1978

A Study of the Macrobenthic Community in Lake Cochrane, South Dakota

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A STUDY OF THE MACROBENTHIC COMMUNITY

IN LAKE COCHRANE, SOUTH DAKOTA

BY

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A thesis submitted
in partial fulfillment of the requirements for the
degree, Master of Science, Major in Biology
South Dakota State University

1978

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IN LAKE COCHRANE, SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser / Date

Head, Botany-Biology Department Date

ACKNOWLEDGEMENTS

I wish to express my gratitude to Dr. Lois Haertel for her criticisms, suggestions and patience throughout the course of this study, and for her assistance in preparation of the manuscript. I also wish to express my appreciation to Dr. Burrus McDaniel for his suggestions and his availability for consultation throughout the study; to Dr. Donald Hales for stimulating my interests in benthic ecology; to Dr. Gerald Myers for his advice and patience; to Randy Brich for assistance in gathering the samples; to Dr. Lee Tucker for help in the statistical analysis; to Roger Assmus for help with winter sampling; and to Cathy Haan for typing the final manuscript.

I would like to express special thanks to my wife, Barbara, for unfailing support, encouragement and patience during the entire project and for assisting in the laboratory.

This study was partially supported by funds from the Water Resources Institute U.S.D.I. (O.W.R.T.) A-061-SD and the South Dakota State University Agricultural Experiment Station.

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INTRODUCTION

As part of a continuing study of the biological community of Lake Cochrane, South Dakota, a quantitative survey of the macroscopic bottom fauna was made between the early part of April, 1976 and December, 1976. It was hoped that such a study could provide baseline data for an understanding of the interactions that occur between benthic organisms and other biological components of the lake system. The lake's primary productivity and phytoplankton and zooplankton standing crops have previously been studied by Haertel (1972, 1976) and Steinberg (1972).

When this study was being conducted, sediment control dams were being built on three ephemeral streams entering the lake on the southwest end. The dams are part of an experiment in lake restoration. If changes occur in the water quality of Lake Cochrane because of the presence of the sediment dams, changes may also occur in the benthic community. In that event the baseline data presented here may be useful for comparison with future investigations.

The major objectives of this study were as follows: 1) to describe the macrobenthic composition and estimate standing crop at selected sampling sites in Lake Cochrane; 2) to describe seasonal changes in the populations and the life histories of the major species.

LITERATURE SURVEY

Complete benthic studies of lakes in South Dakota have been limited to Lake Kampeska (Hartung, 1968) and Lake Poinsett (Smith, 1971). Hartung (1968) reported that several species of *Chironomus* dominated the benthos of Lake Kampeska. The most numerous species was *Chironomus plumosus.* Smith (1971) reported that *Chironomus attenuatus* and *Chironomus plumosus* were the most numerous benthic organisms in Lake Poinsett.

Donaldson (1976) conducted a rigorous study of two seasonal marshes in eastern South Dakota. He found that in both Bothwell and Lund marshes *Chironomus* spp. dominated the benthos in May and *Glyptotendipes* spp. dominated in June.

Other lakes and ponds in South Dakota that have received limited study include Lake Francis Case (Benson and Hudson, 1975), Lake Yankton (Boehmer et al. 1975), Lewis and Clark Reservoir (Schmulbach and Sandhom, 1962) and (Hudson, 1970), Beaver Lake (Wolf and Goeden, 1973), and Abbey Pond (Gengerke and Nickum, 1972). None of the above studies included estimates of standing crop.

There are numerous studies of lakes in the United States that have included estimates of standing crops. Several of those studies that allow useful comparisons with Lake Cochrane include: Lake Mendota (Juday, 1921), Linsley Pond and 18 other lakes (Deevey, 1941), Lake Itasca (Cole and Underhill, 1965), Lake Ashtabula (Peterka, 1972), Lake Okoboji (Clampitt et al., 1951), Lizzard Lake (Tebo, 1955), Lake Texoma (Sublette, 1957) and Clear Lake (Mracheck and Bachman, 1967).

In quantitative studies of macrobenthic communities one must collect an adequate number of samples to determine the numerical densities of the benthic organisms at each sampling site. The number of samples required is dependent upon the spatial distribution of the organisms. In a study of lakes in New York and Connecticut Deevey (1941) assumed that each species was randomly distributed and that one Eckman grab sample would adequately estimate the benthic community in a given area. Eggleton (1931) used from 5 to 50 Eckman grab samples from each station to estimate benthic populations in a study of lakes in Michigan and New York. No attempt was made in either study to estimate the spatial distribution of organisms.

In an attempt to determine the optimum number of samples to estimate an aggregated benthic population, Paterson and Fernando (1971) studied the spatial heterogeneity of shallow water benthos. They determined that four Eckman grab samples were usually adequate to estimate the total fauna, the total chironomid fauna and the dominant species within plus or minus 30% of the mean obtained with a larger number of samples.

In benthic studies it is also useful to estimate the standing crop (weight) of benthic organisms per unit area of bottom. Many investigators have used formalin to preserve samples until they can be sorted and weighed (Deevey, 1941; Cole and Underhill, 1965; Peterka, 1972; Clampitt et al. 1960; Smith, 1971; Tebo, 1955). Others have used ethanol (Hartung, 1968; Mrachek and Bachman, 1967). Howmiller (1972) determined the amount of weight loss when the following preservatives

were used: 10% formalin, 70% ethanol with 5% glycerine and 70% isopropyl alcohol with 5% glycerine. Of these preservatives Howmiller found that formalin caused the least amount of weight loss.

To make comparisons between lakes in terms of standing crop it is frequently necessary to convert values expressed in wet weight to their dry weight equivalent. Investigators who have measured both report different values for conversion. Howmiller (1972) on studies with Tubifix worms found dry weight to be 12.3% of wet weight with formalin and 8.1% with ethanol as a preservative. Cole and Underhill (1965) found dry weight to be 15% of formalin wet weight. Hartung (1968) using ethanol as a preservative, found dry weight to be 10.4% of wet weight. Since most authors expressing biomass as wet weight used formalin as a preservative, the method described by Cole and Underhill (1965) is useful for conversion of wet weight to the dry weight equivalent.

STUDY AREA

Lake Cochrane, located in southern Deuel County, has an area of 148 ha (367 acres), a maximum depth of 7.9m and a mean depth of 3.9m (Brich, 1978). Surface drainage from a watershed of 202 ha. enters the lake from three ephemeral streams on the south and west sides. Sediment control dams were being built on these streams at the time of this study. The lack of a surface outlet probably contributes to the slightly brackish nature of the water. The lake is moderately eutrophic, brackish (2100-2670 ppm salinity) and experiences blue-green algal blooms in late summer (Haertel, 1976).

Most of the bottom of Lake Cochrane is covered by a blue-black mud that contains noticeable amounts of hydrogen sulfide and probably methane. Mud with such characteristics is called sapropel (Reid and Wood, 1976), The inshore bottom deposits are composed of mixtures of stones, gravel, sand and hard clay which give way to a mud dominated bottom, as the distance from shore increases. This shoreline transition zone is narrow. Marshy areas in the south-west portion of the lake allow the mud bottom to extend to the shoreline in places. The inshore portion of the lake bottom was not included in this study because of the difficulty of quantitatively sampling such a diverse habitat with limited resources.

Station 1 was located in the center of the southwestern arm of Lake Cochrane (Figure 1). Maximum depth was approximately 3 meters. The bottom was composed of mud with considerable amounts of detritus and mollusc shells. Submarine photometer readings during the study

indicated that enough light for photosynthesis was usually reaching the bottom (Haertel unpublished). The bottom was probably not subject to wave action at this depth (Haertel, 1976).

Station 2 was located in the transition zone on the west end of the lake (Figure 1). The depth was approximately 2 meters. The nature of the bottom deposits varied from sample to sample and from date to date indicating a heterogeneous bottom. The bottom deposits were various mixtures of gravel, sand, and mud which contained large amounts of detritus, mollusc shells and marl. Sufficient light for photosynthesis was probably available at the bottom throughout the study.

Station 3 was located in the deepest depression on the east arm of the lake (Figure 1). The maximum depth sampled was 7 meters. The bottom was composed of finely divided mud with very little detritus or snail shells. Submarine photometer readings showed that less than one percent of the light at the surface was reaching the bottom each of the nine times it was measured. The bottom deposits were probably never disturbed by wave action at this depth (Haertel, 1976).

