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# A MACROFAUNAL SURVEY OF THREE CONTRASTING HABITATS OF THE LITTORAL ZONE IN CEDAR LAKE, ILLINOIS

by

Laura L. Holt

A Thesis Submitted to the Faculty of the Graduate School of Loyola University of Chicago in Partial Fulfillment of the Requirements for the Degree of

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## VITA

The author, Laura L. Holt, is the daughter of William M. Morehouse and Karlen J. Morehouse. She was born February 14, 1949, in Lansing, Michigan.

Her elementary education was obtained in the public schools of Lansing, Michigan. Her secondary education was completed in 1969 at the Lake Zurich High School, Lake Zurich, Illinois.

Ms. Holt graduated from Elmhurst College, Elmhurst, Illinois, receiving a degree of Bachelor of Science in Biology in May, 1979. She held membership in the Tri-Beta Biology Club and the Psi Chi Psychology Club.

In September, 1979, Ms. Holt was granted an assistantship in biology at Loyola University of Chicago, enabling her to study for the Master of Science degree in biology.

Ms. Holt completed secondary education courses at Northeastern Illinois University and is currently an Illinois certified science teacher.

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# INTRODUCTION

The littoral zone of a lake is an area of abundant life. It contains a large number of different species and has a complex community organization (Kendeigh, 1974). According to Odum (1971), it is the physical and chemical characteristics which have the greatest influence on the organisms which live here. Although the temperature and quantity of dissolved oxygen varies with the seasons, one does not find the seasonal stratification which occurs in the other aquatic zones of a lake. A number of different microhabitats occurs among the substrates of sand, rock, organic sediments, and on the macrophytes (Odum, 1971). The littoral zone is a mineral and nutrient rich area. From this zone the minerals and nutrients are dispersed to the less enriched profundal zone of the lake. Generally, as one goes from the littoral zone to the profundal zone, there is a gradual reduction in the number of species (Wetzel, 1975; Connolly, 1981).

According to Connolly (1981), in Cedar Lake the main reason for the high diversity value of the animal community is the presence of macrophytes. The pondweeds provide animals with a resting place, a source of food, a site for laying eggs, a place to hide from predators, and an ample supply of oxygen throughout the summer. Also, the macrophytes and the microflora living on the macrophytes release large quantities of inorganic and organic compounds into the surrounding water, thus providing the essential nutrients for life. The macrophyte debris is a principal food source for the saprophytic bacteria of the littoral zone. These bacteria are between 40 to 120 times more abundant in the littoral zone than in the other zones of the lake (Wetzel, 1975). Macrofauna living in close proximity to the pondweeds have an advantage over the planktonic macrofauna in obtaining nutrients (Wetzel, 1975; Odum, 1971).

The rich biotic environment of Cedar Lake provided an opportunity to examine the macrofauna of the littoral zone. The purpose of this research was to determine the distribution of macroinvertebrates on and near the pondweeds. The samples examined for macroinvertebrates were: the pondweed without the roots which is called "the pondweed;" the roots and mud around the roots of the pondweed which is called "the rooted bottom mud;" and the bottom mud from adjacent non-vegetative areas. It is expected that the distribution of macroinvertebrates may show some division of habitats among macrofauna and will allow identification of the dominant species of the littoral community. The distribution of chironomid larvae may show preferences for pondweed species and possible predator-prey relationships.

Characteristics of the littoral zone suggest the likelihood of some division of habitats among species. One would expect to find habitat partitioning in an environmental setting of high species concentration in a relatively limited space and with species that have low mobility. Odum (1971) noted the relatively small area of the littoral zone, or fringe of the lake, as compared with other lake zones. Also Odum pointed out that the important groups are large weak-swimming species; especially zooplankton of heavier, less buoyant crustacean which often cling to plants or rest on the bottom. Because all three characteristics are found in the littoral zone, it is ideally suited for the investigation of habitat partitioning. The large number of organisms and species in this small space acts to increase interactions among species. Whether the interactions are competitive, cooperative, or predatory, one would expect to find some evidence of behavioral adjustment or accommodation. One behavioral adjustment to the large number of species is habitat partitioning. Possible divisions of the habitat could occur among pondweed foliage, pondweed roots, or bottom mud. Another possible habitat division could be by pondweed species. This study examined these possible divisions of habitat. Other behavioral responses could be periodic shifts in diet to reduce competition or in distribution to avoid predators. Association among faunal species could also influence the distribution within the littoral zone.

A number of researchers have reported that the presence of pondweeds influences both the abundance and the variety of macrofauna (Rosine, 1955; Odum, 1971; Connolly, 1981). However, macrophyte species is important as well. It determines whether the abundance and variety of macrofauna is increased or decreased. Rosine (1955) studied the distribution of invertebrates on macrophytes in Muskee Lake, Colorado, and found the abundance varied with pondweed species. Rosine suggested some explanations for this variation in invertebrate number. The macrophyte bedding pattern is one factor which may influence faunal abundance on a pondweed. It would be expected that a macrophyte in a dense bed should hold greater numbers of invertebrates than a sparse bed of pondweeds or a solitary plant. Dense beds provide not only a plentiful food source for macrofauna but also offer protection and hiding places as well.

Research has generally correlated higher macrofaunal abundances with pondweeds whose leaves are more finely dissected (Krecker, 1939). A more finely dissected leaf would have a larger surface area. The larger surface area would support more periphyton growth, an important nutrient of many littoral species. Another factor which may influence the number of invertebrates on a pondweed may be variations in the periphyton growing on the plant surfaces. Some periphyton may attract or repel a particular macrofaunal species.

According to Rosine (1955), the biochemical properties of a plant species may influence the abundance and diversity of macroinvertebrates on plant surfaces. For example, some plant hormones are known to influence hatching of mosquito larvae. Macrofaunal preferences for a pondweed species have been found to vary seasonally. For example, seven genera of arthropods in Muskee Lake were most abundant on *Polygonum* in June and July; however, in September, they were most abundant on *Chara*. The above listed factors and as yet unknown factors may attract or restrict the use of a particular plant species by macrofauna.

# LITERATURE REVIEW

A review of the literature relating to littoral communities provides comparative data on macrofauna species and population levels and, also, associations between macrofauna and macrophytes.

The species found in the littoral community of many of the freshwater lakes of North America are similar to the species collected in Cedar Lake. Ricker (1952) collected and identified benthic organisms of Cultus Lake, British Columbia. From the area of submerged aquatic plants, 16 benthic species were identified. Of these 16 species, 13 were also found in the Cedar Lake benthos. Of the three species that were not found, two exceeded the limits of sampling sensitivity for the Cedar Lake study.

Associations in benthic macroinvertebrates of the Bay of Quinte, Prince Edward Bay, and Lake Ontario were examined by Johnson and Brinkhurst, (1971). They listed a distinct littoral community dependent upon the presence of pondweeds which included the following species:

1. chironomid larvae: *Chironomus abortivus*, *C. subtendens*, *Crictopus*, *Psectrocladius*
2. isopod: *Lirceus lineatus*

3. amphipod: Hyallela azteca

4. mayfly: Caenis

5. lepidopteran: Synclitus.

All were collected in the Cedar Lake littoral zone except the lepidopteran, Synclitus. In Cedar Lake the isopod and amphipod collections were exclusively Lirceus lineatus and Hyallela azteca respectively.

Dominant chironomid larvae of the littoral zone have been identified in previous studies. A study of Lake Memphremagog,Quebec--Vermont by Dermott, Kalff, Leggett, and Spence (1977) found the greatest abundances of chironomid larvae were Tanytarsus (not studied in further detail), Procladius, Chironomus anthracinus, and Chaoborus. Both species, Procladius and Chironomus anthracinus maintained peak daily growth rates during the sampling months of June through August. Sampling of Cedar Lake occurred during the same sampling months. Tanytarsus was also the most abundant chironomid larvae collected in Cedar Lake. Procladius was the third most abundant.

Other littoral zone studies have found the distribution of animal species influenced by the presence of submerged aquatic plants. Krecker (1939) found that the abundance of individuals within a species and the abundance of species varied with the macrophyte. The pondweed with greater leaf dissection supported higher populations than the pondweed with less leaf dissection. Rosine (1955) found that macrofauna distribution resulted from preferences for pondweed species rather than the amount of leaf dissection. Rosine suggested that there were complex, ecological associations between fauna and pondweeds which were influencing the distribution of fauna. Rosine's study of Muskee Lake, Colorado, showed the distribution of seven genera of arthropods on three plant surfaces, Chara, Polygonum, and Potamogeton. The fauna of Muskee Lake did not utilize plant surface areas equally. Also the study showed that there were seasonal variations in the distribution of fauna on Chara and Polygonum. Only Potamogeton gave evidence of a rather constant density of fauna.

