</u> sp.	0	211	533	133	112	156	34	145	11	0	0	0
<u>Chironomus</u> (<u>Tribelos</u>) sp.	0	0	0	0	11	0	0	0	0	0	0	0
<u>Chironomus</u> (<u>Crytochironomus</u>) sp.	0	0	22	11	34	22	0	11	0	0	0	11
<u>Chironomus</u> (<u>Crytochironomus nais</u>)	34	0	0	0	0	0	11	45	11	0	0	11
<u>Chironomus</u> (<u>Dicrotendipes</u>) sp.	0	0	0	0	56	0	11	11	0	0	0	0
<u>Goeldichironomus</u> (<u>Holoprasimus</u>) sp.	45	0	0	0	0	0	0	0	0	0	0	0
<u>Polypedium</u> sp.	0	0	0	0	11	0	0	0	22	0	0	0
<u>Pseudochironomus</u> sp.	0	0	0	78	34	0	22	0	0	0	0	0
<u>Stenochironomus</u> sp.	11	0	0	0	0	0	11	0	0	0	0	0
<u>Tanytarsus</u> sp.	34	0	11	0	0	0	34	0	0	0	0	0
<u>Psectorocladius</u> sp.	0	0	0	0	0	0	22	0	0	0	0	0
<u>Tanypus</u> sp.	0	0	0	0	0	0	0	0	0	0	0	132
CULICIDAE												
<u>Chaoborus punctipennis</u>	33,354	18,220	40,251	23,520	10,411	12,232	6,255	898	3,144	1,911	3,621	3,066
MEGALOPTERA												
SIALIDAE												
<u>Sialia</u> sp.	11	144	45	156	54	67	11	22	0	67	189	189

TABLE I. Continued.

Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
					Individuals/m^2							
COLEOPTERA												
HYDROPHILIDAE												
<u>Berous</u> sp.	0	0	0	0	100	0	0	0	89	0	0	0
DYTISCIDAE												
<u>Dytiscus</u> sp.	0	0	0	0	0	0	0	0	0	0	11	22
<u>Hydroporus</u> sp.	0	67	34	22	279	156	22	34	0	0	0	0
HALIPLIDAE												
<u>Halipus</u> sp.	0	0	0	0	0	0	0	0	0	0	22	0
ELMIDAE												
<u>Stenelmis</u> sp.	0	0	0	0	0	0	0	11	0	0	0	0
PELECYPODA												
SPHAERIIDAE												
<u>Sphaerium</u> sp.	634	711	411	478	1,656	278	1,022	1,777	1,944	1,889	1,378	1,055
Total individuals	34,634	21,731	43,640	25,765	16,624	13,710	8,744	4,587	6,401	4,244	5,521	4,707
Total taxa	13	16	14	15	19	16	20	20	18	12	12	14

midae, and Culicidae. These three families accounted for 86 % of the total benthic organisms collected.

As a total composite, the majority of the benthic organisms were found at the 4 m depth, where 40 % of the total was collected. Thirty percent was collected at 3 m, 7 % at 2 m, and 10 % at 1 m. At the 4 m depth, 46 % of the total benthic organisms was *Chaoborus punctipennis* Say and where all depths were combined, it accounted for 82 % of the total. The Chironomidae collected showed similar percentages; 40 % at 4 m, 23 % at 3 m, 20 % at 2 m and 15 % at 1 m, but they represented only 4 % of the total benthos. Although almost half of the benthic organisms collected were at the 4 m depth, they were represented by one species, *C. punctipennis* (Table II).

Only five taxa comprised greater than 1 % of the total taxa collected. Of the five taxa, the fingernail clam, *Sphaerium* sp., and the amphipod, *Hyalella azteca*, were not insects and could not be collected in the emergence traps. The mayfly nymph, *Hexagenia* sp., represented 3 % of the total individuals collected, although none was collected in the emergence traps. This was because some mayflies crawl out of the water onto the rocks and vegetation to shed their nymphal exoskeleton (Pennak, 1953). The remaining two taxa, *Procladius* sp. (2 %), and the phantom midge, *Chaoborus punctipennis* (82 %) represented 1 %, or greater of the total. However, the Chironomidae, to which *Procladius* sp. belongs, made up 4 % of the total.