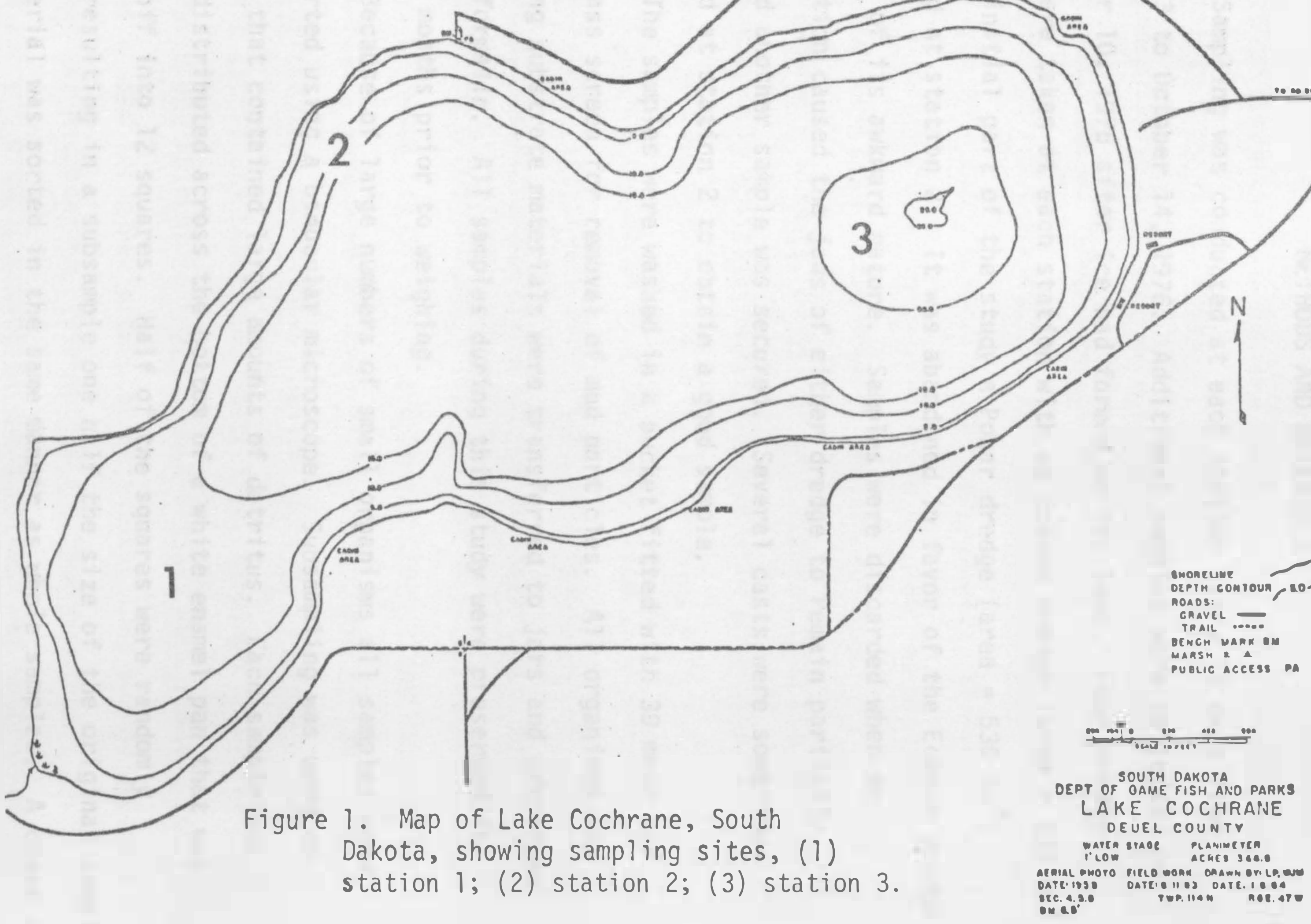


Figure 1. Map of Lake Cochrane, South Dakota, showing sampling sites, (1) station 1; (2) station 2; (3) station 3.

METHODS AND MATERIALS

Sampling was conducted at each station every 18 days from April 13 to October 14, 1976. Additional samples were collected on December 10, 1976 after ice had formed on the lake. Four dredge hauls were taken at each station with an Eckman dredge (area = 232 cm^2). In the initial part of the study a Ponar dredge (area = 536 cm^2) was used at station 2. It was abandoned in favor of the Eckman dredge because of its awkward nature. Samples were discarded when an obstruction caused the jaws of either dredge to remain partially open and another sample was secured. Several casts were sometimes required at station 2 to obtain a good sample.

The samples were washed in a bucket fitted with 30 mesh per inch brass screen for removal of mud particles. All organisms and remaining substrate materials were transferred to jars and preserved in 10% formalin. All samples during this study were preserved for several months prior to weighing.

Because of large numbers of small organisms all samples were hand sorted using a binocular microscope. Subsampling was used on samples that contained large amounts of detritus. Each sample was evenly distributed across the bottom of a white enamel pan that was marked off into 12 squares. Half of the squares were randomly chosen resulting in a subsample one half the size of the original sample. The material was sorted in the same manner as whole samples. A check of the method by determining the standard deviation from the mean for each of the 12 subsamples, indicated that it did not introduce a significant amount of error. The organisms were separated into taxonomic groups,

counted and stored in 10% formalin for weighing. The major species were further separated into instars based on the size of the head capsules (Czeczuga et al. 1968).

Representative organisms were selected for identification and placed in 80% Ethanol. Permanent slides of the Chironomids were made using Euparol after clearing in a 7% KOH solution. Hoyer's mounting media proved more satisfactory for the Tanypodinae. It also allowed mounting directly out of the alcohol with no clearing necessary. Photographs were taken using a Leitz photomicroscope.

To determine biomass, organisms were removed from the formalin solution soaked in distilled water and placed on preweighed slides. Shells were removed from snails prior to weighing with a dilute solution of HCL. The organisms on slides were dried in an oven at 95-100° C for 24 hours. The slides were placed in a dessicator to cool and reweighed to determine the dry weight of the organisms. All material was weighted on a Mettler analytical balance to .1 mg accuracy.

Keys by Mason (1973), Bryce and Hobart (1972), and Hilsenhoff and Narf (1968) were used to identify the chironomid larvae. Chironomus attenuatus (Walker) adults were identified by W. W. Wirth of the Systematic Entomology Laboratory Beltsville, Maryland. Keys by Cook (1956), Ward and Whippel (1959), Pennack (1953), Ross (1944), and Usinger (1956) were used for other groups of organisms. Dr. Burrus McDaniel identified the Hydracarina, Trichoptera and Ephemeroptera.

The percent organic matter in the substrate was determined by the Soil Testing Laboratory at South Dakota State University. The

particle size composition of the bottom sediments was determined using mechanical analysis. The U. S. Department of Agriculture size limits of soil-particle fractions was used to classify the substrate (Kohnke, 1968).

Analysis of variance and simple linear correlation analysis was performed by Dr. Lee Tucker, Experiment Station Statistician, South Dakota State University.

RESULTS AND DISCUSSION

A. Taxonomy

Nematods (Phylum: Nematoda) were collected from all stations but were found most often at station 2. They comprised .04% ($5.0/m^2$) of the mean seasonal numbers and .07% ($.0011\ gm/m^2$) of the mean seasonal standing crop for all stations.

Two members of the phylum Annelida were present in Lake Cochrane. Tubificid worms (Class: Oligochaeta; Family: Tubificidae) were collected from all stations but were rare at station 3. They comprised .53% ($65.1/m^2$) of the mean seasonal numbers and .52% ($.0081gm/m^2$) of the mean seasonal standing crop for all stations. One leech (Class: Hirundinea) was collected at station 3 on August 3, 1976. They formed an insignificant portion of the total benthos.

Snails (Phylum: Mollusca; Class: Gastropoda) were collected from all three stations, but were found most often at station 2. They comprised .02% ($2.81/m^2$) of the mean seasonal numbers and .08% ($.0012gm/m^2$) of the seasonal standing crop for all stations. Living specimens of the following genera were collected: *Physa,* which was collected at all stations and *Gyraulus,* which was found only once at station 2. Genera represented by empty shells included: *Promenetus, Helisoma, Amnicola, Valvata* and *Lymnaea.* Clam shells (Class: Pelecypoda) of the genus *Pisidium* were collected from all stations but were most common at station 2. No living specimens were collected.

Several members of the class Crustacea were collected. Most cladocerans (Order: Cladocera) found in samples were probably included

with lake water used to wash the samples. They included Daphnia, Ceriodaphnia and a member of the Chydoridae. The chydorid is considered a benthic cladoceran. Copepods (Order: Copepoda) found in samples were also accidental and included Diaptomus and Cyclops. Specimens of Hyella azteca (Order: Amphipoda; Family: Tultridae) were collected from both station 2 and station 3 but were most common at station 2. They comprised .02% (2.6/m^2) of the mean seasonal numbers and .03% (.0005gm/m^2) of the mean seasonal standing crop for all stations. Ostracods (Order: Ostracoda) were collected at all stations throughout the study but were not counted or weighed because of their small size and the difficulty of separating live specimens from abundant empty ostracod shells.

Water mites (Class: Arachnoidea; Order: Hydracarina) were collected from all stations. They comprised .02% (2.9/m^2) of the mean seasonal numbers for all stations. The specimens taken were neither large enough nor abundant enough to permit biomass determination. Groups that were present included Hydrachna of the Hydrachinidae, Limnesiidae and an unidentified family.

Mayfly Naiads (Class: Insecta; Order: Ephemeroptera) of Caenis sp. were found at all stations but were most abundant at station 2. They comprised .17% (21.3/m^2) of the mean seasonal numbers and .18 (.0027gm/m^2) of the mean seasonal standing crop for all stations.

Three caddisflies (Class: Insecta; Order: Trichoptera) were collected. Hydroptilla sp. and Orthotrichia sp. (Family: Hydroptilidae) were found at station 1 and station 2. They comprised .02% (2.0/m^2) of the mean seasonal numbers but were too small for an accurate biomass

estimate. Micrasema rusticum (Family: Brachycentridae) was found only at station 2. It comprised .03% (4.1/m^2) of the mean seasonal numbers and .05% (.008gm/m^2) of the mean seasonal standing crop for all stations.