Gerking (1957) did further research on macrofauna preferences for pondweed species. He found higher abundances of benthic fauna among macrophytes with greater root development than among macrophytes with lesser root development. Gerking suggested that greater root development resulted in greater bottom stability and, therefore, could support higher populations of benthic fauna. The study also showed that those organisms which are common to both the plants and mud occurred in quite different proportions in the two habitats. There was evidence of seasonal variation in abundance. It was also demonstrated that some organisms had preferences for certain species of plants. Gerking compared the benthic population among the roots of three macrophytes, Najas flexilis, Anacharis canadensis, and Vallisneria americana. Najas flexilis was found to support greater abundances of mollusks, Odonata, water mites, amphipods, caddisflies, and mayfly larvae. The chironomid larvae, however, were 1/3 fewer on Najas flexilis than the other two macrophyte species.

# METHODS

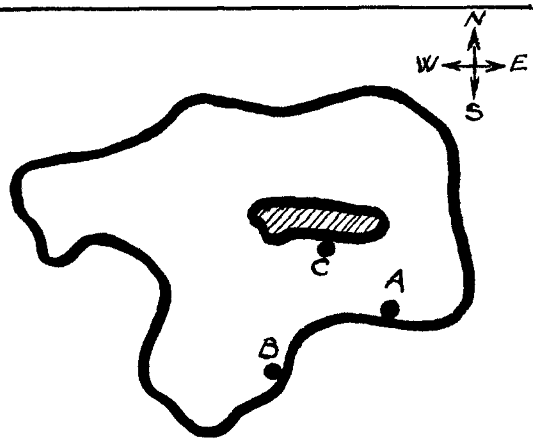
The influence of macrophytes on the invertebrate community in the littoral zone of Cedar Lake, Illinois, was examined. Three habitats were selected for study: pondweed, and two bottom samples. The two bottom samples were taken first from the bottom with the pondweed roots and, secondly, from the bottom of a nearby clear area with no pondweed growth. Pondweed stem samples were taken by cutting the stem at the lake bottom. Selection of an individual pondweed was based on the healthy appearance of the vegetative growth. The pondweed collected was selected from a sparsely vegetative patch with approximately three to six pondweeds in a cluster. The extremes of a solitary pondweed or a pondweed from dense vegetative patches were excluded.

The second sample was the pondweed's roots and mud collected using a 9-inch Ekman dredge. Dredge contents were released into a sieve. Content loss was minimized by rapidly sliding the sieve under the dredge as it broke the water surface. The sieve was washed twice and the residue manually scraped off and placed in a sample bottle.

The third habitat sampled was mud with no roots collected from an adjacent area with no pondweed growth. The sample never ranged farther in distance from the original pondweed than 30 to 100 cm. The sample was taken using the same procedure as in the rooted bottom mud samples. All samples were preserved in 75% ethanol for later laboratory analyses.

A total of 234 samples were collected on seven days within a time period from July through September, 1980, during the daytime hours of 9 a.m. through 5 p.m. The weather conditions at the time of the collections were approximately equivalent; that is, warm and clear skies.

Samples were collected from three locations designated A, B, and C (Fig. 1). Station A was located on the south-eastern shore; B on the southwestern shore; C on the south-eastern shore of a




7 cm. = $1\frac{1}{2}$ km. long
$5\frac{1}{2}$ cm. = 1 km. wide

Fig. 1: Map of Cedar Lake showing the location of the three sampling stations.

small island (approximately 500 sq. meters) in the south-eastern portion of the lake. Since much of the lake front is privately owned, beach access was restricted to selected areas. Within these access areas, sites were selected randomly from undisturbed areas. A total of 57 samples were collected from station A representing four days of sampling. A total of 141 samples were taken on three days of sampling from station B. Station C collections were made on a single day and totaled 36 samples. Note that on one sampling day collections were made from both station B and station C. Each station was approximately 30 meters long. All station collections were taken from within this area. The water depth ranged from 48 cm. to 84 cm.

A total of eight species of macrophytes were collected. Station B had all eight macrophytes, station A had three macrophytes, and station C had four (Table 1). Three of the eight macrophytes collected were common to all stations. They were Potamogeton gramineus, Potamogeton pectinatus, and Myriophyllum verticillatum. The Myriophyllum exalbescens Fern occurred in both stations A and C. The four species exclusive to station B were Najas flexilis, Potamogeton zosteriformis.

TABLE 1: THE NUMBER OF PONDWEEDS COLLECTED FROM THE THREE SAMPLING STATIONS.

| Pondweed Species | Station A | Station B | Station C |
|---|---|---|---|
| *Potamogeton gramineus* | 8 | 16 | 5 |
| *Potamogeton pectinatus* | 8 | 5 | 1 |
| *Myriophyllum verticillatum* | 3 | 3 | 5 |
| *Najas flexilis* | 0 | 1 | 0 |
| *Potamogeton zosteriformis* | 0 | 1 | 0 |
| *Ceratophyllum demersum* | 0 | 1 | 0 |
| *Potamogeton richardsonii* | 0 | 4 | 0 |
| *Myriophyllum exalbescens Fern* | 0 | 15 | 1 |
| TOTAL NUMBER OF PONDWEEDS | 19 | 46 | 12 |

Ceratophyllum demersum, and Potamogeton richardsonii. Two species, Najas flexilis and Ceratophyllum demersum, were collected only once.

Specimens were separated in an aluminum pan using the flotation method. Greater visibility was achieved through the use of an additional light source (60 watt) and straight line magnifying glasses. For pondweed samples, the pondweed was thoroughly rinsed to ensure removal of all organisms before being returned to its sample bottle.

The snail shells presented special handling problems. To minimize shell breakage, elongated-spire gastropod shells were successfully handled by placing one prong of the forceps into the aperture and then picking up the shell. The heliciform or flattened-spire gastropod shells were handled by placing one prong of the forceps at each end of the shell axis and then picking up the shell. The small size (2 mm. - 5 mm.) of the pelecypods resulted in frequent separation of the bivalves during the transfer to specimen bottles. No method was successful in assuring that the bivalves remained undamaged.

The identification of the macrofauna required the use of either a dissection or a compound microscope. Organisms were identified to species level whenever possible. All identification of snail shells and some very large (about 1 cm.) Ephemeroptera, Hemiptera, and Odonata was done with a dissection microscope. Remaining organisms were identified by using a compound microscope. Mollusks and annelids and arthropod crustaceans were keyed to genera; a few were identified to species. Dipteran larvae were taken to either the familial or species level. The teeth are used to identify the chironomids. Generally, chironomids measuring 2 mm. or less in length were not identified because they were too small for their teeth to be seen.

Because of the large number of chironomid genera and their importance to this study, a brief description of the morphological characteristics used in their identification is included here. The larvae were examined ventral side up under a compound microscope; the magnification varied with the specimen size. The following characteristics were used to distinguish subfamilies and genera of chironomid larvae:

1. Subfamily Tanypodinae are distinguished by forkshaped lingua, superlinguae, and sometimes

paralabial comb. Genera are distinguished by lingua characteristics.

2. Subfamily Chironominae are distinguished by a pair of striated, paralabial plates. Tribe Chironomini (except Xenochironomus and Pseudochironomus) are distinguished by paralabial plates distinctly separate. Tribe Tanytarsini have paralabial plates that are wider than long and meet on the midline of the head capsule. Both genera are distinguished on the basis of teeth characteristics.

3. Subfamily Orthocladiinae larvae never possess striated paralabial plates. Genera are distinguished by teeth characteristics.

4. Subfamily Diamesinae are distinguished by annulations on the third antennal segment. Genera are distinguished by teeth characteristics.

Previous research has indicated chironomids have preferences for particular pondweed species. To test the assumption that a chironomid species would be randomly distributed among the pondweeds within each station, a Chi square analysis was made. Because the number of individual pondweeds collected from each species was not the same, a percentage was calculated. The species percent multiplied by the total number of chironomids gave the number of chironomids expected to occur on that particular macrophyte if the distribution were random. This expected frequency was compared by Chi square analysis to the actual number of chironomids collected on a particular macrophyte. Any significant differences would reflect either preference or avoidance of a certain macrophyte by the chironomids.

## RESULTS

A total of 20,845 organisms were collected from the three habitats and analyzed (Table 2). Tabulation of the collected organisms showed the major community components of the littoral zone of Cedar Lake were comprised of the following: gastropods 65%, chironomid larvae 12%, amphipods 10%, pelecypods 7%, oligochaetes 1%, Trichoptera 1%, Ephemeroptera 1%, and all others 2%. Ninety-five percent of all the organisms were from only four groups: gastropods, chironomid larvae, amphipods, and pelecypods. At the other extreme 16 of the least common groups accounted for less than 2% of the total number of occurrences.