TABLE II. Monthly Mean Numbers of Benthic Macroinvertebrates

Depth (meters)	1	2	3	4
	Individuals/m^2			
CRUSTACEA				
AMPHIPODIA				
TALITRIDAE				
Hyalella azteca	98	40	13	11
INSECTA				
EPHEMEROPTERA				
EPHEMERIDAE				
Hexagenia sp.	281	154	104	25
BAETIDAE				
Caenis sp.	13	3	-	-
ODONATA				
LIBELLULIDAE				
Libellula sp.	2	-	-	-
Tetragoneuria sp.	-	-	-	1
COENAGIONIDAE				
Enallagma sp.	1	-	-	-
Ischnura sp.	1	-	2	-
Lestis sp.	-	1	-	-
DIPTERA				
CERATOPOGONIDAE				
Palpomyia sp.	137	71	34	14
CHIRONOMIDAE				
Procladius sp.	29	68	99	183
Coelotanypus sp.	30	24	7	-
Ablabesmyia sp.	11	11	3	2
Clinotanypus sp.	3	-	-	-
Chironomus (*Tribelos*) sp.	-	1	-	-
Chironomus sp.	1	3	29	61
Chironomus (*Crytochironomus*) sp.	-	-	4	3
Chironomus (*Crytochironomus nais*)	4	2	1	-
Chironomus (*Dicrotendipes*) sp.	1	5	-	-
Goeldichironomus (*Holoprasimus*) sp.	3	-	-	-
Polypedium sp.	1	1	-	-
Pseudochironomus sp.	8	1	-	1
Stenochironomus sp.	1	-	-	-
Tanytarsus sp.	3	1	1	-
Psectorocladius sp.	1	1	-	-
Tanypus sp.	2	8	-	-

TABLE II. Continued.

Depth (meters)	1	2	3	4
	Individuals/m^2			
CULICIDAE				
Chaoborus punctipennis	81	601	5600	8039
MEGALOPTERA				
SIALIDAE				
Sialia sp.	31	18	13	11
COLEOPTERA				
HYDROPHILIDAE				
Berous sp.	15	-	-	-
DYTISCIDAE				
Dytiscus sp.	-	2	-	-
Hydroporus sp.	25	6	-	1
HALIPLIDAE				
Haliplus sp.	-	-	-	1
ELMIDAE				
Stenelmis sp.	1	-	-	-
PELECYPODA				
SPHAERIIDAE				
Sphaerium sp.	913	176	1	-

Three taxa showed maximum density during the early winter months (Table I). *Hexagenia* sp. had a high density during October and November, and exhibited a gradual decline in numbers the remainder of the year. Although no *Hexagenia* sp. adults appeared in the emergence traps, their decline was attributed to possible predation by fish and emergence. *Chironomus* sp. had the highest density in November and then dropped off in numbers during the summer. Few benthic members of the Chironomidae were collected in the late summer (Fig. I), although the highest number of emerged Chironomidae were trapped during this time period (Fig. 2).

The population peak for *C. punctipennis* occurred in November and showed a steady decline the rest of the year (Fig. 1). Ransom and Dorris (1972) reported that the peak abundance for *C. punctipennis* in Keystone Reservoir, Oklahoma, was during August. *C. punctipennis* was collected from all depths every month except at the 1 m depth in September, January, March, May, June, and August. It was significantly more abundant in the profundal zone (3-4 m), where 95 % of the *C. punctipennis* occurred.

Benthic macroinvertebrates were most abundant in November, and least abundant in the summer months between April and August (Table I). Funk (1973) reported that benthic macroinvertebrates in John Redmond Reservoir, Kansas, were least abundant from September through November. This could have been caused by low water levels, stress due to abundant feedlot runoff into the Cottonwood River and by insect emergence.