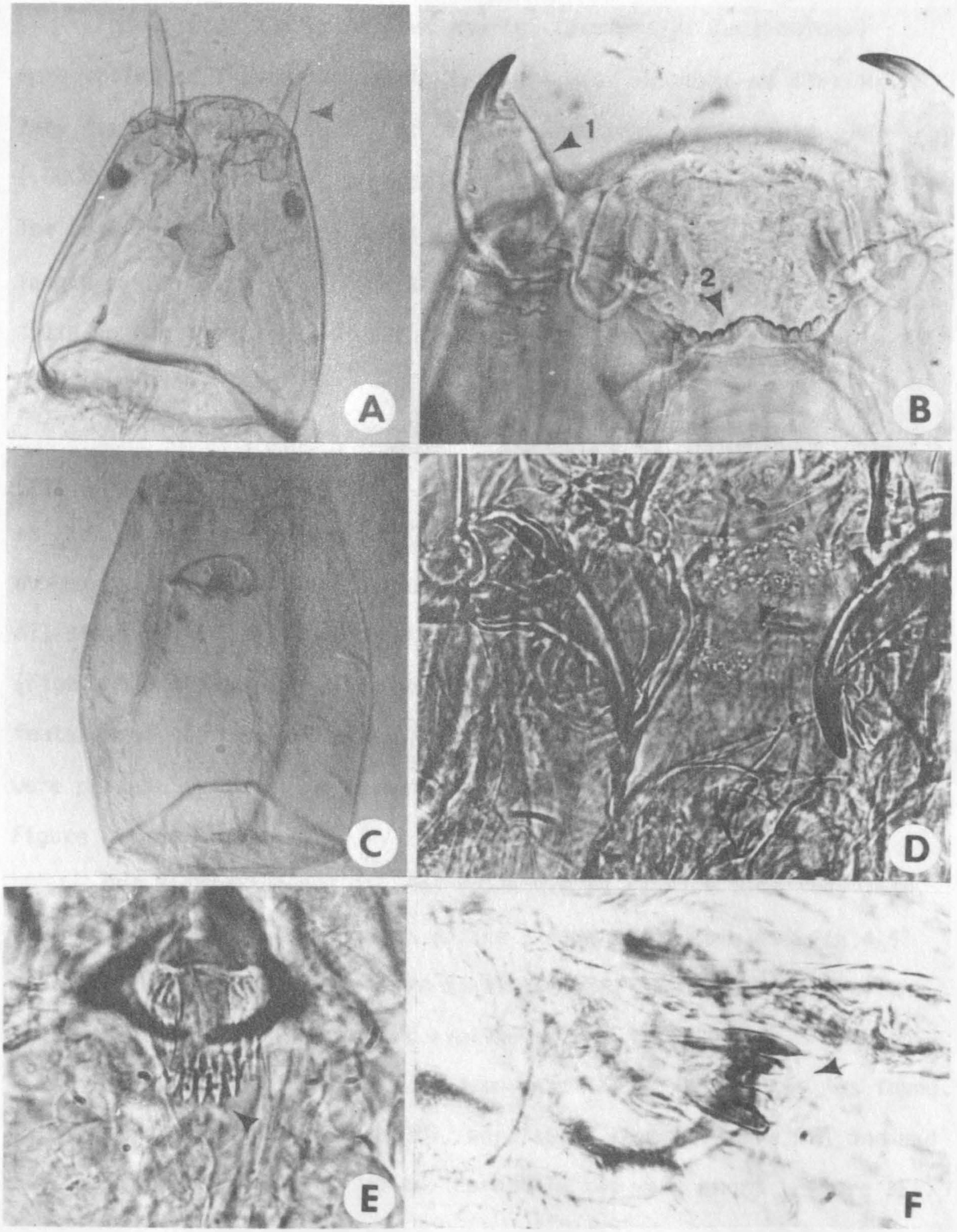
The order Diptera (Class: Insecta) formed a very large part of the benthic community in Lake Cochrane. Chaoborus punctipennis was collected (Family: Chaoboridae) from all stations but was most abundant at station 3. It comprised 56.45% (6905.8/m^2) of the mean seasonal numbers and 42.34% (.6609gm/m^2) of the mean seasonal standing crop for all stations.

Ceratopogonid (Family: Ceratopogonidae) larvae were collected from all stations but were most abundant at station 2. They comprised .21% (25.6/m^2) of the mean seasonal numbers and .22% (.0034gm/m^2) of the mean seasonal standing crop for all stations.

Due to the difficult taxonomy of the family Chironomidae, descriptions and photomicrographs showing key characteristics will be included to lend credibility to their identification.

Tanypus spp. (Subfamily: Tanypodinae; Tribe: Tanypodini) were collected from all stations but were most abundant at station 3. They comprised .17% (20.5m^2) of the mean seasonal numbers and .10% (.0016gm/m^2) of the mean seasonal standing crop for all stations. Antennae about 1/3 the length of the head capsule, (Figure 2A), robust mandibles, the presence of paralabial combs (Figure 2B) and 5 light subequal teeth on the lingua (Figure 2E) are distinguishing features of the genus Tanypus (Mason, 1973).

Figure 2. (A) Tanypus, headcapsule x 100; (B) Tanypus, 1. mandibles, 2. paralabial combs x 400; (C) Pentaneurini, headcapsule x 100; (D) Pentaneurini, headcapsule x 400, note the absence of paralabial combs; (E) Tanypus, lingua x 400; (F) Pentaneurini, lingua x 400.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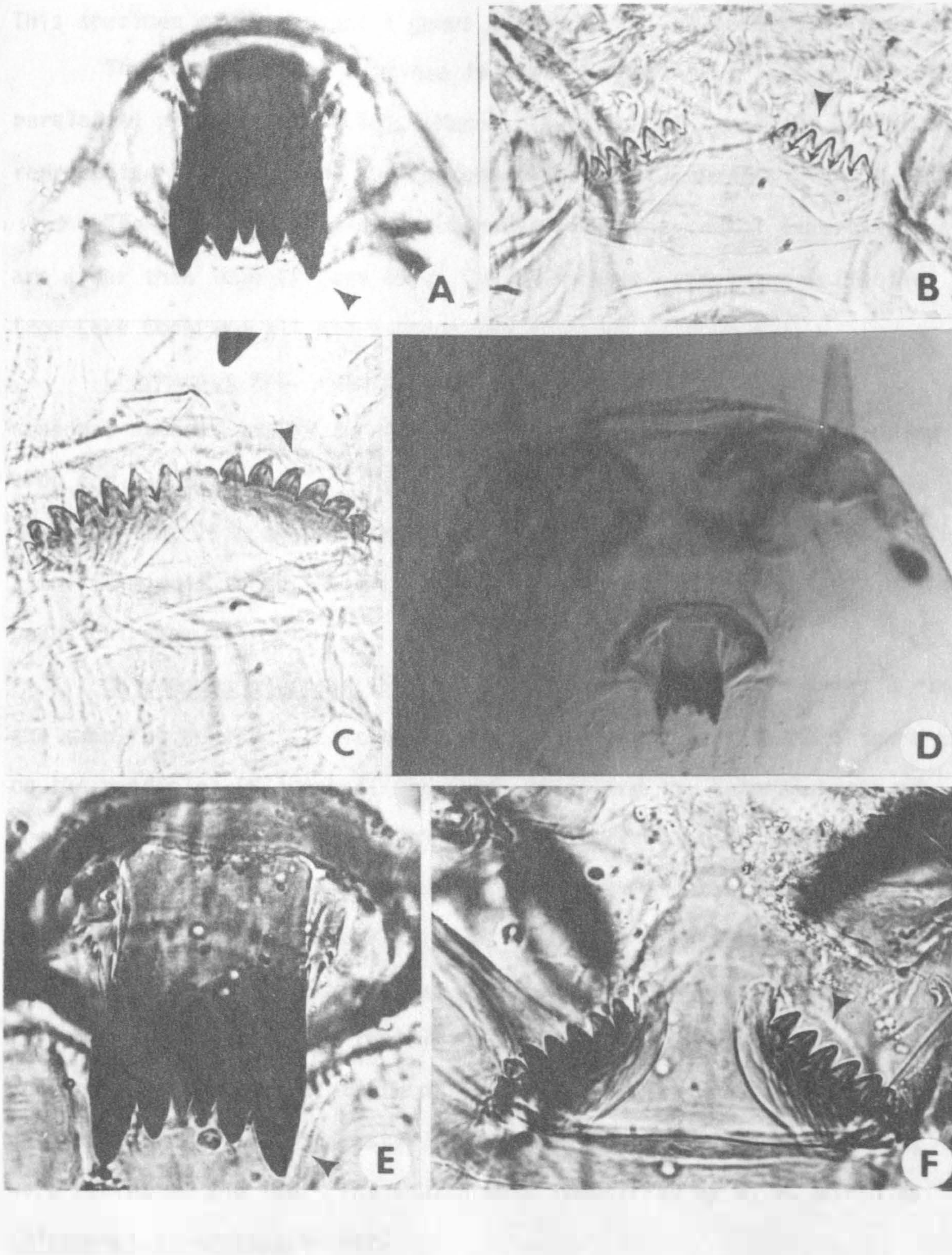
Members of the tribe Pentaneurini (Subfamily: Tanypodinae) were collected from all stations but were most abundant at station 2. They comprised .05% (6.5/m^2) of the mean seasonal numbers and .04% (.0006gm/m^2) of the mean seasonal standing crop for all stations. The absence of paralabial combs (Figure 2C, D), a head index (Breadth: length x 100) of 45-66 (Bryce and Hobart, 1972) and 5 pointed dark teeth on the lingua (Figure 2F) are distinguishing features of the Pentaneurini.

The tribe Macropelopiini was represented by two genera. Procladius spp. were collected from all stations but were most abundant at station 2. They comprised 3.42% (418.8/m^2) of the mean seasonal numbers and 3.48 (.0543gm/m^2) of the mean seasonal standing crop for all stations. Five black teeth, middle tooth shortest, on the lingua (Figure 3A) and paralabial combs (Figure 3B) are all distinguishing features of the genus (Mason, 1973). Different species of Procladius were present as shown by differences in the paralabial combs shown in Figure 3B and Figure 3C.

One Psectrotanypus sp. was collected at station 3 on July 16th. Paralabial combs, 4 equal teeth on the lingua and mandibles with 4-5 teeth on the inner shoulder, are distinguishing characteristics of the genus (Mason, 1973) (no picture available).

One specimen of an unknown genus similar to Procladius was found. It had short antennae (Figure 3D), paralabial combs (Figure 3F) and had six teeth on the lingua of which the middle two were short (Figure 3E).

Figure 3. (A) *Procladius*, lingua x 400; (B) *Procladius*, paralabial combs x 400; (C) *Procladius*, paralabial combs x 400; (D) Tanypodinae unknown genus, headcapsule x 100; (E) Tanypodinae unknown genus, lingua x 400; (F) Tanypodinae unknown genus, paralabial combs x 400.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This specimen may represent a genus that has not yet been described.

The subfamily Chironominae is distinguished by a pair of striated paralabial plates (Figure 4B), (Mason, 1973). This subfamily was well represented by members of the Chironomini and the Tanytarsini.

The tribe Chironomini is characterized by antennal tubercles that are wider than long (Figure 4B). The Chironomini specimens collected from Lake Cochrane all had 5-segmented antennae (Figure 4C).