Excluding the gastropods which were not subject to further examination, the most abundant single group of organisms at all stations (Table 3) were the chironomid larvae totaling 2,508 individuals from 42 genera. The dipteran family, Chironomidae, was the dominant insect component of each habitat, making up 40% of all organisms collected from pondweeds, and 10% respectively from each bottom habitat. The generic names and their percent of the total chironomid population are presented in Table 4. Table 5 shows the chironomid genera collected on each

TABLE 2: THE NUMBER OF ORGANISMS COLLECTED IN EACH HABITAT OF CEDAR LAKE, ILLINOIS

| Taxonomic Group | Pondweed | Rooted Area | Non-vegetative Area |
|---|---|---|---|
| Cnidaria | | | |
| c. Hydrozoa (*Hydra*) | 14 | 0 | 0 |
| Nematoda | | | |
| c. Phasmidia (*Tylenchus*) | 3 | 14 | 8 |
| Tardigrada | | | |
| c. Eutardigrada | 1 | 0 | 1 |
| Annelida | | | |
| c. Oligochaeta | 189 | 32 | 28 |
| c. Hirudinea | 4 | 13 | 11 |
| Mollusca | | | |
| c. Gastropoda | 221 | 6,251 | 7,012 |
| c. Pelecypoda | 1 | 680 | 800 |
| Arthropoda | | | |
| c. Arachnida | | | |
| Hydrachnellae | 1 | 7 | 1 |
| SUBTOTAL | 434 | 6,997 | 7,861 |

TABLE 2 (CONTINUED)

| Taxonomic Group | Pondweed | Rooted Area | Non-vegetative Area |
|---|---|---|---|
| Arthropoda (Continued) | | | |
| c. Eucrustacea | | | |
| Cladocera | 103 | 39 | 38 |
| Isopoda (*Lirceus lineatus*) | 0 | 6 | 4 |
| Amphipoda (*Hyallela azteca*) | 232 | 1,271 | 692 |
| c. Insecta | | | |
| Hemiptera | 0 | 10 | 14 |
| Odonata | 8 | 29 | 10 |
| Ephemeroptera | 30 | 85 | 96 |
| Lepidoptera | 5 | 0 | 0 |
| Coleoptera | 0 | 2 | 0 |
| Trichoptera | 45 | 102 | 69 |
| Megaloptera | 0 | 0 | 1 |
| Collembola | 0 | 1 | 0 |
| Diptera | | | |
| Chironomidae | 563 | 955 | 990 |
| Culicidae | 1 | 1 | 5 |
| Ceratopogonidae | 8 | 47 | 89 |
| Dixidae | 0 | 1 | 0 |
| Tipulidae | 0 | 0 | 1 |
| SUBTOTAL | 995 | 2,549 | 2,009 |
| SUBTOTAL FROM PAGE 1 | 434 | 6,997 | 7,861 |
| GRAND TOTAL | 1,429 | 9,546 | 9,870 |

TABLE 3: THE NUMBER OF ORGANISMS COLLECTED IN EACH SAMPLING STATION OF CEDAR LAKE, ILLINOIS

| Taxonomic Group | Station A | Station B | Station C |
|---|---|---|---|
| Cnidaria | | | |
| c. Hydrozoa (Hydra) | 0 | 11 | 3 |
| Nematoda | | | |
| c. Phasmidia (Tylenchus) | 0 | 25 | 0 |
| Tardigrada | | | |
| c. Eutardigrada | 0 | 1 | 1 |
| Annelida | | | |
| c. Oligochaeta | 24 | 212 | 13 |
| c. Hirudinea | 7 | 20 | 1 |
| Mollusca | | | |
| c. Gastropoda | 2,888 | 8,899 | 1,697 |
| c. Pelecypoda | 182 | 1,085 | 214 |
| Arthropoda | | | |
| c. Arachnida | | | |
| Hydrachnellae | 2 | 7 | 0 |
| SUBTOTAL | 3,103 | 10,260 | 1,929 |

TABLE 3 (CONTINUED)

| Taxonomic Group | Station A | Station B | Station C |
|---|---|---|---|
| Arthropoda (Continued) | | | |
| c. Eucrustacea | | | |
| Cladocera | 57 | 115 | 8 |
| Isopoda (*Lirceus lineatus*) | 4 | 6 | 0 |
| Amphipoda (*Hyallela azteca*) | 354 | 1,334 | 507 |
| c. Insecta | | | |
| Hemiptera | 3 | 21 | 0 |
| Odonata | 2 | 14 | 31 |
| Ephemeroptera | 92 | 49 | 70 |
| Lepidoptera | 0 | 4 | 1 |
| Coleoptera | 1 | 1 | 0 |
| Trichoptera | 30 | 119 | 67 |
| Megaloptera | 0 | 1 | 0 |
| Collembola | 0 | 1 | 0 |
| Diptera | | | |
| Chironomidae | 560 | 1,760 | 188 |
| Culicidae | 2 | 5 | 0 |
| Ceratopogonidae | 2 | 142 | 0 |
| Dixidae | 0 | 1 | 0 |
| Tipulidae | 0 | 1 | 0 |
| SUBTOTAL | 1,107 | 3,574 | 872 |
| SUBTOTAL FROM PAGE 1 | 3,103 | 10,260 | 1,929 |
| GRAND TOTAL | 4,210 | 13,834 | 2,801 |

TABLE 4: THE CHIRONOMID GENERA ARE LISTED BY PERCENT OF TOTAL CHIRONOMIDS COLLECTED FROM THE LITTORAL ZONE OF CEDAR LAKE, ILLINOIS. ALSO SHOWN ARE THE NUMBER OF EACH CHIRONOMID GENERA COLLECTED FROM THE THREE HABITATS.

| Chironomid Genera | Percent Of All Chironomids | Total Pondweed Habitat | Total Rooted Habitat | Total Non-vegetative Bottom Habitat |
|---|---|---|---|---|
| Tanytarsus | 26.3 | 89 | 336 | 235 |
| Pseudochironomus | 15.5 | 39 | 138 | 212 |
| Procladius | 7.2 | 7 | 79 | 95 |
| Cryptochironomus | 6.9 | 10 | 67 | 96 |
| Ablabesmyia | 4.9 | 53 | 42 | 29 |
| Psectrocladius | 3.8 | 78 | 9 | 8 |
| Micropsectra | 2.9 | 6 | 27 | 41 |
| Paralauterborniella | 2.9 | 3 | 29 | 42 |
| Chironomus | 2.5 | 35 | 19 | 8 |
| Dicrotendipes | 1.8 | 9 | 17 | 18 |
| Cryptochironomus abortivus | 1.6 | 33 | 3 | 4 |
| Endochironomus | 1.3 | 9 | 15 | 9 |
| C. tribelos | 1.1 | 5 | 17 | 6 |
| Prodiamesa | 1.0 | 11 | 7 | 6 |
| Trichocladius | .7 | 9 | 2 | 7 |
| Nanocladius sordens | .6 | 7 | 2 | 7 |
| Cricotopus | .6 | 13 | 1 | 1 |
| Psectrotanyus | .5 | 7 | 0 | 6 |
| Endochironomus tendens | .5 | 5 | 7 | 0 |
| B. par | .4 | 4 | 1 | 6 |
| C. einfelda | .4 | 7 | 2 | 1 |

TABLE 4 (CONTINUED)

| Chironomid Genera | Percent Of All Chironomids | Total Pondweed Habitat | Total Rooted Habitat | Total Non-vegetative Bottom Habitat |
|---|---|---|---|---|
| Smittia | .4 | 9 | 0 | 0 |
| Cryptochironomus nais | .3 | 2 | 3 | 3 |
| G. holoprasinus | .3 | 0 | 0 | 8 |
| Metriocnemus | .3 | 3 | 2 | 3 |
| Tanypus | .3 | 4 | 2 | 2 |
| Dicrotendipes nervosus | .3 | 4 | 0 | 3 |
| P. bathyphilia | .3 | 4 | 0 | 3 |
| Stenochironomus | .3 | 3 | 4 | 0 |
| G. senilis | .2 | 4 | 2 | 0 |
| Diamesa | .2 | 5 | 1 | 0 |
| Polypedilum | .2 | 0 | 5 | 0 |
| Glyptotendipes | .16 | 2 | 0 | 2 |
| C. concinnus | .16 | 2 | 2 | 0 |
| Microtendipes | .1 | 0 | 2 | 1 |
| Strictochironomus | .08 | 0 | 1 | 1 |
| P. longimanus | .08 | 1 | 0 | 1 |
| S. aterrima | .08 | 0 | 1 | 1 |
| Clinotanypus | .04 | 0 | 1 | 0 |
| Diplocladius | .04 | 0 | 1 | 0 |
| Xenolabis | .04 | 1 | 0 | 0 |
| Orthocladius | .04 | 1 | 0 | 0 |
| O. nivoriundus | .04 | 0 | 0 | 1 |
| Kiefferulus | .04 | 1 | 0 | 0 |
| Pupae | .9 | | | |
| Unidentified | 11.5 | | | |

TABLE 5: THE NUMBER OF EACH CHIRONOMID GENERA COLLECTED ON THE EIGHT MACROPHYTES OF CEDAR LAKE, ILLINOIS.