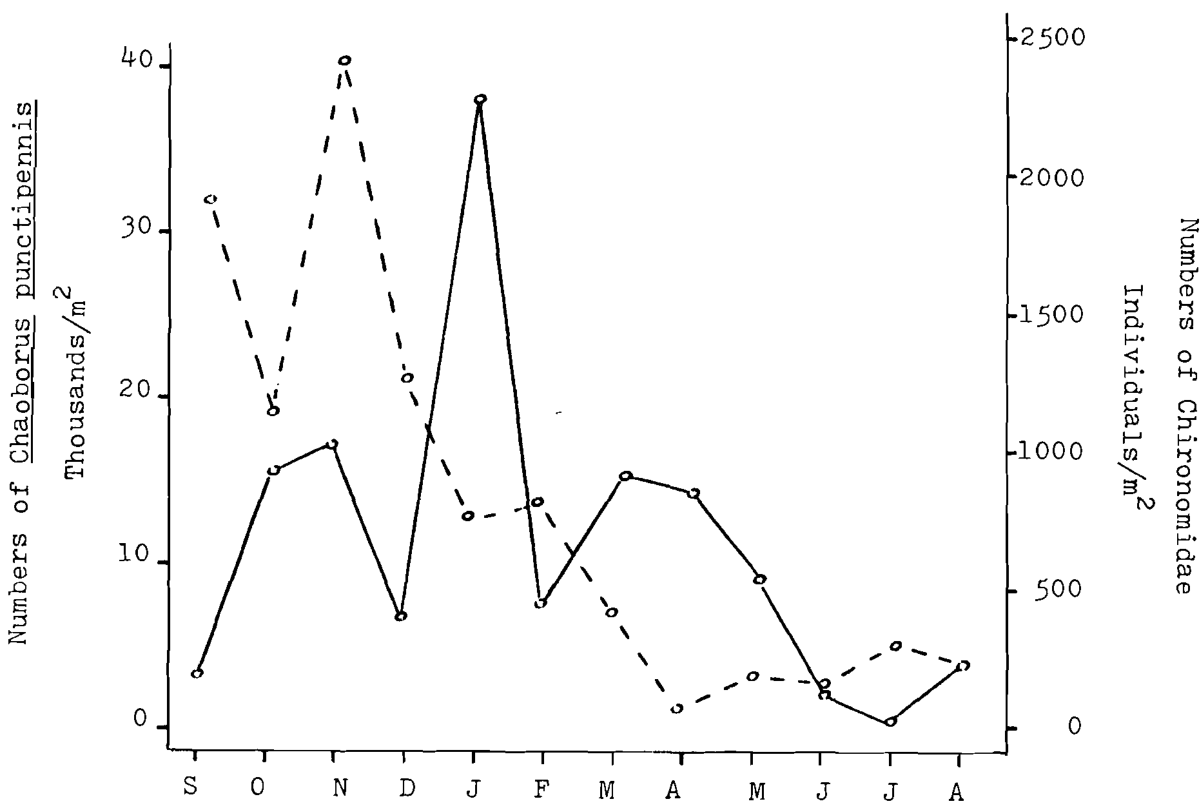

Figure 1. Comparison by month of the benthic change between the Chironomidae and C. punctipennis. (—— = Chironomidae; --- = C. punctipennis).

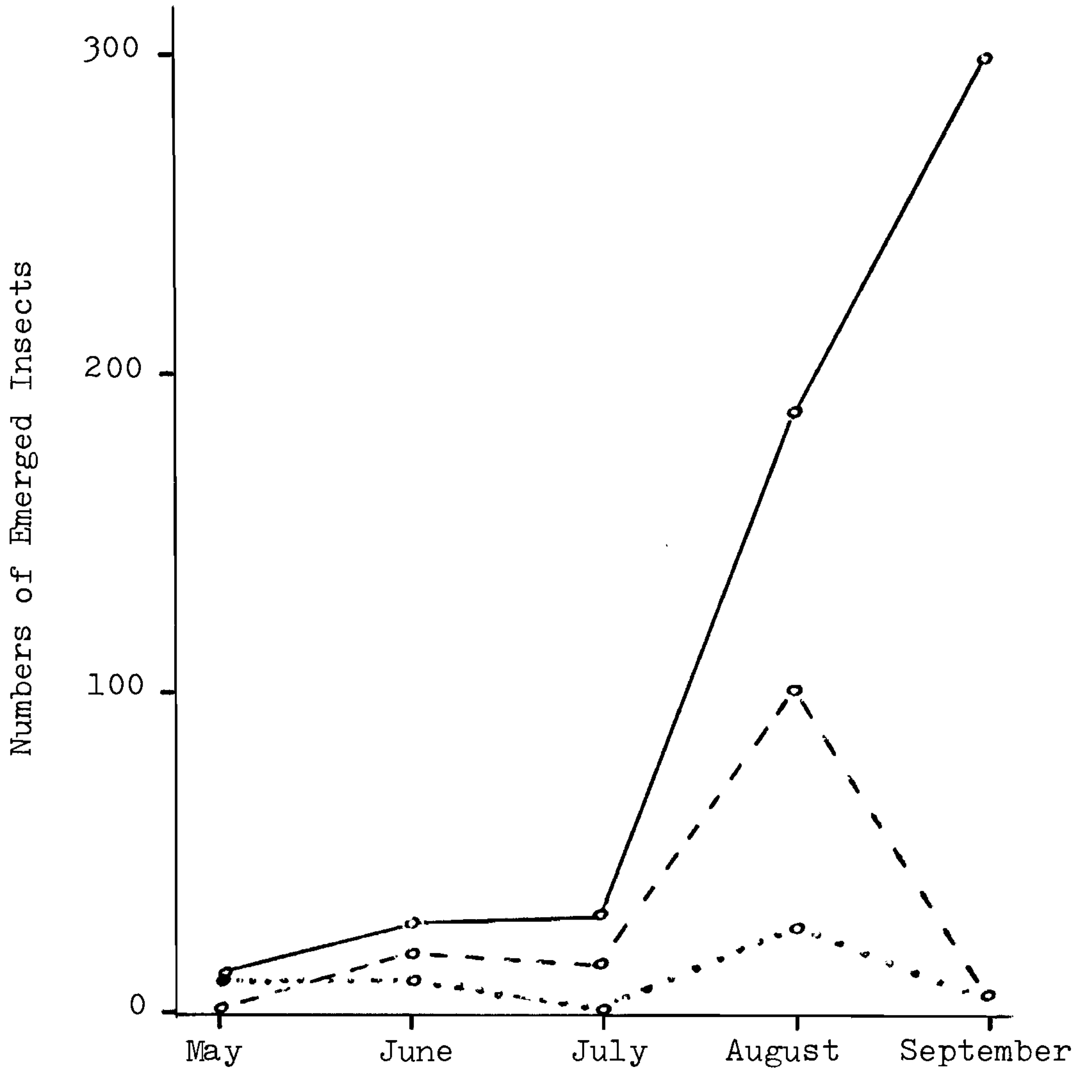

Figure 2. Emerged insects by month. (—— = Chironomidae; --- = C. punctipennis; ... = all other insects combined).