Chironomus spp. comprised 11.28% (1380.1/m^2) of the mean seasonal numbers and 39.38% (.6147gm/m^2) of the mean seasonal standing crop for all stations. 5-segmented antennae (Figure 4C), ventral tubuli on the 11th segment and 13-15 teeth on the labial plate with a trifid middle tooth (Figure 5A) are distinguishing features of the genus Chironomus.

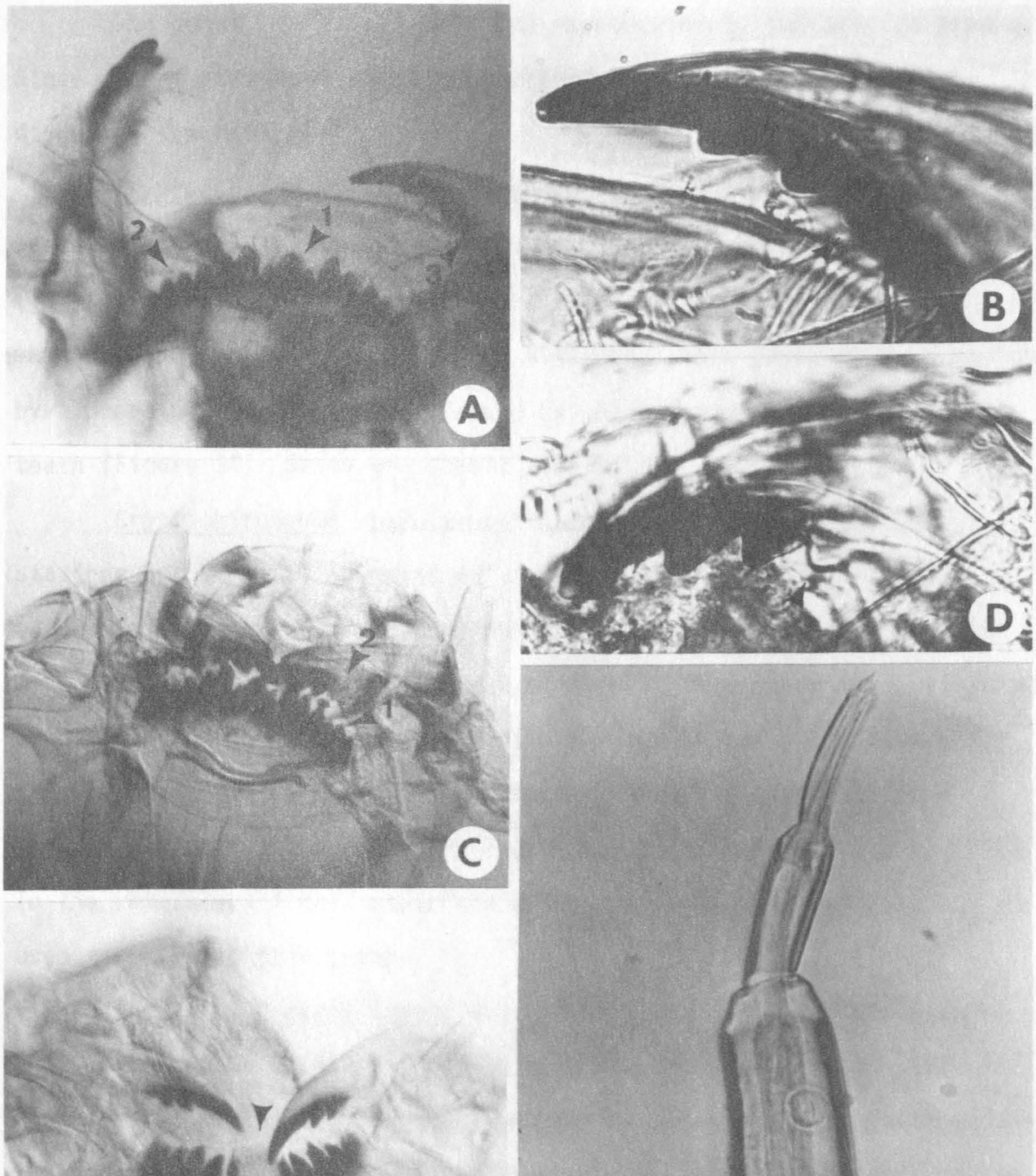
Chironomus plumosus Linnaeus was collected only four times during the sampling period. It is distinguished by the 4 dark teeth (Figure 5B) on the mandibles (Hilsenhoff and Narf, 1968) and the lateral teeth of the labial plate (Figure 5A) which are of similar height (Rempel, 1936).

All other Chironomus specimens seemed to fit the description of Chironomus attenuatus Walker. It has mandibles with three dark teeth and a lighter basal tooth (Figure 5D). Like C. plumosus it has a trilobed middle tooth but the fifth lateral tooth protrudes past the fourth and sixth lateral tooth of the labial plate (Figure 5C) (Hilsenhoff and Narf, 1968). Fourth Instar larvae with the above characteristics were reared in the lab. The adults were identified by W. W. Wirth as Chironomus attenuatus Walker.

Figure 4. (A) *Parachironomus*, striated paralabial plates x 400; (B) harnischia, antennal tubercle x 400; (C) *Chironomus attenuatus*, antenna x 400.


A
B
C

Figure 5. (A) Chironomus plumosus, 1. trifid middle tooth of the labial plate, 2. lateral teeth of the labial plate, 3. mandible x 100; (B) Chironomus plumosus, mandible x 400; (C) Chironomus attenuatus, 1. fifth tooth of the labial plate, 2. mandible x 100; (D) Chironumus attenuatus, mandible x 400; (E) Cryptochironomus "defectus" group, labial plate x 100; (F) Cryptochironomus "defectus: group, antenna x 400.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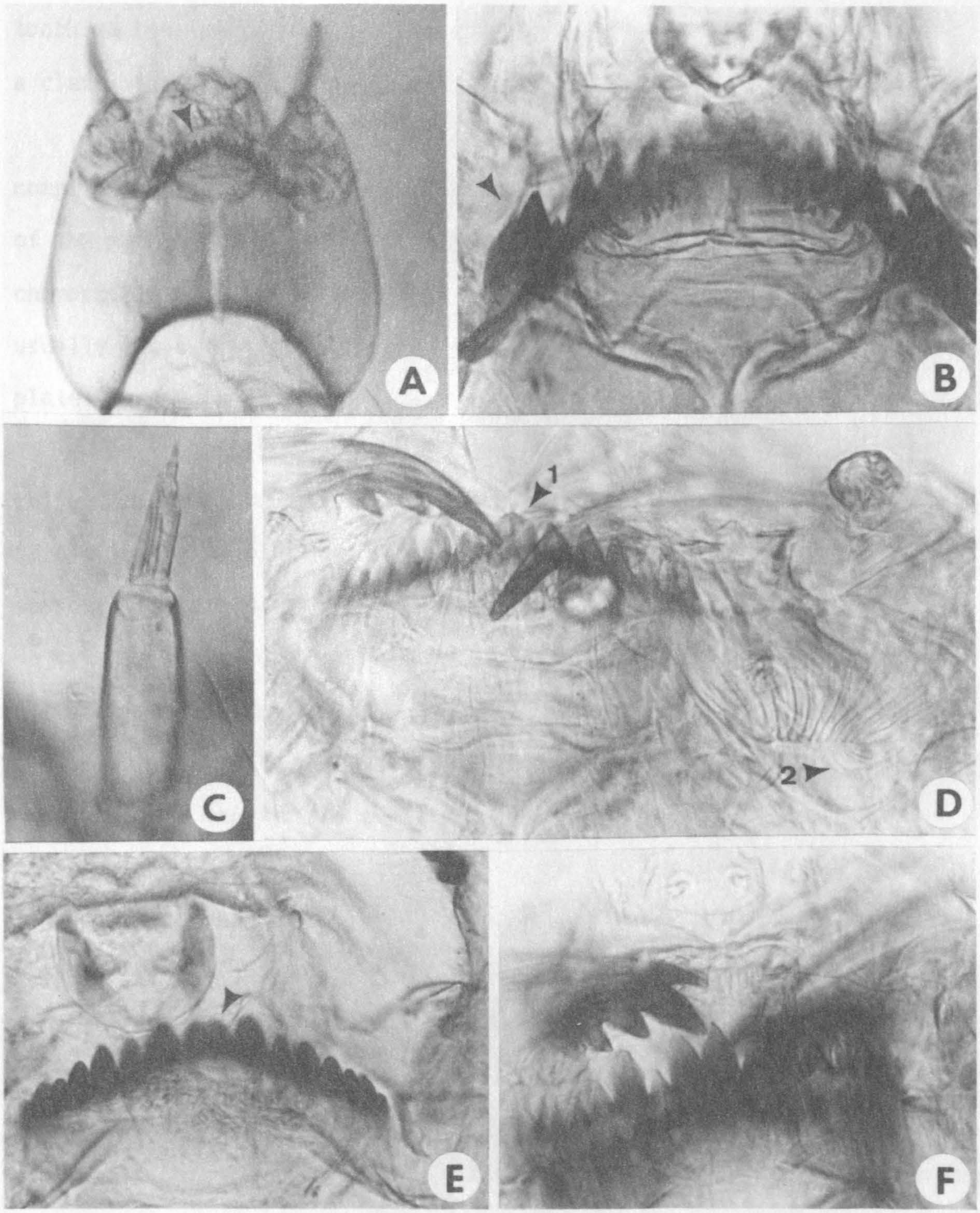
The genus Cryptochironomus was represented by two species groups. Since one of them formed a major portion of the benthos they will be discussed separately.

Cryptochironomus "defectus" group was collected from all stations but was most abundant at station 2. They comprised .12% (14.8/m^2) of the mean seasonal numbers and .73% (.0113gm/m^2) of the mean seasonal standing crop for all stations. This group is distinguished by a broad pale median tooth flanked by oblique rows of darker lateral teeth (Figure 5E) (Bryce and Hobart, 1972).