| Chironomid Genera | Macrophytes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | PG | MV | ME | PP | NF | PZ | CD | PR |
| *Tanytarsus* | 36 | 10 | 22 | 10 | 5 | 0 | 1 | 5 |
| *Pseudochironomus* | 2 | 0 | 1 | 7 | 0 | 0 | 0 | 29 |
| *Procladius* | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 3 |
| *Cryptochironomus* | 3 | 0 | 3 | 2 | 0 | 0 | 0 | 2 |
| *Ablabesmyia* | 26 | 3 | 3 | 9 | 0 | 0 | 2 | 10 |
| *Psectrocladius* | 20 | 2 | 26 | 20 | 3 | 0 | 5 | 2 |
| *Micropsectra* | 4 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| *Paralauterborniella* | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Chironomus* | 21 | 0 | 8 | 4 | 0 | 0 | 0 | 2 |
| *Dicrotendipes* | 1 | 2 | 3 | 1 | 0 | 0 | 0 | 2 |
| *Cryptochironomus abortivus* | 18 | 3 | 6 | 1 | 3 | 2 | 0 | 0 |
| *Endochironomus* | 2 | 0 | 4 | 0 | 1 | 0 | 0 | 2 |
| *C. tribelos* | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |

TABLE 5 (CONTINUED)

| Chironomid Genera | Macrophytes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | PG | MV | ME | PP | NF | PZ | CD | PR |
| Prodiamesa | 3 | 1 | 3 | 2 | 0 | 0 | 0 | 2 |
| Trichocladius | 2 | 0 | 1 | 6 | 0 | 0 | 0 | 0 |
| Nanocladius sordens | 5 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| Cricotopus | 3 | 5 | 4 | 0 | 1 | 0 | 0 | 0 |
| Psectrotanyus | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Endochironomus tendens | 2 | 0 | 2 | 1 | 0 | 0 | 0 | 0 |
| B. par | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| C. einfelda | 4 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| Smittia | 3 | 0 | 2 | 4 | 0 | 0 | 0 | 0 |
| Cryptochironomus nais | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| G. holoprasinus | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Metriocnemus | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 |
| Tanypus | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |

TABLE 5 (CONTINUED)

| Chironomid Genera | Macrophytes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | PG | MV | ME | PP | NF | PZ | CD | PR |
| *Dicrotendipes nervosus* | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| *P. bathyphilia* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| *Stenochironomus* | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| *G. senilis* | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diamesa* | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 0 |
| *Polypedilum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Glyptotendipes* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *C. concinnus* | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Microtendipes* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Strictochironomus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *P. longimanus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *S. aterrima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Clinotanypus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

TABLE 5 (CONTINUED)

| Chironomid Genera | Macrophytes PG | MV | ME | PP | NF | PZ | CD | PR |
|---|---|---|---|---|---|---|---|---|
| *Diplocladius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Xenolabis* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Orthocladius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *O. nivoriundus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Kiefferulus* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| GRAND TOTAL | 181 | 29 | 105 | 77 | 13 | 2 | 8 | 70 |

LEGEND

PG = *P. gramineus*
MV = *M. verticillatum*
ME = *M. exalbescens Fern*
PP = *P. pectinatus*
NF = *N. flexilis*
PZ = *P. zosteriformis*
CD = *C. demersum*
PR = *P. richardsonii*

pondweed species. Of the nine collected insectan orders, Trichoptera and Ephemeroptera, were the second and third most abundant.

The gastropoda shells collected from the littoral zone of Cedar Lake represented the following 16 species: Planorbula, Amnicola, *Amnicola limosa*, *Valvata sincera*, *Valvata tricarinata*, Gyraulus, *Lymnaea abrussa* (Galba), *Lymnaea palustris* (Stagnicola), Physa, *Stagnicola exilis*, Viviparous, *Bithnia tentaculata*, *Helisoma antrosa*, *Aplexa hyporum*, and *Prominetus exacuatus*. Pelecypoda were exclusively genera of the "fingernail clams," viz. *Musculim*, *Pisidium*, and *Sphaerium*.

The amphipods, as a major littoral component, were exclusively one species, *Hyallela azteca*. Though found in all three habitats, the greatest abundance was collected from the bottom habitats.

Specimens from ten taxonomic classes (Table 2) were collected. Several taxa were collected exclusively in a single habitat. *Hydra* was found only on pondweeds. Moreover, half of the *Hydra* occurred on one species, *Ceratophyllum demersum*. The insecta order, Lepidoptera, was exclusive to the pondweed habitat as well. Exclusive habitat collections of all other taxonomic groups from Table 2 had such low abundances overall, it could not be statistically determined whether the exclusivity reflected habitat selection or random distribution. The collection of Hydra on the pondweed was statistically significant at $x^2$ at 5% = 27.98 and of the order Lepidoptera at $x^2$ at 5% = 13.0. The orders Hemiptera (Insecta) and Isopoda (Eucrustacea) were collected in both bottom habitats. The total number of organisms collected from each pondweed species is shown in Table 6. In parenthesis is the average number of organisms collected on an individual pondweed.

## Habitat

Figure 2 shows the percent of each taxonomic class collected from each habitat. Populations of gastropods, pelecypods, amphipods, and chironomid larvae were significantly lower for the pondweed habitat determined by Neuman-Keuls Multiple Range Test of $q_{0.05\infty p}$. No significant difference was detected between the rooted bottom and the non-vegetative bottom for three of the four major groups of the littoral zone. The amphipod, Hyallela azteca, was the exception with greatest abundance among the rooted bottom. The amphipod results

TABLE 6: THE NUMBER OF ORGANISMS COLLECTED ON EACH PONDWEED SPECIES. BECAUSE THE NUMBER OF PONDWEEDS OF A SPECIES VARIED, THE AVERAGE OF ORGANISMS COLLECTED ON EACH IS SHOWN IN PARENTHESES.

| | Pondweeds | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Taxonomic Group | PG | PP | MV | ME | NF | PZ | CD | PR |
| Cnidaria | | | | | | | | |
| c. Hydrozoa | 1 | 0 | 2 | 3 | 0 | 0 | 8 | 0 |
| Nematoda | | | | | | | | |
| c. Phasmidia | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Tardigrada | | | | | | | | |
| c. Eutardigrada | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Annelida | | | | | | | | |
| c. Oligochaeta | 68 | 42 | 9 | 45 | 3 | 4 | 9 | 9 |
| c. Hirudinea | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 |
| Mollusca | | | | | | | | |
| c. Gastropoda | 77 | 40 | 17 | 58 | 1 | 7 | 7 | 14 |
| c. Pelecypoda | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Arthropoda | | | | | | | | |
| c. Arachnida | | | | | | | | |
| Hydrachnellae | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| c. Eucrustacea | | | | | | | | |
| Cladocera | 36 | 25 | 3 | 7 | 1 | 14 | 15 | 2 |
| Isopoda | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Amphipoda | 21 | 14 | 28 | 119 | 1 | 0 | 22 | 27 |

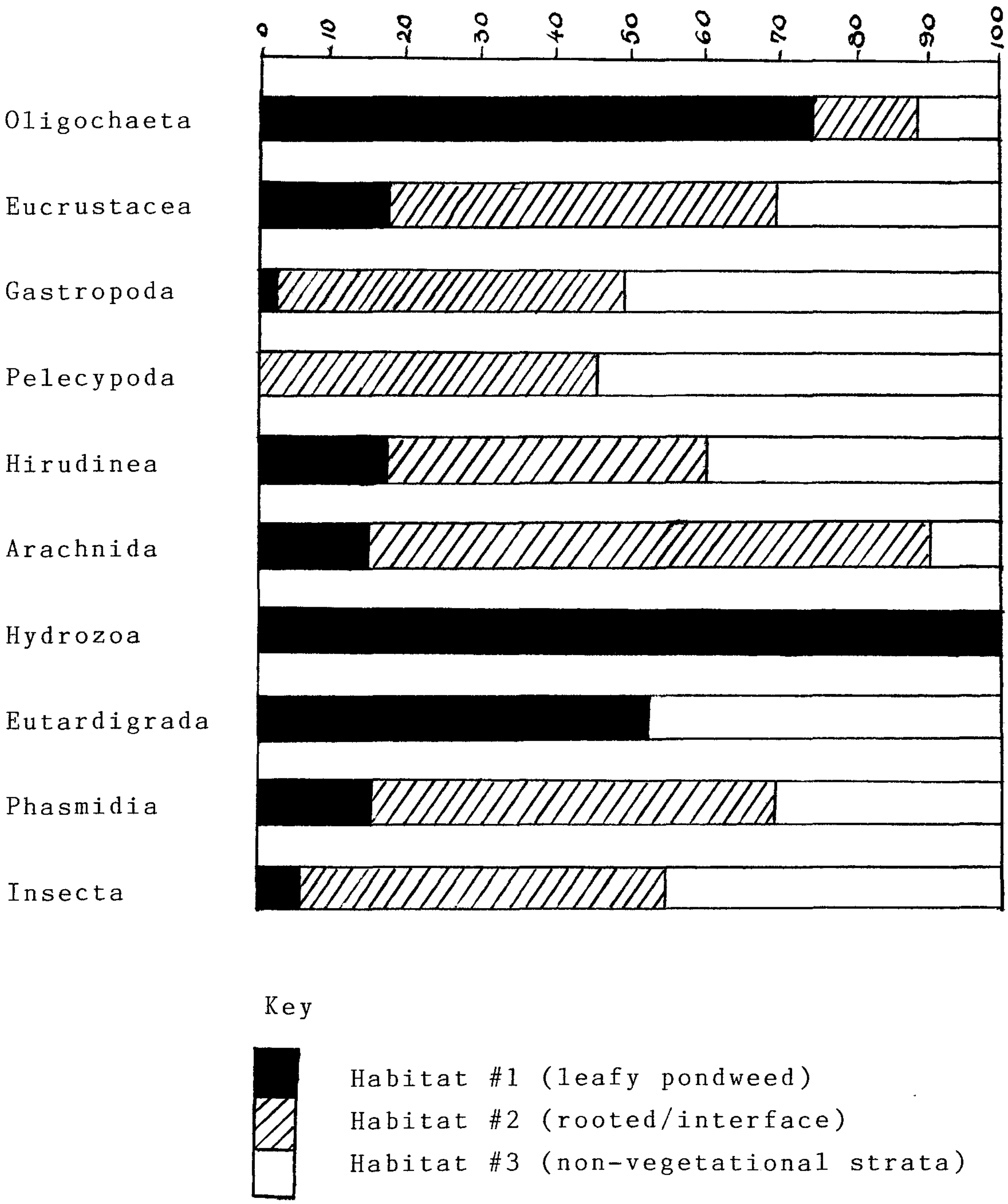
TABLE 6 (CONTINUED)