Abundance and distribution of emerged insects

Although the immature forms of *C. punctipennis* were higher in number, the density of *C. punctipennis* collected in the emergence traps was lower. The long and variable periods of 3 to 7 days between collections during peak emergence probably added some to mortality. Some larvae could have avoided the emergence traps since the traps appear as dark structures on the water surface. Assuming that these organisms could detect light, they could make avoidance movements and not be caught. Also, some adults could have fallen out of the collecting jars.

Using a Student t-test at $p = .05$, no significant differences were found among collections from the three emergence traps. Trap A, which was positioned closest to shore, had the highest number of insects caught, 70 % of the total. Trap B collected 10 % of the total, and trap C, which was over the deepest water, collected 19 % (Fig. 3).

Seventy-four percent of all emerged insects collected belonged to the family Chironomidae. Eighty-four percent of the Chironomidae were collected in trap A, 6 % in trap B, and 10 % in trap C. In comparison to the emerged insects, only 26 % of all benthic individuals collected were Chironomidae, 12 % at 1 m, 12 % at 2 m, and 2 % at 3 m (Table III).

The emergence patterns for the phantom midge, *C. punctipennis*, and all Chironomidae are similar in scope. *C. punctipennis* had its peak emergence August 24 (Fig. 4). Chironomidae's peak emergence was three weeks later although there was