Cryptochironomus "harnischia" group was collected from all stations but was most abundant at station 1. They comprised 24.53% (3000.7/m^2) of the mean seasonal numbers and 9.79% (.1528gm/m^2) of the mean seasonal standing crop for all stations. This group is distinguished by a strongly convex labial plate with the median teeth anterior and the lateral teeth progressively posterior, except that the extreme lateral are again more anterior (Figure 6A, B) (Bryce and Hobart, 1972). In the remainder of this paper the group name harnischia will be used to refer to this group.

The genus Parachironomus was collected from all three stations. They comprised .03% (3.7/m^2) of the mean seasonal numbers and .02% (.0004gm/m^2) of the mean seasonal weight for all stations. Distinguishing characteristics of the genus Parachironomus include 15 teeth on the labial plate (Figure 6E) and distinct paralabial striations (Figure 6D) which may be recurved (Mason, 1973). Two species of Parachironomus were collected. Parachironomus species "A" had a large, peaked middle

Figure 6. (A) harnischia, headcapsule with convex labial plate x 100; (B) harnischia, labial plate with protruding lateral teeth x 400; (C) harnischia, antenna x 400; (D) Parachironomus species "A", 1. middle tooth of the labial plate, 2. recurved striations of paralabial plate x 400; (E) Parachironomus species "B", middle tooth of the labial plate x 400; (F) Polypedilum, short second tooth of the labial plate x 400.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tooth on the labial plate (Figure 6D). Parachironomus species "B" had a cleft middle tooth on the labial plate (Figure 6E).

The genus Polypedilum was collected only at station 2. They comprised .07% (8.0/m^2) of the mean seasonal numbers and .08% (.0013gm/m^2) of the mean seasonal standing crop for all stations. Distinguishing characteristics of the genus Polypedilum included an even number of teeth, usually 16, and short first lateral teeth (Figure 6F) on the labial plate (Mason, 1973).

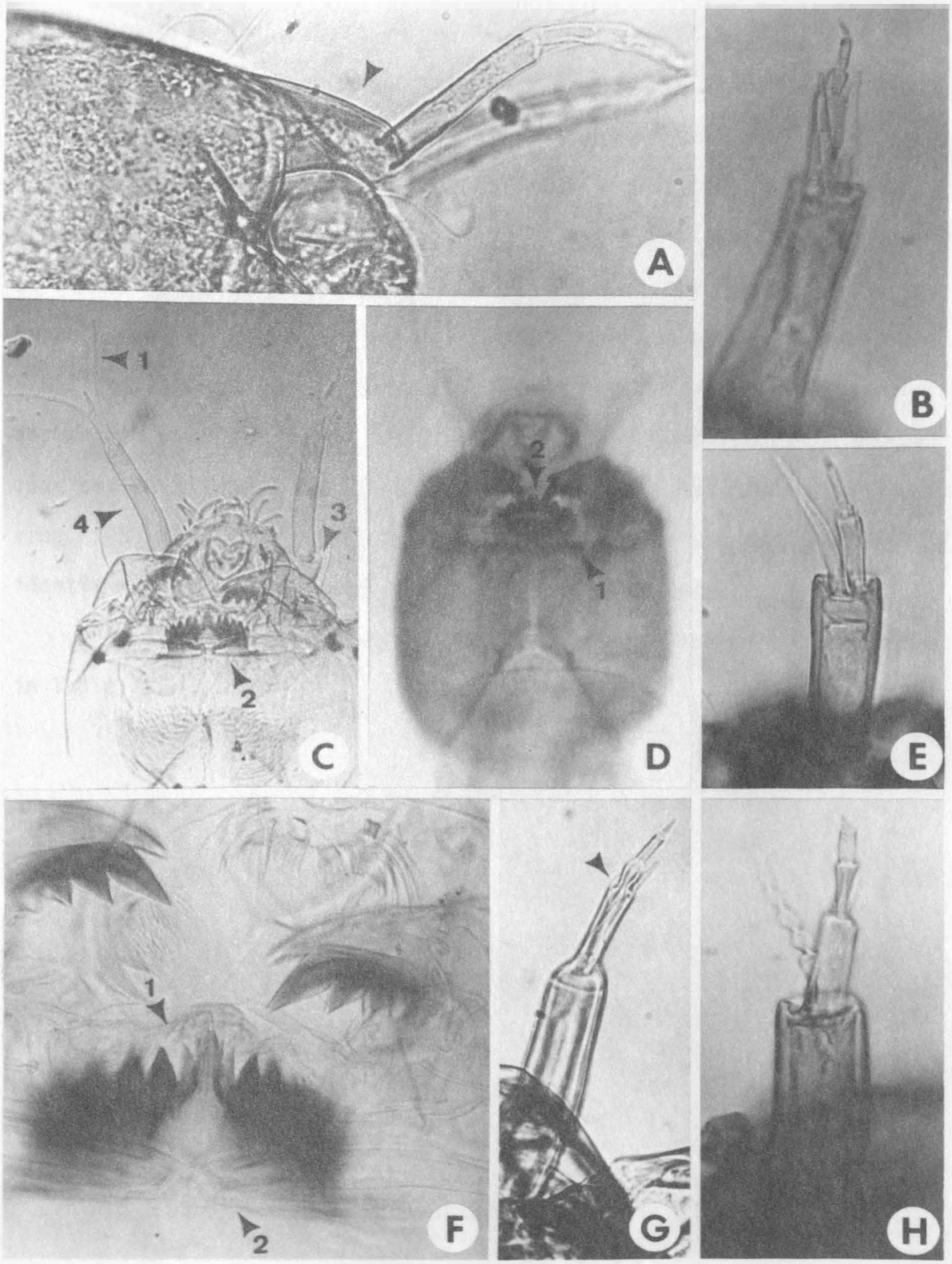
Several specimens that represented the tribe chironomini were collected and could not be identified. They represented only .02% (2.4/m^2) of the mean seasonal numbers and .01% (.0001gm/m^2) of the mean seasonal standing crop for all stations.

Representatives of the tribe Tanytarsini were collected from all stations but were most abundant at station 2. They comprised 1.99% (243.8/m^2) of the mean seasonal numbers and 1.25% (.0197gm/m^2) of the mean seasonal standing crop for all stations. The Tanytarsini are distinguished by prominent antennal tubercles (Figure 7A), which are longer than they are wide and a long curved first antennal segment (Figure 7C).

Two genera of the tribe Tanytarsini were collected. They were Calopsectra and Paratanytarsus. Calopsectra is distinguished by wide and short paralabial plates which nearly touch at the midline of the head capsule (Figure 7C). The petiole of the lauterborn organs is longer than the last three antennal segments and the antennal tubercle lacks a spur (Figure 7C) (Bryce and Hobart, 1972).

Paratanytarsus also has wide and short paralabial plates which

Figure 7. (A) Calopsectra, antennal tubercle x 400; (B) Parachironomus species "A" antenna x 400; (C) Calopsectra, 1. petiole of the lauterborn organ, 2. paralabial plates, 3. antennal tubercle, 4. first antennal segment x 100; (D) Paratanytarsus, headcapsule with 1. paralabial combs, 2. labial plate x 100; (E) Polypedilum, antenna x 400; (F) Calopsectra 1. labial plate, 2, paralabial combs x 400; (G) Paratanytarsus antenna with lauterborn organ x 400; (H) Parachironomus species "B", antenna x 400.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nearly touch at the midline of the head capsule (Figure 7D). The lauterborn organs are sessile on the tip of the second antennal segment (Figure 7G) (Bryce and Hobart, 1972).

Chironomid pupae were collected from all stations. They appeared in two distinct size classes. Large pupae were believed to be mostly Chironomus attenuatus because of their large size. Large pupae comprised .10% (12.4/m^2) of the mean seasonal numbers and .78% (.0121gm/m^2) of the mean seasonal standing crop. Smaller pupae were assumed to be harnischia. Small pupae comprised .68% (83.7/m^2) of the mean seasonal numbers and .85% (.0133gm/m^2) of the mean seasonal standing crop. Chaoborus pupae and those of the Tanypodinae could be readily identified to genus and were included with those groups.

A list of taxa that were collected from Lake Cochrane is presented in Table 1.

Table 1. Taxa of benthos collected from Lake Cochrane, South Dakota

- Phylum Nematoda
- Phylum Annelida
  - Class Oligochaeta
    - Family Tubificidae
  - Class Hirudinea
- Phylum Mollusca
  - Class Gastropoda
    - Family Physidae
      - *Physa* sp.
    - Family Planorbidae
      - *Gyraulus* sp.
- Phylum Arthropoda
  - Class Crustacea
    - Order Cladocera
      - Family Daphnidae
        - *Daphnia* sp.
        - *Ceriodaphnia* sp.
      - Family Chydoridae
    - Order Copepoda
      - Suborder Calanoida
        - *Diaptomus*
      - Suborder Cyclopoida
        - *Cyclops*
    - Order Ostracoda
    - Order Amphipoda
      - Family Tultridae
        - *Hyella azteca*
  - Class Arachnoidea
    - Order Hydracarina
      - Family Hydrachnidae
        - *Hydrachna* sp.
      - Family Limnesiidae
  - Class Insecta
    - Order Ephemeroptera
      - Family Caenidae
        - *Caenis* sp.
    - Order Trichoptera
      - Family Hydroptilidae
        - *Hydroptillia* sp.
        - *Orthotrichia* sp.
      - Family Brachycentridae
        - *Micrasema rusticum*
    - Order Diptera
      - Family Chaoboridae
        - *Chaoborus punctipennis*
      - Family Ceratopogonidae
      - Family Chironomidae
        - Subfamily Tanypodinae
          - Tribe Tanypodini
            - *Tanypus* sp.
          - Tribe Pentaneurini
          - Tribe Macropelopiini
            - *Procladius* spp.
            - *Psectrotanypus* sp.
            - Unknown genus
        - Subfamily Chironominae
          - Tribe Chironomini
            - *Chironomus plumosus*
            - *Chironomus attenuatus*
            - *Cryptochironomus* "defectus" group
            - *Cryptochironomus* "harnischia" group
            - *Parachironomus* spp.
            - *Polypedilum* sp.
          - Tribe Tanytarsini
            - *Calopsectra* sp.
            - *Paratanytarsus* sp.