| Taxonomic Group | Pondweeds PG | PP | MV | ME | NF | PZ | CD | PR |
|---|---|---|---|---|---|---|---|---|
| Arthropoda (Continued) | | | | | | | | |
| c. Insecta | | | | | | | | |
| Hemiptera | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Odonata | 1 | 0 | 3 | 3 | 0 | 0 | 0 | 1 |
| Ephemeroptera | 1 | 2 | 13 | 11 | 0 | 0 | 0 | 3 |
| Lepidoptera | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Coleoptera | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Trichoptera | 10 | 7 | 4 | 14 | 0 | 1 | 2 | 7 |
| Megaloptera | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Collembola | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Diptera | | | | | | | | |
| Chironomidae | 214 | 77 | 48 | 110 | 13 | 17 | 8 | 76 |
| Culicidae | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ceratopogonidae | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 2 |
| Dixidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tipulidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| GRAND TOTAL | 436 | 208 | 127 | 380 | 19 | 43 | 72 | 144 |
| Average per pondweed | (15) | (15) | (12) | (24) | (19) | (43) | (72) | (144) |

LEGEND

PG = *P. gramineus*
MV = *M. verticillatum*
ME = *M. exalbescens Fern*
PP = *P. pectinatus*
NF = *N. flexilis*
PZ = *P. zosteriformis*
CD = *C. demersum*
PR = *P. richardsonii*

FIGURE 2: PERCENT OF MACROFAUNAL TAXA COLLECTED IN THREE CONTRASTING HABITATS OF THE LITTORAL ZONE OF CEDAR LAKE.



were 3 vs. 1, q=6.49; 3 vs. 2, q=4.83; and 2 vs. 1, q= 14.55.

Selected chironomid genera of high abundances were tested separately. Four chironomid genera, Cryptochironomus, Tanytarsus, Procladius, and Pseudochironomus, were significantly lower for the pondweed habitat as determined by Neuman-Keuls Multiple Range Test of $q_{0.05 \infty p}$. (Cryptochironomus results were 3 vs. 1, q= 5.28 and 2 vs. 1, q=5.88; Tanytarsus results were 3 vs. 1, q=4.728; 2 vs. 1, q=2.806; Procladius results were 3 vs. 1, q=5.28 and 2 vs. 1, q=7.708; and Pseudochironomus results were 3 vs. 1, q=4.728 and 2 vs. 1, q=2.772.) Though collected in significantly lower numbers, specimens from all of the above groups did occur in the pondweed habitat.

Arbitrarily selecting 20 total occurrences as a cut-off point for major chironomid genera of the littoral zone, 13 of the 42 genera collected were then correlated with habitat and with macrophyte species. Based on the percentage of each pondweed species within a sampling station, an expected occurrence of chironomid genera was calculated. Chi square analysis gave significant differences in the association of a chironomid genus with a macrophyte species. The results are presented in the station subsection.

The value for oligochaetes was significantly higher for the pondweed habitat having a Neuman-Keuls Multiple Range Test $q_{0.05 \infty p}$ result of 3 vs. 1, q=2.34. There was no significant difference between either of the bottom mud habitats. (Flannagan in 1970 reported the tendency of the Ekman dredge to underestimate oligochaete density.)

## Station A

The distribution of chironomid larvae among the three habitats of station A was 15.3% on the pondweeds, 56.0% in the rooted bottom mud, and 28.7% in the non-vegetative bottom mud. The most abundant chironomid genera during July were Tanytarsus (284 specimens) and Pseudochironomus (53 specimens). This represented 60% of all chironomids collected in station A. Both chironomids were almost excluded from the pondweed habitat entirely. Between the two bottom mud habitats, the largest number of Tanytarsus was found in the rooted bottom mud and of Pseudochironomus, in the clear bottom mud. The distribution of Tanytarsus in the bottom mud was non-random with the greatest abundance among the roots of the macrophyte species, M. verticillatum ($x^2$ at 5% = 985.8) and also among the clear bottom mud adjacent to M. verticillatum ($x^2$ at 5% = 108.87). Pseudochironomus distribution in the bottom habitats was significantly different also. The greatest abundance occurred among the roots of M. verticillatum ($x^2$ at 5% = 6.84) and in the non-vegetative areas near the sampled pondweed, P. pectinatus ($x^2$ at 5% = 15.99).

The chironomid genera, Ablabesmyia, Cryptochironomus, and Paralauterborniella, were also collected in abundance in station A during July and principally from both bottom habitats. Cryptochironomus was significantly distributed among the rooted bottom mud only. The greatest numbers were obtained among M. verticillatum roots ($x^2$ at 5% = 27.64). No significant differences in distribution among the bottom habitats were detected for Ablabesmyia and Paralauterborniella and Cryptochironomus in the non-vegetative bottom mud (Table 7).

TABLE 7: SIGNIFICANT DIFFERENCES AT 5% IN THE DISTRIBUTION OF SELECTED CHIRONOMID GENERA IN THREE HABITATS IN STATION A DURING THE FIVE-WEEK PERIOD OF JULY AND AUGUST.

| | Three Habitats of Station A | | |
|---|---|---|---|
| Macrophyte Species | Pondweed | Rooted Bottom | Non-vegetative Bottom |
| *P. pectinatus* | - | - | *Pseudochironomus* |
| *M. verticillatum* | - | *Tanytarsus*<br>*Pseudochironomus*<br>*Cryptochironomus* | *Tanytarsus* |
| *P. gramineus* | - | - | - |

## Station B

The distribution of chironomid larvae among the three habitats of station B was 25.9% on the pondweeds, 32.3% in the rooted bottom mud, and 41.8% in the non-vegetative bottom mud. The most abundant chironomid genera of station B for the six-week period of August and the beginning of September were *Tanytarsus* (330 specimens), *Pseudochironomus* (279 specimens), *Procladius* (162 specimens), and *Cryptochironomus* (140 specimens). This represented 52% of all chironomids collected in station B. *Tanytarsus* was significantly distributed among the eight pondweed species collected from station B during this period. Significant abundances of *Tanytarsus* were collected in the pondweed habitat of the macrophytes, *M. verticillatum* and *Najas flexilis* ($x^2$ at 5% = 16.63). *Tanytarsus* was significantly associated with the rooted bottom mud of the macrophyte species, *M. exalbescens* and *P. zosteriformis* ($x^2$ at 5% = 17.86). In addition *Tanytarsus* was significantly abundant in the clear bottom mud areas adjacent to the macrophyte species, *P. gramineus* ($x^2$ at 5% = 24.8).

*Pseudochironomus* was significantly associated with *P. richardsonii* ($x^2$ at 5% = 226) in station B and with the area of clear bottom mud adjacent to P. gramineus ($x^2$ at 5% = 39.8). Procladius was collected in abundance in the rooted bottom samples of M. exalbescens Fern ($x^2$ at 5% = 16.5). Cryptochironomus was significantly distributed in the clear bottom mud adjacent to P. gramineus ($x^2$ at 5% = 23.25).

Other abundant chironomids collected in station B were Ablabesmyia, Psectrocladius, C. tribelos, and Micropsectra. Ablabesmyia was significantly distributed in the pondweed habitat of P. richardsonii ($x^2$ at 5% = 27.4). The two pondweeds, P. pectinatus and C. demersum, were the habitats for significant numbers of Psectrocladius ($x^2$ at 5% = 31.57). C. tribelos was significantly distributed between the roots of M. verticillatum and P. gramineus ($x^2$ at 5% = 40.15). The clear bottom mud areas near the pondweeds, M. exalbescens Fern and N. flexilis, held significant abundances of the chironomid, Micropsectra ($x^2$ at 5% = 19.83) (Table 8).