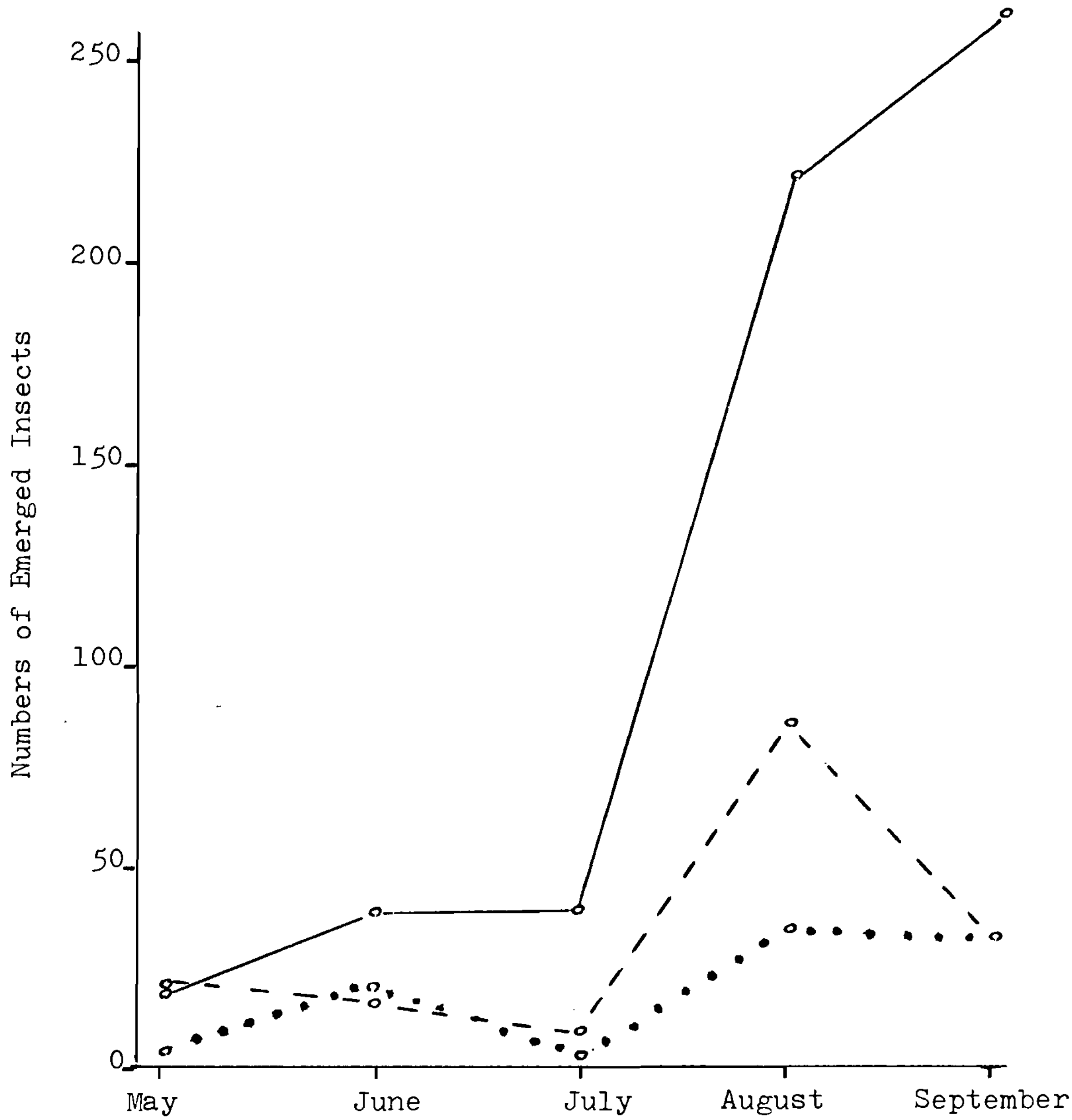

Figure 3. Monthly comparison of emerged insects from the three floating traps. (—— = Trap A-one meter or less; ... = Trap B-two meters; --- = Trap C-three meters depth)

TABLE III. Total Emerged Insects

Date and Trap		*C. punctipennis*	Chironomidae	Dolichopidae	Simuliidae	Rhagionidae	Cynipidae	Chalcidoidae	Hydroptilidae	Staphylinidae	Coleoptera	Baetidae	Coenagrionidae	Other	Totals
May 23	A	1	7	-	-	-	-	-	-	-	-	-	-	4	12
	B	1	-	1	1	-	-	-	-	-	-	-	-	1	4
	C	-	12	-	-	-	3	-	-	-	-	-	-	-	15
Jun 2	A	2	4	-	-	-	-	-	-	-	-	-	-	-	6
	B	3	-	-	-	-	-	-	-	-	-	-	-	-	3
	C	3	9	-	-	-	-	-	-	-	-	-	-	-	12
Jun 14	A	-	2	-	-	-	-	-	-	-	-	-	-	-	2
	B	-	1	-	-	-	-	-	-	-	-	-	-	-	1
	C	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Jun 17	A	-	1	1	-	-	-	-	1	-	-	-	-	-	3
	B	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	C	1	1	-	-	-	-	-	1	-	-	-	-	-	3
Jun 23	A	-	6	1	-	-	-	-	1	-	-	-	-	-	8
	B	3	-	-	-	-	-	-	-	-	-	-	-	-	3
	C	3	1	-	-	-	-	-	-	1	-	-	-	-	5
Jun 30	A	-	1	2	-	-	-	-	1	-	-	-	1	-	5
	B	2	-	1	-	-	-	-	2	-	1	-	-	-	6
	C	-	2	-	-	-	-	-	-	-	-	-	-	-	2
Jul 5	A	-	2	-	-	-	-	-	-	-	-	-	-	-	2
	B	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	C	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Jul 12	A	4	2	-	-	-	-	-	-	-	-	-	1	-	7
	B	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	C	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Jul 19	A	-	22	2	-	-	-	-	-	-	-	-	-	-	24
	B	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	C	6	-	-	-	-	-	-	-	-	-	-	-	-	6
Aug 3	A	4	8	-	1	-	-	-	1	-	-	-	-	-	14
	B	-	-	-	-	-	-	-	1	-	-	-	-	-	1
	C	-	-	-	-	-	-	-	-	-	-	-	-	-	0

TABLE III. Continued

Date and Trap		*C. punctipennis*	Chironomidae	Dolichopidae	Simuliidae	Rhagionidae	Cynipidae	Chalcidoidae	Hydroptilidae	Staphylinidae	Coleoptera	Baetidae	Coenagrionidae	Other	Totals
Aug 10	A	3	22	-	1	-	-	-	1	-	-	1	-	4	32
	B	1	-	-	-	-	-	-	-	-	-	-	-	-	0
	C	1	-	-	-	-	-	-	-	-	-	-	-	-	0
Aug 17	A	1	53	-	-	-	-	-	-	-	1	1	-	-	56
	B	3	2	-	-	-	-	-	-	-	-	-	-	-	5
	C	16	4	-	-	-	-	-	-	-	-	-	-	-	20
Aug 24	A	-	9	-	2	-	-	-	-	-	-	-	-	-	11
	B	18	4	-	-	-	-	-	-	-	-	-	-	-	22
	C	56	2	-	-	-	-	-	-	-	-	-	-	-	58
Aug 31	A	1	89	-	8	-	-	-	2	-	2	-	1	-	103
	B	1	-	-	-	-	-	-	-	-	-	-	-	-	1
	C	2	-	-	-	-	-	-	-	-	-	-	-	-	2
Sep 7	A	-	175	1	-	-	-	-	1	-	-	-	-	-	177
	B	-	3	-	-	-	-	-	-	-	-	-	-	-	3
	C	2	2	-	-	-	-	-	-	-	-	-	-	-	4
Sep 14	A	-	45	-	-	-	-	-	-	-	-	-	-	1	46
	B	-	6	-	-	-	-	-	-	-	-	-	-	-	6
	C	1	1	-	1	-	-	-	-	-	-	-	-	-	3
Sep 21	A	-	16	-	-	-	-	1	-	-	-	-	-	-	17
	B	-	1	-	-	-	-	-	-	-	-	-	-	-	1
	C	1	3	-	-	-	-	-	-	-	1	-	-	-	5
Sep 28	A	-	14	-	-	-	-	-	-	-	-	-	-	-	14
	B	1	18	-	-	-	-	-	-	-	-	-	-	-	19
	C	1	21	-	-	-	-	-	-	-	-	-	-	-	22