B. Comparison of Benthos Between Stations

A least-squares analysis of variance of the most numerous benthic organisms indicated that each of the stations studied were significantly different from each other in terms of the numbers of various organisms present and standing crop (gm/m^2) present. The numerical abundance of most organisms changed significantly from date to date (Table 2). Two that did not, *Caenis* and Tubificidae, were present in very low numbers and the standard sampling technique used probably did not give a representative sample for rare species. The numerical abundance of all groups except Tubificidae and large pupae showed significant differences between stations (Table 2). All standing crop determinations on individual samples showed significant differences between dates and stations.

Those groups that showed a significant date by station interaction were significantly different by date and by station but were not consistent in the way they varied. In a least-squares analysis stations are viewed as treatments. In a laboratory experiment one would expect one treatment to always be higher or lower than another. If they were not and a significant interaction was present one would conclude that something that was not being considered was affecting the outcome. In population sampling date by station interaction may be a natural result of the seasonal fluctuations in the population as affected by migration behavior. Migration includes the movement of organisms from one area to another to seek more favorable conditions. It can also mean the decline of populations in one area due to emergence and the

Table 2. Analysis of variance between stations and sampling dates

ANOVA						
				F		
Variable	DF	Date	DF	Station	DF	DxS Interaction
Chaoborus #/m^2	11	12.994***	2	93.66 ***	22	5.169***
Chaoborus gm/m^2	11	12.391***	2	32.089***	19	4.285***
Harnischia #/m^2	11	14.913***	2	60.01 ***	22	4.351***
Harnischia gm/m^2	8	35.503***	2	229.59 ***	11	8.739***
Chironomus #/m^2	11	14.763***	2	54.18 ***	22	9.245***
Chironomus gm/m^2	11	60.977***	2	30.54 ***	18	17.514***
Procladius #/m^2	11	13.648***	2	239.94 ***	22	5.233***
Procladius gm/m^2	4	18.773***	2	45.08 ***	4	12.021***
Tanytarsini #/m^2	11	5.653***	2	22.71 ***	22	5.065***
Ceratopogonidae #/m^2	11	2.143*	2	36.07 ***	22	1.492n.s.
Caenis #/m^2	11	1.944n.s.	2	5.02 ***	22	.948n.s.
Tubificidae #/m^2	11	1.064n.s.	2	3.88n.s.	22	1.627n.s.
Large pupae #/m^2	11	13.162***	2	.95n.s.	22	1.737n.s.
Small pupae #/m^2	11	8.457***	2	26.91 ***	22	1.128n.s.
Total Benthos #/m^2	11	10.734***	2	12.65 **	22	6.390***

*indicates significance at .05
**indicates significance at .01
***indicates significance at .001

growth of populations in other areas where eggs have been deposited. Therefore, a significant date by station interaction may be a reflection of the dynamic nature of the system and not an indication that estimates of the population are invalid.

Since significant differences existed between stations, each station will be discussed separately.

1. Station 1

Station 1 had the highest mean seasonal numbers (13,630.6/m^2) and mean seasonal standing crop (2.1227gm/m^2) for total macrobenthos. The lowest numbers were observed on May 5th (8,053/m^2). The lowest standing crop was observed on July 16th (.5935gm/m^2). From July 16th until December a steady rise in both numbers and weights was observed until the maximum numbers (29,516/m^2) and standing crops (6.6705gm/m^2) were reached on December 10th (Figure 8).

Chaoborus punctipennis was the most numerically important benthic group at station 1 with 47.1% (6408.8/m^2) of the mean seasonal numbers. Harnischia and Chironomus attenuatus were the next most abundant groups with 33.1% (4514.5/m^2) and 16.5% (2245.9/m^2) of the mean seasonal numbers respectively. Chironomus was the most gravimetrically important benthic group with 54.5% (1.1561gm/m^2) of the mean seasonal standing crop. Chaoborus and harnischia followed with 29.3% (.6213gm/m^2) and 12.0% (.2541gm/m^2) of the mean seasonal standing crop respectively (Figure 9). The term "gravimetrically" will be used when referring to the importance of a group in terms of standing crop (gm/m^2).

The mud at station 1 contained 4.3% organic matter (Table 3).

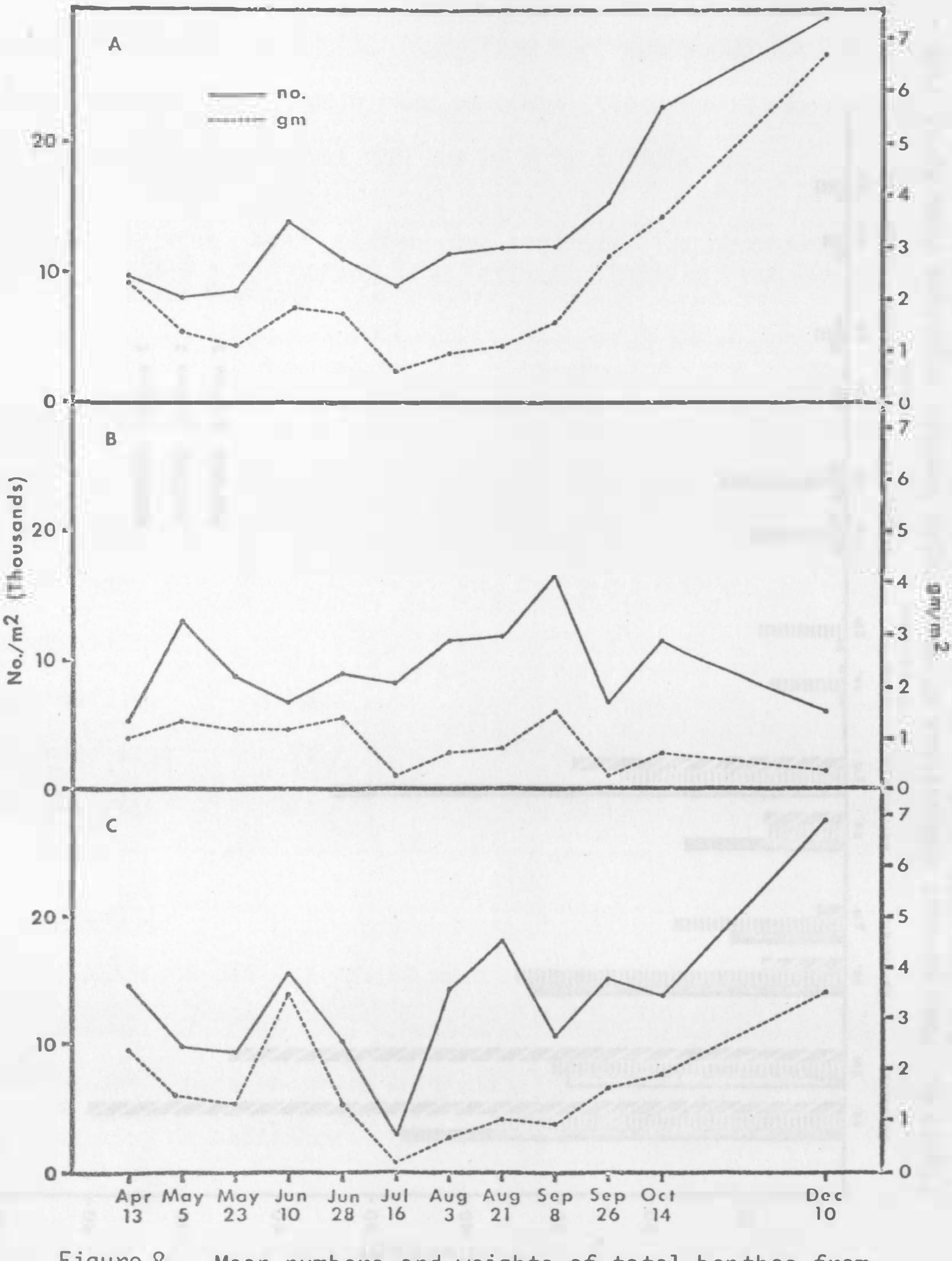

Figure 8. Mean numbers and weights of total benthos from three stations in Lake Cochrane, South Dakota