## Station C

The distribution of chironomid larvae among the three habitats of station C was 16.6% on the pondweeds, 36.6% in the rooted bottom mud, and 46.8% in the non-

TABLE 8: SIGNIFICANT DIFFERENCES AT 5% IN THE DISTRIBUTION OF SELECTED CHIRONOMID GENERA IN THREE HABITATS IN STATION B DURING THE SIX-WEEK PERIOD OF AUGUST AND THE BEGINNING OF SEPTEMBER.

| | Three Habitats of Station B | | |
|---|---|---|---|
| Macrophyte Species | Pondweed | Rooted Bottom | Non-vegetative Bottom |
| *P. pectinatus* | *Psectrocladius* | - | - |
| *M. verticillatum* | *Tanytarsus* | *C. tribelos* | - |
| *P. gramineus* | - | *C. tribelos* | *Tanytarsus*<br>*Pseudochironomus*<br>*Cryptochironomus* |
| *P. richardsonii* | *Pseudochironomus*<br>*Ablabesmyia* | - | - |
| *M. exalbescens Fern* | - | *Tanytarsus*<br>*Procladius* | *Micropsectra* |
| *N. flexilis* | *Tanytarsus* | - | *Micropsectra* |
| *C. demersum* | *Psectrocladius* | - | - |
| *P. zosteriformis* | - | *Tanytarsus* | - |

36.6% in the rooted bottom mud, and 46.8% in the non-vegetative bottom mud. Of all chironomid genera collected in station C in September, the three most abundant genera were Pseudochironomus (57 specimens), Tanytarsus (46 specimens), and Ablabesmyia (23 specimens). This represented 67% of all chironomids collected in station C. The distribution of Tanytarsus and Pseudochironomus appears not to be random among the four pondweeds collected in this station. Tanytarsus occurred with greatest abundances in the bottom habitats of station C as well as stations A and B. Some selection of macrophyte areas is evidenced. Tanytarsus maintained high population levels in both bottom habitats, rooted and non-rooted, in association with the pondweed, P. gramineus ($x^2$ at 5% = 17.97, rooted, and 10.8, clear). Pseudochironomus, too, was significantly distributed in the bottom habitats, rooted and non-rooted, of the pondweed, P. gramineus ($x^2$ at 5% = 25.23, rooted, and 8.22, clear). It appears that the chironomid Ablabesmyia is randomly distributed on the four pondweeds collected in station C (Table 9).

## Chironomid Distribution

This non-random distribution of chironomid genera

TABLE 9: SIGNIFICANT DIFFERENCES AT 5% IN THE DISTRIBUTION OF SELECTED CHIRONOMID GENERA IN THREE HABITATS IN STATION C DURING THE MONTH OF SEPTEMBER.

| | Three Habitats of Station C | | |
|---|---|---|---|
| Macrophyte Species | Pondweed | Rooted Bottom | Non-vegetative Bottom |
| *P. pectinatus* | - | - | - |
| *M. verticillatum* | - | - | - |
| *P. gramineus* | - | *Tanytarsus*<br>*Pseudochironomus* | *Tanytarsus*<br>*Pseudochironomus* |
| *M. exalbescens Fern* | - | - | - |

varied with pondweed species among the three sampling stations. Of particular contrast is the *Tanytarsus*-*M. verticillatum* association of station A and the *Tanytarsus*-*P. gramineus* association of station C. In each station both *P. gramineus* and *M. verticillatum* were available alternative resources during their respective sampling periods. Also of note is the variation in habitat utilization by *Tanytarsus*. *Tanytarsus* was collected in large abundance in both bottom habitats. The pondweed habitat held the least number of *Tanytarsus*. However, there was some evidence of pondweed species preferences. In station B, *Tanytarsus* was non-randomly distributed among the eight pondweeds with significantly greater abundances on the macrophytes, *M. verticillatum* and *N. flexilis*.

Of the 13 arbitrarily selected chironomid genera (greater than 20 specimens), five genera were excluded from the pondweed habitat in two of the three sampling stations. They were *Pseudochironomus*, *Procladius*, *Paralauterborniella*, *Micropsectra*, and *Dicrotendipes*. In station B some specimens of each were collected on pondweeds though low in number.

The chironomid-Potamogeton association resulting from laboratory reared larvae was not consistent with results obtained from the field study in Cedar Lake (Berg, 1949). Laboratory reared Tanytarsus larvae were reported not to associate with the Potamogeton species, P. zosteriformis and P. pectinatus. However, results of the Cedar Lake sampling do show association of Tanytarsus with these two species. Also, since the benthos is the favored habitat of Tanytarsus, the exclusion of the roots from the laboratory investigation did not adequately reflect Tanytarsus' utilization of these pondweeds (Table 10).

## Hyallela Azteca Distribution

Some significant differences in the distribution of Hyallela azteca among the pondweed species in station A occurred for the sampling period of July (Table 11). Hyallela azteca was collected in greatest abundance on the pondweed, M. verticillatum ($x^2$ at 5% = 25.5) and among the roots and in the adjacent clear area of the macrophyte, P. gramineus ($x^2$ at 5% = 9.9, roots, and 31.0, clear).

TABLE 10: THE NUMBER OF *TANYTARSUS* FOUND ON FOUR *POTAMOGETON* SPECIES AND OTHER (NON-*POTAMOGETON*) SPECIES IN CEDAR LAKE COMPARED WITH LABORATORY REARED *TANYTARSUS-POTAMOGETON* ASSOCIATIONS.

| | | Cedar Lake | |
|---|---|---|---|
| Macrophyte Species | Lab Reared | Pondweed | Roots |
| *P. gramineus* | x | 35 | 62 |
| *P. pectinatus* | | 10 | 22 |
| *P. richardsonii* | x | 5 | 5 |
| *P. zosteriformis* | | 0 | 5 |
| Other (non-*Potamogeton*) | | 39 | 242 |
| TOTAL | | 89 | 336 |

TABLE 11: SIGNIFICANT DIFFERENCES AT 5% IN THE DISTRIBUTION OF *HYALLELA AZTECA* IN THREE HABITATS IN STATION A DURING THE FIVE-WEEK PERIOD OF JULY AND AUGUST.

| Macrophyte Species | Three Habitats of Station A | | |
|---|---|---|---|
| | Pondweed | Rooted Bottom | Non-vegetative Bottom |
| *P. pectinatus* | - | - | - |
| *M. verticillatum* | *Hyallela azteca* | - | - |
| *P. gramineus* | - | *Hyallela azteca* | *Hyallela azteca* |

*Hyallela azteca* collections in station B during the month of August were distributed non-randomly among the eight pondweed species (Table 12). Significantly high populations of *Hyallela azteca* occurred on the pondweeds, *P. richardsonii*, *M. exalbescens Fern*, and *C. demersum* ($x^2$ at 5% = 201.5). The rooted habitat for the macrophytes, *M. exalbescens Fern*, *N. flexilis*, and *P. zosteriformis*, held significantly higher than expected numbers of *Hyallela azteca* ($x^2$ at 5% = 189.1). *Hyallela azteca* was also collected in significantly greater abundances from the clear area near the macrophyte, *M. exalbescens Fern* ($x^2$ at 5% = 56.3) in station B.

In station C *Hyallela azteca* collections for the period of September held significantly greater than expected numbers on the pondweeds, *M. exalbescens Fern* and *P. pectinatus* ($x^2$ at 5% = 52.07). Also in station C the rooted and adjacent clear bottom of the macrophyte, *P. gramineus* held greater than expected numbers of *Hyallela azteca* ($x^2$ at 5% = 106.6, roots, and 22.6, clear) (Table 13).