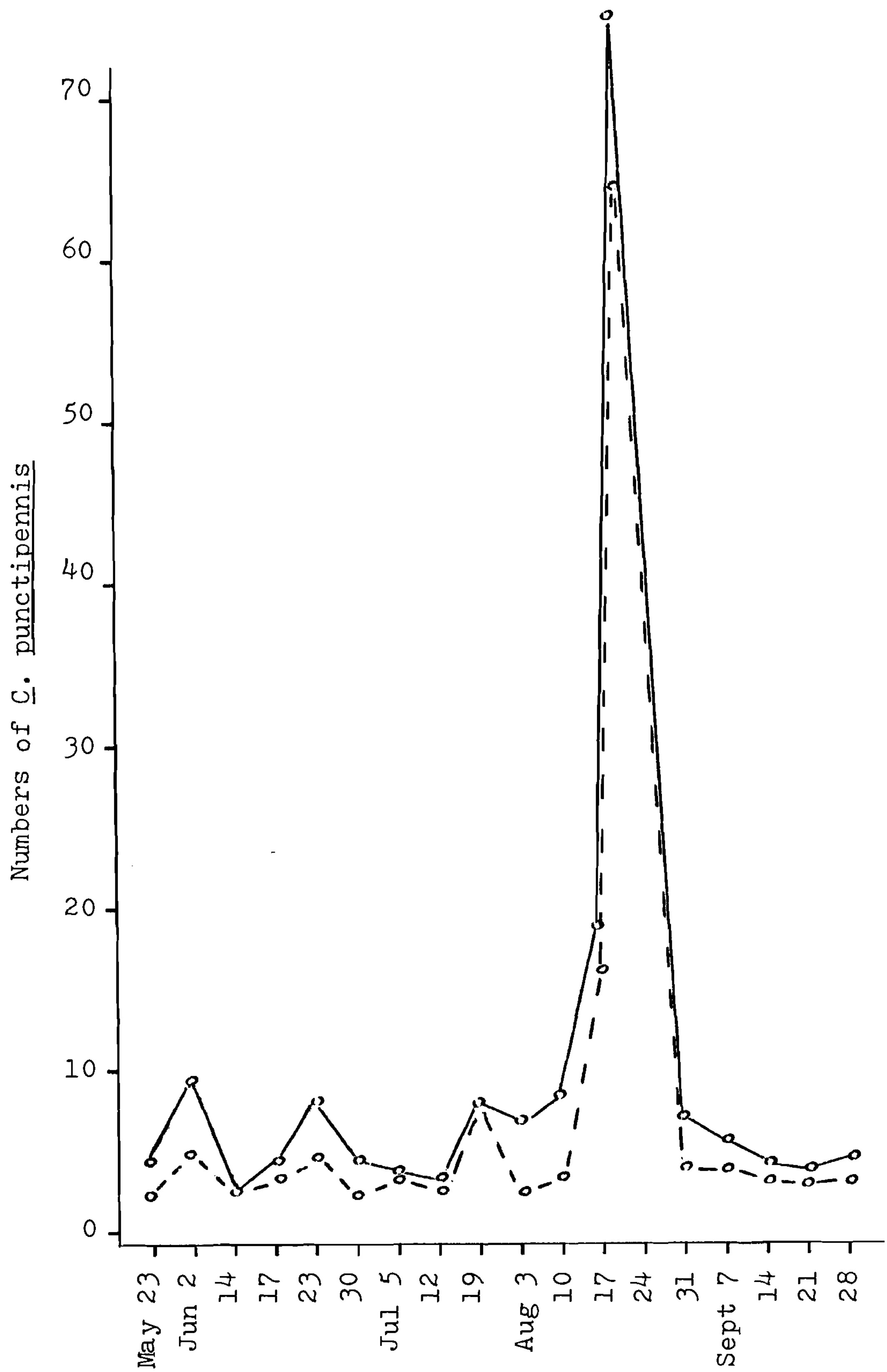

Figure 4. Emergence pattern for C. punctipennis. (Trap C = ---; Total C. punctipennis = ——.)

a small peak August 17 (Fig. 5).

The harsh winters in Kansas cause ponds to freeze over for a couple months of the year and that was reflected in the reproductive behavior of the Chironomidae. The water temperature on the bottom varied between 4 C and 15 C and limited active growing periods for the various instars. Cessation of feeding occurs at temperatures of 5 C or below (Hilsenhoff, 1966). Very little growth would occur during the cold temperatures. It was not determined in which instar the Chironomidae overwinter.