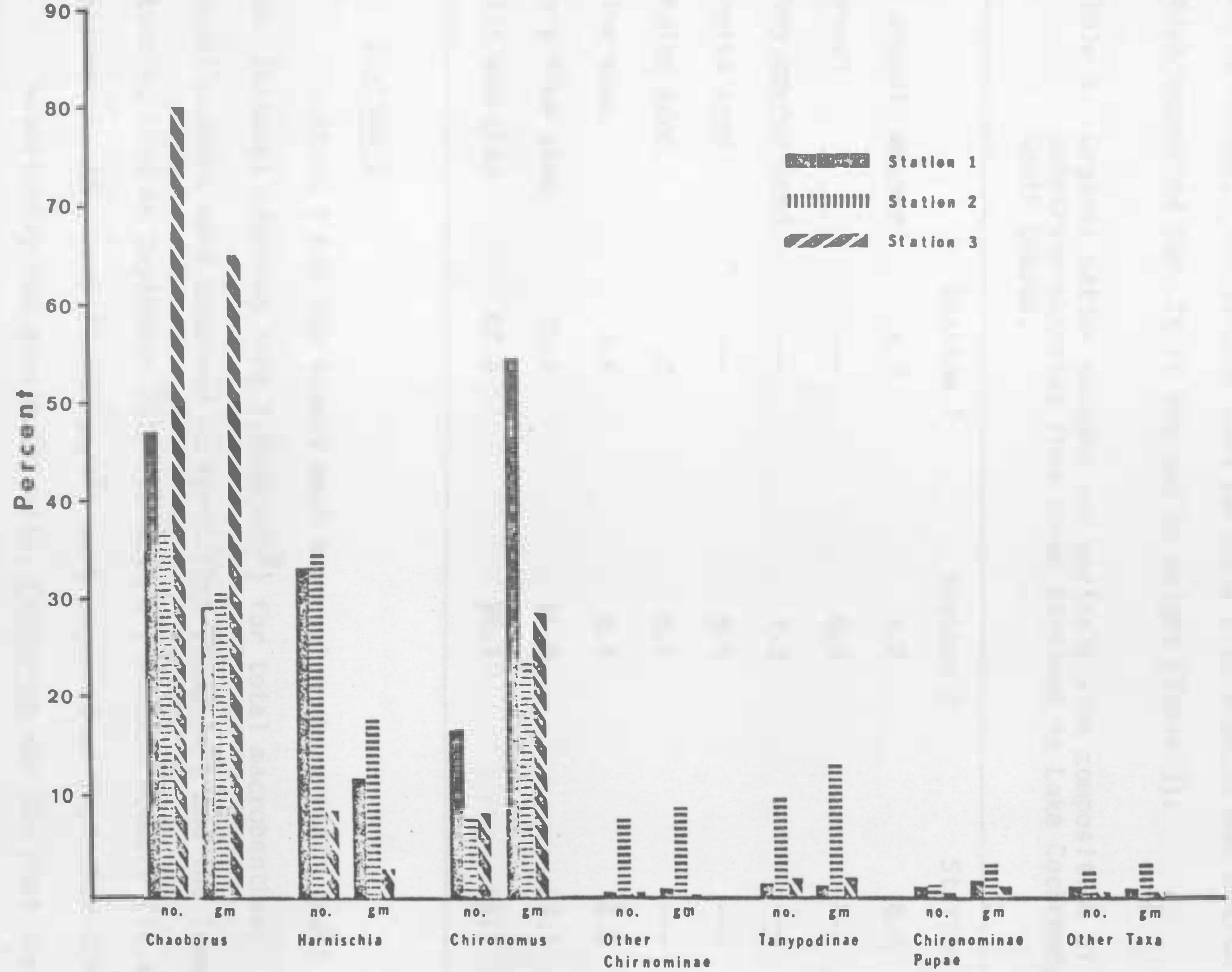

Figure 9. Mean percent composition of macroscopic benthic organisms from April 1976 - December 1976 at three stations in Lake Cochrane, South Dakota

Mechanical analysis of the mud indicated that silt and clay formed the largest fraction with 62.6%. Very fine sand accounted for 30.1% of the mud by weight. The largest sand particle size present was medium sand, which accounted for .2% of the mud by weight (Table 3).

Table 3. Organic matter content and particle size composition of substrate material from three stations in Lake Cochrane, South Dakota.

	Station 1	Station 2	Station 3
% organic matter	4.3	4.2	8.0
Gravel	---	8.8	---
Very course sand	---	1.3	---
Course sand	---	5.0	---
Medium sand	.2	6.1	---
Fine sand	3.6	8.5	2.2
Very fine sand	29.2	31.0	24.1
Silt and clay	62.6	35.1	65.7

2. Station 2

Station 2 had the lowest mean seasonal numbers (9618.1/m^2) and mean seasonal standing crop (.8858gm/m^2) for total macrobenthos. The lowest numbers were observed on April 13th (5,386/m^2) and the lowest standing crop on September 26th (.2480gm/m^2) Maximum numbers (16,475/m^2) and maximum standing crop (1.5081gm/m^2) were observed on September 8th (Figure 8).

Numerically and gravimetrically, *Chaoborus* was the most important group at station 2 with 36.7% (3527.8/m^2) of the mean numbers and 30.7%

(.2717gm/m^2) of the mean standing crop. Several other groups formed a significant part of the benthic community at station 2. They were, in order of importance numerically, harnischia 34.6% (3326.5/m^2), Tanypodinae 9.7% (941.4/m^2), Chironomus 7.8% (750.0/m^2) and other Chironominae 7.7% (742.3/m^2). Gravimetrically Chironomus was second in importance with 23.5% (.2083gm/m^2). The less abundant taxa were much more abundant at station 2 than at the other stations (Figure 9).

The mud at station 2 contained 4.2% organic matter (Table 3). Mechanical analysis of the mud indicated that silt and clay formed the largest fraction but accounted for only 35.1% of the mud by weight. Sand of different sizes was more important at station 2 than it was at the other stations. The largest particles present were gravel which formed 8.8% of the mud by weight (Table 3).

3. Station 3

Station 3 had seasonal means nearly as high as station 1 with numbers of 13,451.7/m^2 and a standing crop of 1.6743gm/m^2. The benthos reached a seasonal low on July 16th with numbers of 8,205/m^2 and a standing crop of .2800gm/m^2. There was a gradual increase in standing crop and numbers until maximum standing crop (3.5098gm/m^2) and numbers (27,581/m^2) were reached on December 10th (Figure 8).

Chaoborus dominated the benthos at station 3 with 80.1% (10.780.8/m^2) of the mean seasonal numbers and 65.1% (1.0898gm/m^2) of the mean seasonal standing crop. Chironomus and harnischia were the next highest in both numbers and standing crop. They accounted for 8.5% (1144.3/m^2) and 8.6% (1161.2/m^2) of the mean seasonal numbers, respectively, and 28.75%

(.4797gm/m^2) and 2.9% (.0486gm/m^2) of the mean seasonal standing crop, respectively (Figure 9).

The mud at station 3 contained 8.0% organic matter (Table 3). Mechanical analysis of the mud indicated that silt and clay formed the largest fraction with 65.7%. Very fine sand accounted for 24.1% of the mud by weight. The largest sand particle size present was fine sand which formed 2.2% of the mud by weight (Table 3).

C. Benthos of the Entire Lake Bottom

In a discussion of the entire lake bottom as represented by the three combined stations two limitations concerning the accuracy of an estimate of the total macrobenthos must be recognized. 1) As previously mentioned the inshore benthos was not studied and is not represented in the estimate. 2) The area of the substrate types represented by each station is not equal and is not known. Because of this, the result is not a weighted mean but is instead a biased estimate based on an arithmetic mean.

Even with the above limitations the estimate is the best that is available. It is of use in putting the major taxonomic groups into perspective and in comparing Lake Cochrane with other lakes.

Chaoborus had the highest numbers and standing crop for all stations combined, with 56.5% (6905.8/m^2) of the mean seasonal numbers and 42.3% (.6609gm/m^2) of the mean seasonal standing crop. Chironomus had a relatively low 11.3% (1380.1/m^2) of the mean seasonal numbers but was second gravimetrically with 39.4% (6147gm/m^2) of the mean seasonal standing crop. Harnischia was second numerically with 24.5% (3000.7/m^2)

of the mean seasonal numbers. Gravimetrically harnischia was third with 9.8% (.1528gm/m^2) of the mean seasonal standing crop (Figure 10).

Members of the Tanypodinae (*Tanypus*, Pentaneurini, *Procladius*, *Psectrotanypus* and an unknown genus) and other Chironominae (Tanytarsini, *Parachironomus* spp., *Polypedilum*, *Cryptochironomus* and unidentified Chironomini) were next highest in both numbers and standing crop. Tanypodinae accounted for 3.7% (446.0/m^2) and other Chironominae 2.2% (272.7/m^2) in mean seasonan numbers respectively and 3.6% (.0565gm/m^2) and 2.1% (.0328gm/m^2) of the mean seasonal standing crop respectively (Figure 10).

The mean seasonal standing crop for all macrobenthic organisms in Lake Cochrane was 1.5609gm/m^2. The mean seasonal density of organisms was 12,233/m^2. These calculations may underestimate the annual standing crop since standing crops in many lakes reach a summer minimum and are typically high in winter months and early spring (Sublette, 1957). Samples taken in the summer show a minimum in standing crop occurring on July 16th. The one winter sample taken in Lake Cochrane seems to indicate that winter standing crops are high in Lake Cochrane (Figure 11). If the months that were not sampled had been included the estimate of standing crop may have been higher.

D. Comparison with Other Lakes

The standing crop of benthos in Lake Cochrane is low when compared to seasonal marshes in South Dakota (Donaldson, 1976) or to Lake Mendota (Juday, 1921), Linsley Pond (Deevey, 1941) or Lake Itasca (Cole and Underhill, 1965); however, it is comparable to many other lakes in