TABLE 12: SIGNFICANT DIFFERENCES AT 5% IN THE DISTRIBUTION OF *HYALLELA AZTECA* IN THREE HABITATS IN STATION B DURING THE SIX-WEEK PERIOD OF AUGUST AND THE BEGINNING OF SEPTEMBER.

| | Three Habitats of Station B | | |
|---|---|---|---|
| *Macrophyte Species* | *Pondweed* | *Rooted Bottom* | *Non-vegetative Bottom* |
| *P. pectinatus* | - | - | - |
| *M. verticillatum* | - | - | - |
| *P. gramineus* | - | - | - |
| *P. richardsonii* | *Hyallela azteca* | - | - |
| *M. exalbescens Fern* | *Hyallela azteca* | *Hyallela azteca* | *Hyallela azteca* |
| *N. flexilis* | - | *Hyallela azteca* | - |
| *C. demersum* | *Hyallela azteca* | - | - |
| *P. zosteriformis* | _ | *Hyallela azteca* | - |

TABLE 13: SIGNIFICANT DIFFERENCES AT 5% IN THE DISTRIBUTION OF *HYALLELA AZTECA* IN THREE HABITATS IN STATION C DURING THE MONTH OF SEPTEMBER.

| | Three Habitats of Station C | | |
|---|---|---|---|
| Macrophyte Species | Pondweed | Rooted Bottom | Non-vegetative Bottom |
| *P. pectinatus* | *Hyallela azteca* | - | - |
| *M. verticillatum* | - | - | - |
| *P. gramineus* | - | *Hyallela azteca* | *Hyallela azteca* |
| *M. exalbescens Fern* | *Hyallela azteca* | - | - |

## DISCUSSION

A distinct littoral species association dependent upon the presence of vascular vegetation has been reported in numerous freshwater lakes of North America (Rawson, 1953; Johnson and Brinkhurst, 1971; and Johnson, 1975). This littoral association is represented by a core of four groups: the gastropods, chironomid larvae, amphipods, and pelecypods (sphaeriidae), which comprise 95% of the Cedar Lake samples, and 88.6% of the Great Slave Lake collections (Table 14) (Rawson, 1953). This littoral species association extends to a number of less abundant though persistent species. They include: oligochaetes, the isopod *Lirceus lineatus*, the mayfly *Caenis*, the lepidopteran *Synclitus*, trichoptera larvae, ephemeroptera larvae, and Corixidae.

Some variation in the core groups of the littoral zone was reported for the Bay of Quinte, Prince Edward Bay, and Lake Ontario (Johnson and Brinkhurst, 1971). The group of greatest abundance was oligochaetes, rather than the gastropods of Cedar Lake. A possible explanation for this may be varying levels of calcium between Cedar Lake and the other lakes. Higher calcium

TABLE 14: A COMPARISON OF THE PERCENT OF THE POPULATION OF EACH FAUNAL GROUP COLLECTED FROM GREAT SLAVE LAKE, SASKATCHEWAN (RAWSON, 1953) AND CEDAR LAKE, ILLINOIS.

| Faunal Group | Percent of Population | |
|---|---|---|
| | Great Slave Lake | Cedar Lake |
| Amphipoda | 46.5 | 10.5 |
| Sphaeriidae | 19.3 | 7.1 |
| Oligochaeta | 9.0 | 1.2 |
| Chironomid Larvae | 12.2 | 12.1 |
| Ostracoda | .8 | 0 |
| Gastropoda | 10.6 | 64.7 |
| Nematoda | .1 | .1 |
| Miscellaneous | 1.5 | 4.3 |
| All organisms | 100.0% | 100.0% |

levels support larger mollusk and crustacean populations and lower calcium levels are known to favor populations of planarian and annelids. The second, third, and fourth most abundant groups (pelecypods, chironomid larvae, and crustaceans) are consistent with Cedar Lake results. This littoral association for the Bay of Quinte, Prince Edward Bay, and Lake Ontario comprised 96.5% of the total animals collected.

A comparison of the abundances collected from the three habitats suggests that the benthos (both rooted and non-vegetative) maintains the bulk of the littoral population (93.1% of the total specimens). Each benthos habitat held a similar percent of the population (rooted, 45.8% and non-vegetative, 47.3%). This large benthos abundance was due to the large numbers of the four dominant littoral groups. One of the four dominant littoral groups, the chironomid larvae, had abundances which varied among the sampling stations. In station A the largest numbers were collected from the rooted bottom mud. This agrees with Gerking's (1957) results suggesting that benthic fauna occur in greatest abundance in the bottom areas stabilized by extensive root development. However, in both stations

B and C higher numbers of chironomid larvae were collected in the non-vegetative bottom mud. Gerking's study did not sample the non-vegetative bottom mud. Also, no definition for non-vegetative bottom mud was provided specifying the distance of collections from the pondweed. Of the four major littoral groups, one species was found to select between the rooted and non-vegetative benthos habitats. *Hyallela azteca* was most abundant in the rooted bottom.

Organisms from most of the taxonomic groups of Table 2 occurred in the pondweed habitat even though the abundances were low. This also does not agree with Gerking's (1957) report of Bryant's Creek Lake, Indiana. He reported the almost complete absence of amphipods, water mites (hydrachnellae), mayflies (ephemeroptera), dragonflies and damselflies (odonata), true bugs (hemiptera), caddisflies (trichoptera), and beetles (coleoptera) from the benthos.

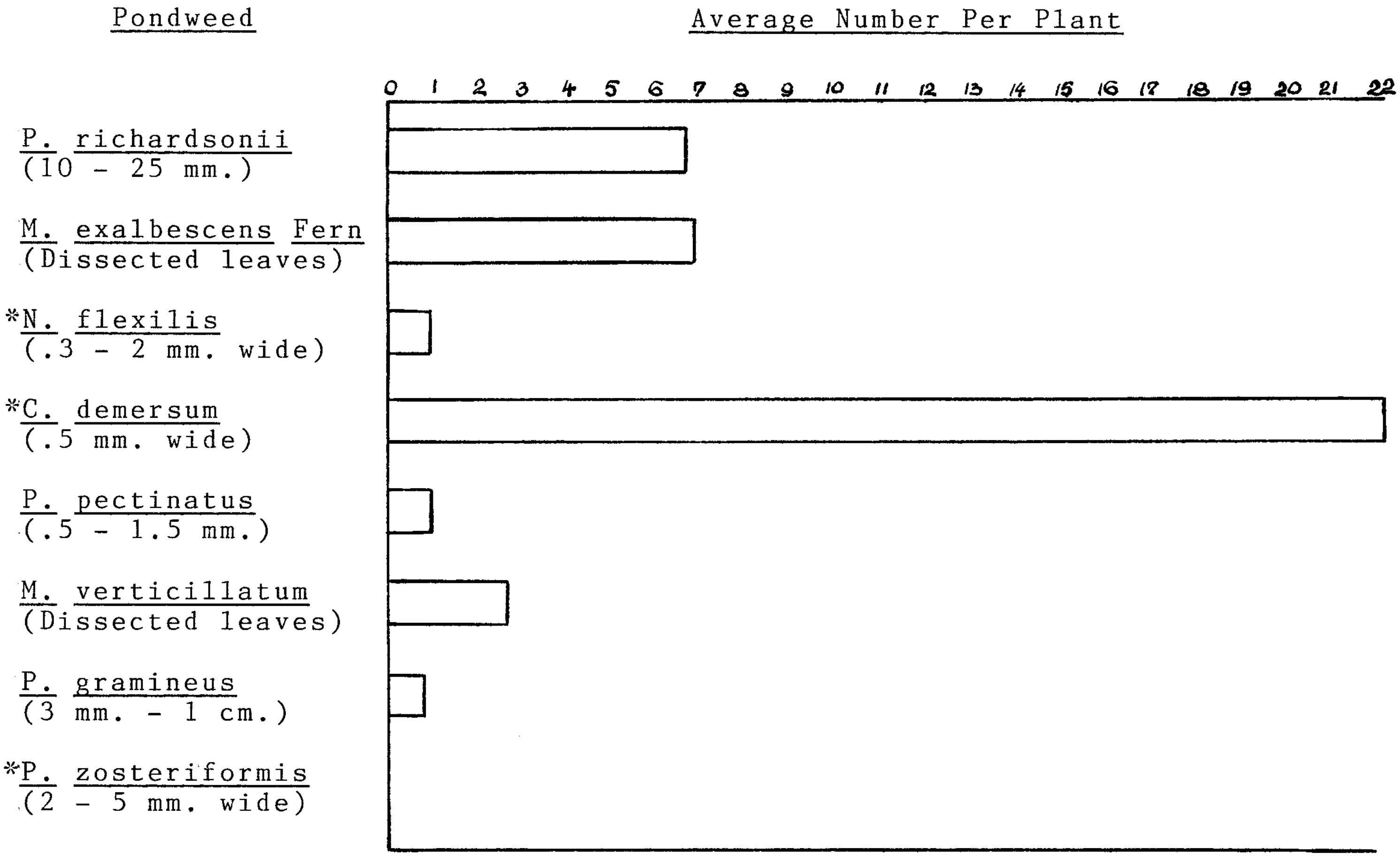
The distribution of the macrofauna in the littoral zone show habitat divisions among community members. In the pondweed habitat, collections were of *Hydra* and lepidoptera exclusively and of oligochaeta and cladocera in significant abundances. In the benthos habitat, collections were of pelecypoda, hemiptera, and isopoda (Lirceus lineatus) exclusively and of gastropoda and chironomid larvae in significant abundances. In the rooted benthos habitat, collections were of coleoptera, collembola, and dixidae exclusively and of trichoptera and amphipoda (Hyallela azteca) in significant numbers. In the non-vegetative benthos habitat, collections were of megaloptera and tipulidae exclusively.