The gradual buildup of emergence rates for Chironomidae was slow, with a peak in September (Fig. 5). This parallels studies done in the southern United States where peak emergence of Chironomidae was in late September and early October (Buckley and Sublette, 1964). The number of adults emerging from the littoral zone (0-1 m) was much greater than from the profundal zone (2-4 m) and the transition zone (1-2 m) combined. The emergence of profundal chironomids occurred throughout the emergence period, but the peak occurred at the beginning and at the end, 24 and 42 individuals/m^2 respectively. The number of individuals emerging from the profundal zone was small in comparison to the total chironomid emergence. The emergence of littoral chironomids was much higher at 350 individuals/m^2.

The predominant family emerging from the littoral zone (0-1 m) was Chironomidae (89 %), followed by Culicidae (*C. punctipennis* at 2.2 %) and Simuliidae (1.5 %). The predomi-

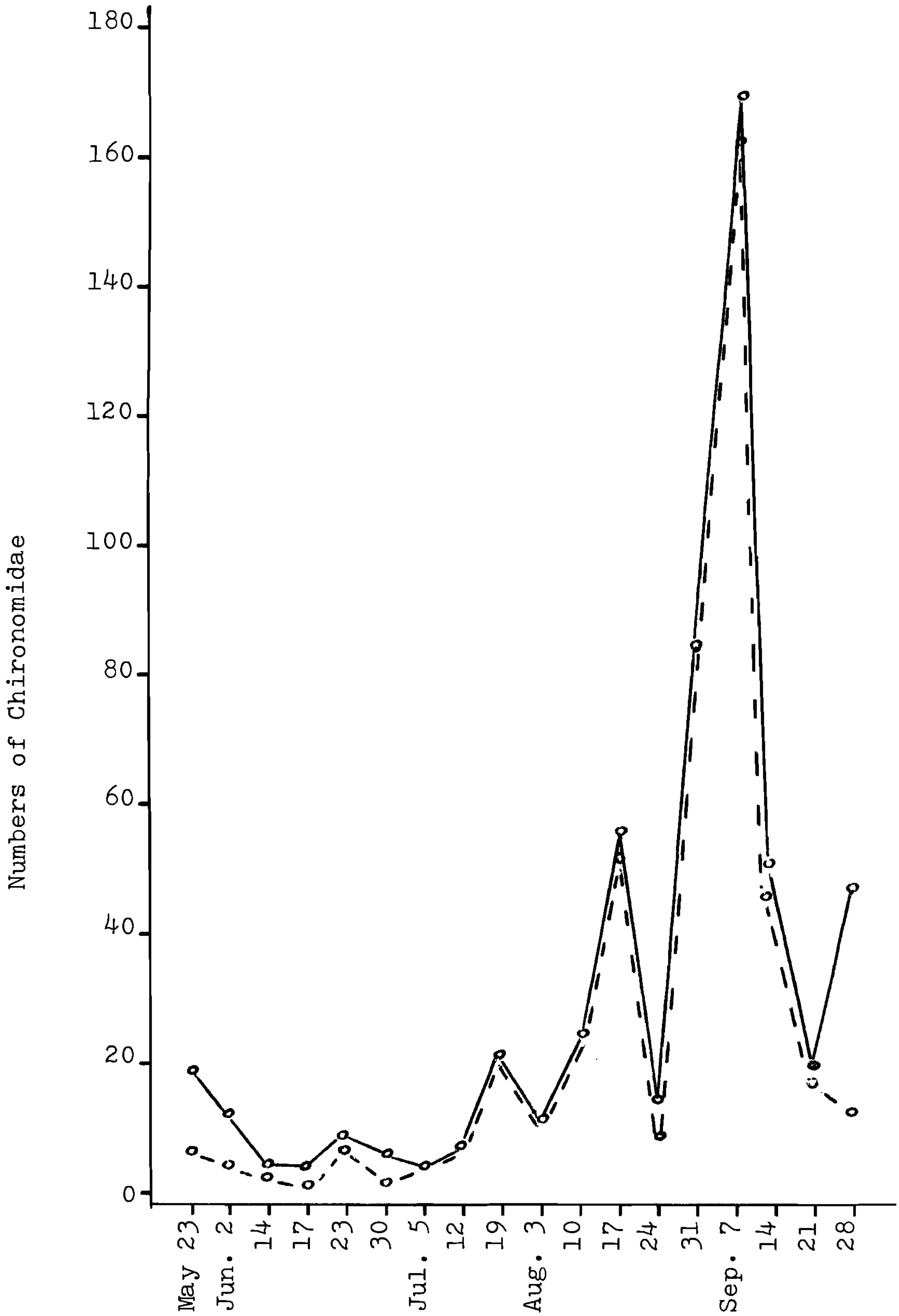

Figure 5. Emergence pattern for Chironomidae. (Trap A = ---; Total Chironomidae = ——.)

nant family emerging from the transition zone (1-2 m) was Chironomidae (46 %), followed closely by Culicidae (C. punctipennis at 43 %). The remaining 10.5 % was spread among four other families, of which only one, Hydroptilidae, had two individuals collected. The predominant family trapped from the profundal zone (3-4 m) was Culicidae (C. punctipennis at 59 %). The second most abundant family was Chironomidae with 37 %. The remaining 4 % was spread among four other families.