Significantly different abundances of Hyallela azteca occurred among all three habitats. The rooted benthos held the greatest abundance at 58% of the total specimens collected. Distribution of Hyallela azteca in the rooted benthos was random for all macrophyte species of stations A and C. In station B one plant each of N. flexilis and P. zosteriformis was collected. Both plants' roots held a greater than expected number of Hyallela azteca. The non-vegetative benthos held 31.5% of all specimens. The distribution of the remaining 10.5% collected from the pondweed habitat suggests some macrophyte species preferences. Greater than expected abundances occurred in station A on M. verticillatum, in station B on P. richardsonii, and *C. demersum*, and in station C on *P. pectinatus* and *M. exalbescens Fern*. The macrophyte preferences are not consistent among sampling stations and may reflect a seasonal variation in pondweed utilization. Such a seasonal variation on macrophyte species was previously reported for *Hyallela azteca* by Rosine, 1955.

Rosine (1955) also found variation in the extent to which *Hyallela azteca* were found on equal surface areas of three plants. Although no plant surface area data was taken for the Cedar Lake study, Table 15 gives the average number of *Hyallela azteca* collected per pondweed with reference to leaf width.

The distribution of chironomid larvae also indicated habitat divisions. Omitting the species with a single chironomid larva collected, the following chironomid distribution was found, *Smittia* was collected exclusively in the pondweed habitat. *S. aterrima*, *Strictochironomus*, and *Microtendipes* were collected from the benthos only. *Polypedilum* was collected in the rooted benthos and *G. holoprasinus* in the non-vegetative benthos.

TABLE 15: AVERAGE NUMBER OF <u>HYALLELA AZTECA</u> COLLECTED ON EACH PONDWEED. THE APPROXIMATE LEAF WIDTH OF EACH PONDWEED SPECIES IS SHOWN IN PARENTHESIS (WINTERRINGER AND LOPINOT, 1966).




*Macrophyte species occurring only once.

In addition to the macrophyte preferences of Hyallela azteca, the distribution of other littoral organisms suggested some selection of pondweed species. Most chironomid genera occurred on a number of plant species. Seven chironomid larvae genera were collected on or among the roots of the Potamogeton pondweeds only. Again excluding genera of a single collection, they were Microtendipes, C. concinnus, Glyptotendipes, P. bathyphilia, Cryptochironomus nais, Smittia, and Psectrotanyus. Also collections of lepidoptera and phasmidia were both on Potamogeton pondweed species only.

The distribution of the most abundant chironomid genera also suggested macrophyte preferences. Note that statistical analyses of the chironomid larvae were done selectively. The 13 chironomid genera of highest abundances (collections greater than 170 specimens) were analyzed. It was assumed that the larger sampling size would give a more valid approximation of the population. However, this was an arbitrary decision and it should not be inferred that the selected genera are of inherently more importance to the community organization. Clearly, persistence at low population levels is a valid survival strategy and can reflect a stable component of the community organization. Chironomid larvae genera were found in association with the following pondweeds. The (H) indicates herbivore and (C) indicates carnivore chironomid genera.

| Pondweed | Chironomid Genera |
|---|---|
| **Station A - Rooted Habitat** | |
| *M. verticillatum* | *Pseudochironomus* (H) and *Cryptochironomus* (C) |
| **Station B - Pondweed Habitat** | |
| *P. pectinatus* | *Psectrocladius* (H) |
| *C. demersum* | *Psectrocladius* (H) |
| *M. verticillatum* | *Tanytarsus* (H) |
| *M. exalbescens Fern* | *Tanytarsus* (H) |
| *P. richardsonii* | *Pseudochironomus* (H) and *Ablabesmyia* (C) |
| **Station B - Rooted Habitat** | |
| *M. verticillatum* | *C. tribelos* (H) |
| *P. gramineus* | *C. tribelos* (H) |
| *M. exalbescens Fern* | *Tanytarsus* (H) and *Procladius* (C) |
| *P. zosteriformis* | *Tanytarsus* (H) |

The collection data of the five most numerous genera corresponds well with anticipated predator-prey populations. The burrower-detritus feeders, *Tanytarsus* (660 specimens) and *Pseudochironomus* (389 specimens), exceeded by a wide margin all other collected chironomid populations. The abundances for the predator species were *Procladius* (180 specimens), *Cryptochironomus* (173 specimens), and *Ablabesmyia* (124 specimens).

Odum (1971) suggests that plant resources are generally underused by herbivore populations. Therefore, it is highly unlikely that competition would control herbivore population size. Rather the population would be predator-controlled with the distribution a reflection of predation. Some support for this may be the coincident overabundances of *Tanytarsus* and *Pseudochironomus* in the non-vegetative bottom of *P. gramineus* in station B, in the rooted bottom of *M. verticillatum* in station A, and in both bottom habitats of *P. gramineus* of station C.

Three carnivorous genera occurred in significantly greater numbers than expected on macrophytes within station A and station B (Tables 7 and 8). The genera were *Cryptochironomus*, *Ablabesmyia*, and *Procladius*. Two of the three carnivorous chironomid larvae have reported population peaks consistent with the sampling time of this study. This was reported for *Procladius* (Heuschele, 1969; and Dermott, Kalff, Leggett, and Spence, 1977) and for Cryptochironomus (Heuschele, 1969). Since the population size of predator species is likely to be food-limited, competition is a factor influencing the distribution of predators (Odum, 1971; Burton, 1977). The reported population peaks for Procladius and Cryptochironomus, assuming this is true of Cedar Lake as well, suggest the likelihood that the three chironomids are in competition. Some evidence for competition among them is found in their distribution. Unlike the Tanytarsus-Pseudochironomus association, which as Odum suggests do not compete for food, no two predator genera were collected together in statistically significant numbers from a single habitat.

If competition among the three chironomids was occurring, the distributions should indicate some division of habitat, or food resources. Also some scattering in food selection from more customary choices is another possible result of competition. However, this possibility is beyond the scope of this research. Some division of possible prey resources is suggested by the associations of Pseudochironomus-Ablabesmyia, Tanytarsus-Procladius, and Tanytarsus-Pseudochironomus-Cryptochironomus in greater than expected abundances in stations A and B

(Tables 5 and 6). Some division of habitats was found among the three carnivorous chironomid larvae. Forty-three percent of Ablabesmyia specimens were collected from the pondweed habitat. However, greatest abundances of Cryptochironomus and Procladius were from the benthos with only 6% of Cryptochironomus collected on the pondweed and 4% of Procladius on the pondweed. The distribution of the two benthos carnivores are somewhat dissimilar. For all three sampling stations, the distribution of Cryptochironomus is similar to the distribution of Tanytarsus and Pseudochironomus. Procladius' distribution, however, does not correspond well with other chironomid larvae distributions. The data seem to indicate a distribution similar to amphipoda-ephemeroptera distributions. Monakov (1972) reported, "Procladius and Ablabesmyia larvae eat larvae of silt-eating Chironomidae readily and those of oligochaeta and crustacea reluctantly." If this is true of Cedar Lake as well, this suggests that Procladius may be altering its food items.

The data in this research will not support any definitive conclusions about the relationships among the carnivorous larvae; Cryptochironomus, Procladius, and Ablabesmyia, nor their relationships to the burrower and detritus feeders, Tanytarsus and Pseudochironomus. It is suggested that areas of further research interest would be:

1. Stomach analysis of the carnivores; Procladius, Cryptochironomus, and Ablabesmyia extended beyond the summer season sampled and through a five-year study period.

2. Annual population levels for Procladius, Cryptochironomus, and Ablabesmyia throughout a five-year study period.

3, Investigation of the variation of macrophyte-chironomid associations with sampling stations in other sections of the littoral zone (eliminating the time variable of this research).

4. Investigation of the variation of macrophyte-Hyallela azteca associations with sampling stations in other sections of the littoral zone (eliminating the time variable of this research).

# SUMMARY

The dominant macrofaunal members of the littoral community of Cedar Lake are gastropods, chironomid larvae, amphipods, and sphaeriids, which total 95% of all organisms collected. Though individuals from nearly all groups were collected in all three sampled habitats, the abundances were consistently lower for the pondweed habitat for all taxonomic classes except hydrozoa and oligochaeta. With one exception, the bottom habitats of roots and of non-vegetative mud were found to hold similar species in approximately equal abundances. The one exception was Hyallela azteca, which was most abundant in the rooted bottom habitat.

Macrophyte preferences were found for Hyallela azteca and for some chironomid larvae. However, these associations varied among the sampling stations. Of the 42 genera of chironomid larvae collected, only five occurred in abundant numbers. The two most abundant were burrower-detritus feeders, Tanytarsus and Pseudochironomus. The three remaining were the carnivores, Cryptochironomus, Procladius, and Ablabesmyia. Tanytarsus and Pseudochironomus were frequently found

together in significant numbers. Often one carnivorous chironomid larvae, either *Cryptochironomus*, *Procladius*, or *Ablabesmyia*, were collected with *Tanytarsus*, with *Pseudochironomus*, or with both together.

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APPROVAL SHEET

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The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval by the Committee with reference to content and form.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Science.

July 22, 1985
Date

Jan Savitz
Director's Signature