Species diversity analyses

The species diversity index ($\bar{d}$) reflects the manner in which individuals are distributed among species in a community. As the probability of collecting a species increases, $\bar{d}$ decreases and as the probability decreases, $\bar{d}$ increases. If an aquatic environment is polluted, some degree of stress will be exerted upon those communities involved and after a period of time only the more stress-tolerant species will remain. This is not to say all individuals of the less tolerant species will be eliminated, but their abundance will remain low while the abundance of individuals of the more tolerant species will remain high. Therefore, the probability is high that an individual in a sample will belong to a species already collected, causing $\bar{d}$ to be low. The opposite is true in clean water environments.

Diversity per individual ($\bar{d}$) values of benthic fauna generally range from 0-4, or more, in aquatic environments. Values of less than one sometimes indicate the existence of stress on organisms in streams and lakes, while values of 1-3 sometimes indicate areas of moderate stress, and values greater than three are often found in relatively stress-free environments (Wilhm and Dorris, 1966).

A diversity index ($\bar{d}$) was calculated for each depth with all months combined. Mean annual diversity per individual ($\bar{d}$) was never more than 2.8, but it dropped to 0.5 at the 4 m depth. This and the 0.58 value at the 3 m depth can be explained by high numbers of C. punctipennis and fewer numbers of species (Table IV). However, a Student t-test at the p = .05 level of significance, indicated no significant difference among depths for $\bar{d}$. Monthly $\bar{d}$ values with all depths combined were higher in January after values of 0.7 were recorded for November and December and highest in April with a $\bar{d}$ of 2.9 (Table V). At the beginning of the study in September, $\bar{d}$ was lowest at 0.3. Applying a Student t-test at p = .05, a significant difference existed among monthly diversity indices. This seems to be supported by relatively high numbers of individuals and fewer species.

TABLE IV. Diversity ($\bar{d}$) by Depth, All Months Combined

Depth (meters)	1	2	3	4
Diversity Index	2.6	2.8	.58	.5
Maximum Diversity	5.0	4.8	4.5	4.0
Equitability	.52	.59	.13	.12
Richness	2.1	2.2	.45	.37
Individuals	20,636	14,916	72,391	78,551
Taxa	31	27	22	16

TABLE V. Diversity ($\bar{d}$) by Month, All Depths Combined

Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Diversity Index	.3	1.4	.7	.7	2.2	1.4	1.7	2.9	2.3	1.8	1.5	1.6
Maximum Diversity	3.7	3.9	3.8	3.9	4.2	4.0	4.3	4.3	4.2	3.6	3.6	3.8
Equitability	.08	.36	.17	.17	.52	.34	.38	.67	.56	.50	.41	.42
Richness	.23	1.1	.48	.5	1.7	1.0	1.3	2.2	1.8	1.3	1.1	1.2
Individuals	34,645	23,864	44,106	25,887	17,080	15,510	8,823	4,754	6,812	4,389	5,576	47,707
Taxa	13	16	14	15	19	16	20	20	18	12	12	14

SUMMARY

Benthic and emergent fauna were investigated at Gladfelter Pond from September, 1972, through September, 1973. Species diversity analyses were conducted on the benthic community. Relationships between benthic fauna and emergence fauna were established.

A total of 15,419 benthic organisms representing 33 taxa were collected. Eighty-two percent of the total individuals collected were represented by the phantom midge larva, *Chaoborus punctipennis* Say. Six percent were represented by the fingernail clam, *Sphaerium* sp. *Hexagenia* sp. composed 3 % of the total benthic fauna collected, although none was caught in the emergence traps.

The majority of the benthic organisms collected was from the 3 m and 4 m depths, 34 % and 49 % respectively. Six percent of the total were collected at the 2 m depth and 9 % at 1 m.

A total of 775 emerged insects were collected. Seventy percent were collected in less than 1 m. Ten percent were collected at 2 m and 19 % at 3 m. Seventy-four percent of all emerged insects collected belonged to the family Chironomidae. In comparison, only 26 % of the benthos were Chironomidae. There were no significant differences among the individuals caught in the three traps.

The two major, emerged families, Culicidae, represented by one species, C. punctipennis, and Chironomidae had peak

emergence periods only two weeks apart. Chironomidae was predominant at the 1 m depth and C. punctipennis was predominant at the 3 m depth. Both families were about equal in abundance at the 2 m depth.

There were no significant differences in annual diversity ($\bar{d}$) by depth, but there were significant differences in monthly diversity indices when all depths were combined.

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