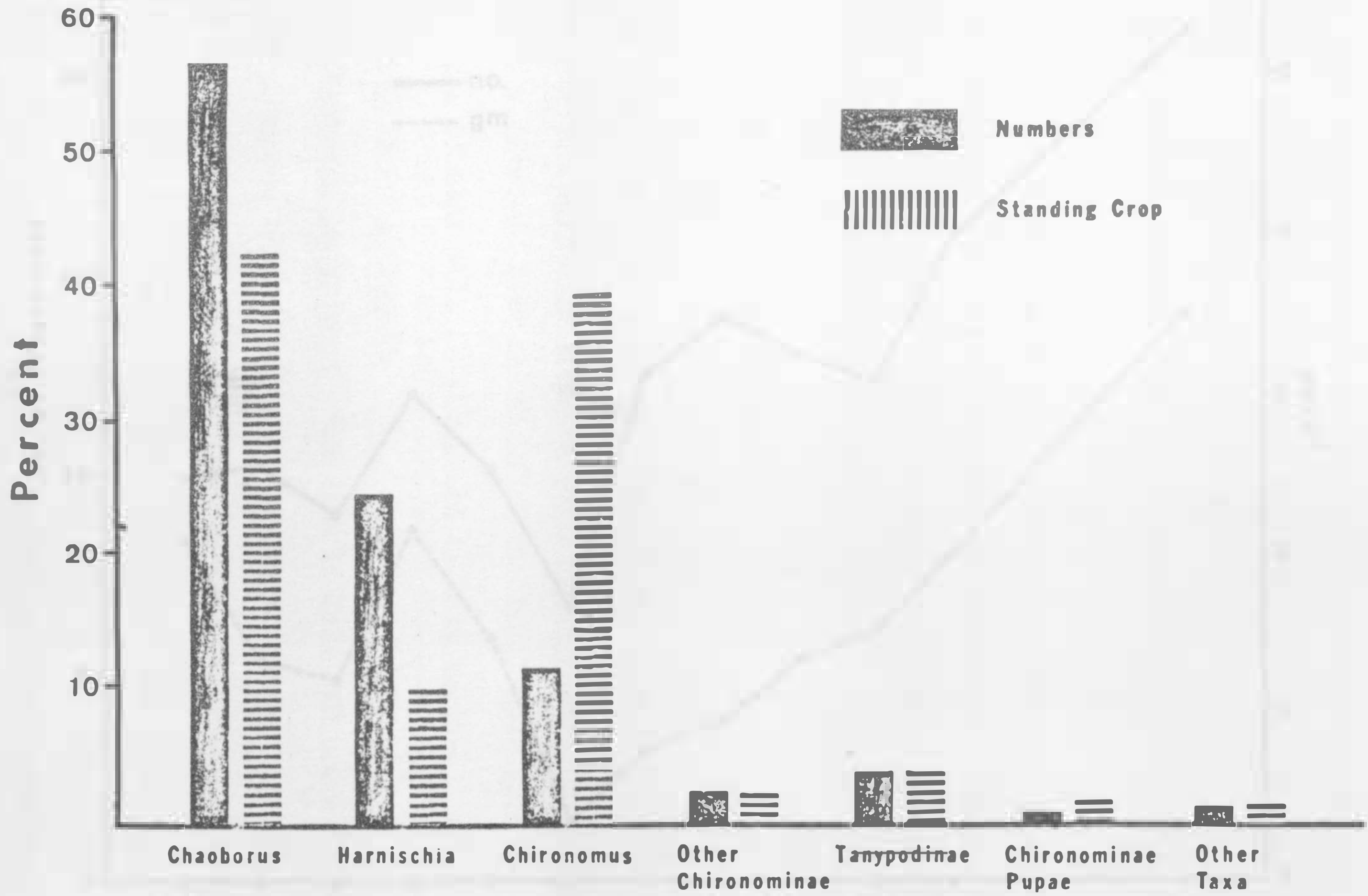

Figure 10. Mean percent composition of macroscopic benthic organisms from April 1976 - December 1976 over entire lake bottom on Lake Cochrane, South Dakota

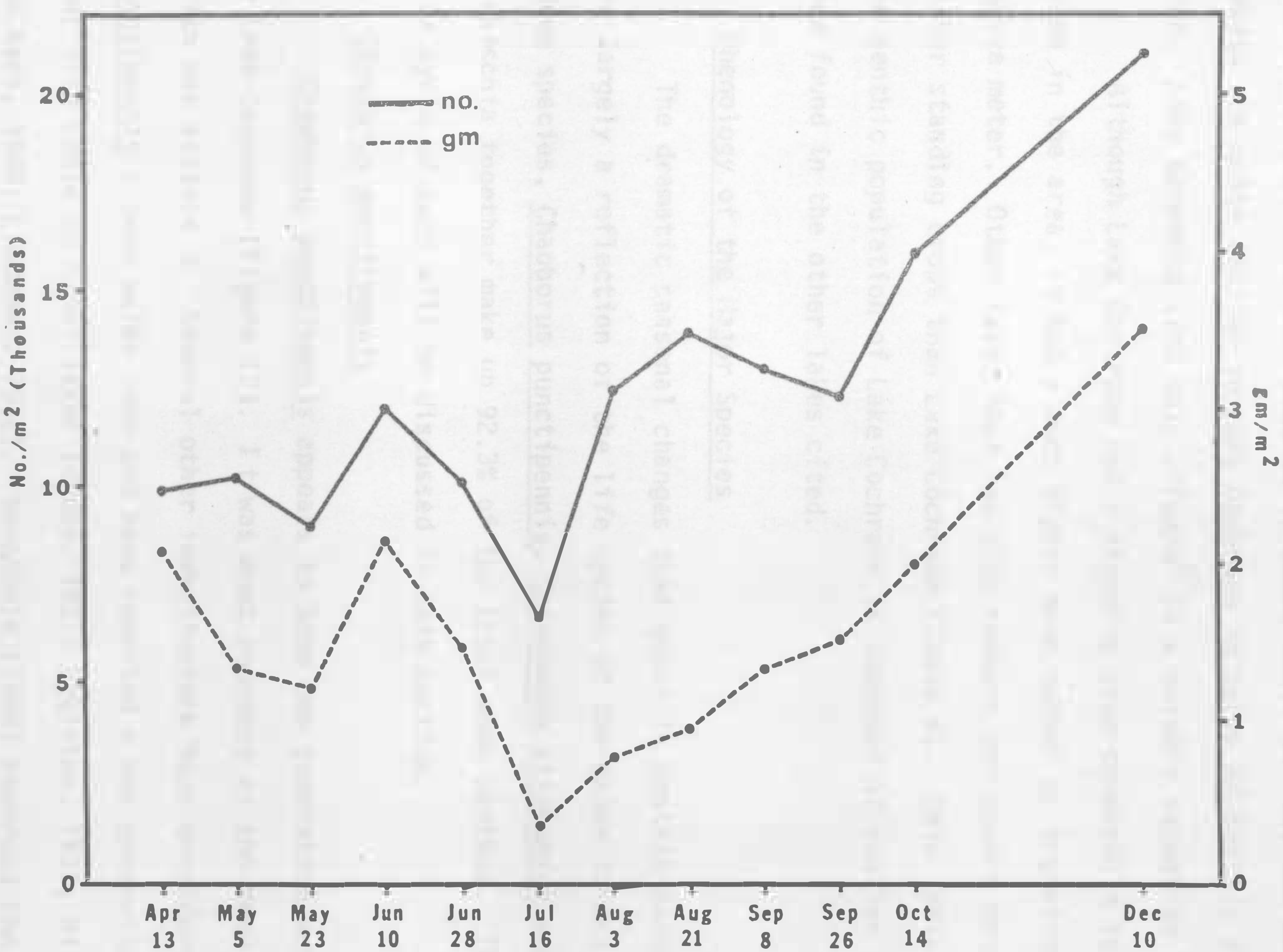

Figure 11. Mean monthly numbers and weights of macroscopic benthos in Lake Cochrane from April 13 to December 10th

the United States (Table 4). For example, 18 lakes other than Linsley Pond in Connecticut had a mean standing crop of 1.6gm/m^2 (Deevey, 1941). Also lakes that have been studied in Iowa, South Dakota, and North Dakota are quite similar to Lake Cochrane in terms of benthic standing crop. Lake Kampeska with only .17gm/m^2 is a notable exception (Table 4).

Although Lake Cochrane had a standing crop comparable to many lakes in the area, it had a much higher mean number of organisms per square meter. Other lakes that had high numbers per square meter had higher standing crops than Lake Cochrane (Table 4). This indicates that the benthic population of Lake Cochrane is composed of smaller organisms than found in the other lakes cited.

E. Phenology of the Major Species

The dramatic seasonal changes that occur in benthic associations are largely a reflection of the life cycles of the major insect species. Three species, Chaoborus punctipennis, Chironomus attenuatus and harnischia together make up 92.3% of the total mean benthos. The life cycle of each will be discussed in this section.

1. Chaoborus punctipennis

Chaoborus punctipennis appears to have one generation per year in Lake Cochrane (Figure 12). I t was most abundant at the deep station, which was station 3. Several other investigators have considered C. punctipennis a deep water form and have reported a one generation per year life cycle in other lakes (Juday, 1921; Eggleton, 1931; Hilsenhoff and Narf, 1968; Lindeman, 1942). Heuschele (1969) reported the occurrance of two generations per year in Pickerel Slough a shallow, oxbow lake in Minnesota.

Table 4. Dry weights and numerical abundance of benthos in selected lakes within the United States.

Lake	gm/m^2	$\#/m^2$	Length of Study	Source
Bothwell Marsh, SD	10.0	14,060	April - June	Donaldson (1976)
Mendota, WI	7.7	----	three years	Juday (1921)
Lund Marsh, SD	7.3	17,370	May - June	Donaldson (1976)
Linsley Pond, CT	5.2*	18,936	One Year	Deevey (1941)
Itasca, MN	4.5	1,517	One Series (July)	Cole & Underhill (1965)
18 Lakes, CT	1.6*	7,817	One Series/Lake (Summer)	Deevey (1941)
Cochrane, SD	1.5	12,233	April - December	Present Study
Lizzard, IA	1.4	3,819	July - October	Tebo (1955)
Poinsett, SD	1.3	1,303	One Year	Smith (1971)
Astabula, ND	1.1*	2,126	April - August	Pterka (1972)
Texoma, TX and OK	.9*	----	One Year	Sublette (1957)
Clear, IA	.86	----	June - September	Mrachek & Bachman (1967)
Okoboji (Millers Bay), IA	.78*	3,041	One Series (Summer)	Clampitt et al. (1960)
Kampeska, SD	.17	1,178	One Year	Hartung (1968)

*The value was derived by calculation from wet weight

The mean weight of individual larvae rose sharply in early spring until a peak was reached on June 10th (Figure 13A). Emergence as evidenced by the presence of pupae began at the same time and continued until August 21st (Figure 12D). The peak emergence period was followed by a large increase in third instar larvae (Figure 12A, B, C) which caused the mean weight of individuals to drop to a minimum on July 16th (Figure 13A). On June 28th and July 16th it appeared that the fourth instar group was made up of both overwintering larvae and larvae that had hatched in the spring. It appears the first three instars are short and C. punctipennis spends most of its life cycle in the fourth instar.

Large fluctuations in the mean number of C. punctipennis occurred in the fall and early spring (Figure 12A, B, C). These changes might be attributed to either emergence, reproduction or to the motility of the larvae. Emergence is probably not the only cause since a drop in the population of fourth instar larvae in the early spring at station 3, for example, occurs at a time when no pupae are present (Figure 12C, D). Reproduction, likewise, cannot explain the rise in the population on June 10th as the rise was occurring at a time when mean individual larval weight had reached a peak (Figure 13A). If the population increase at this time had been the result of reproduction, a decrease in the mean individual larval weight would have been expected. Likewise, fluctuations in the fall are not accompanied by pupal formation and emergence, (Figure 12A, B, C) nor do they occur during a time of decreased mean larval weight (Figure 13A). Deevey (1941) observed similar phenomena in Linsley Pond and considered it to be the result of the migratory habit of the larvae.

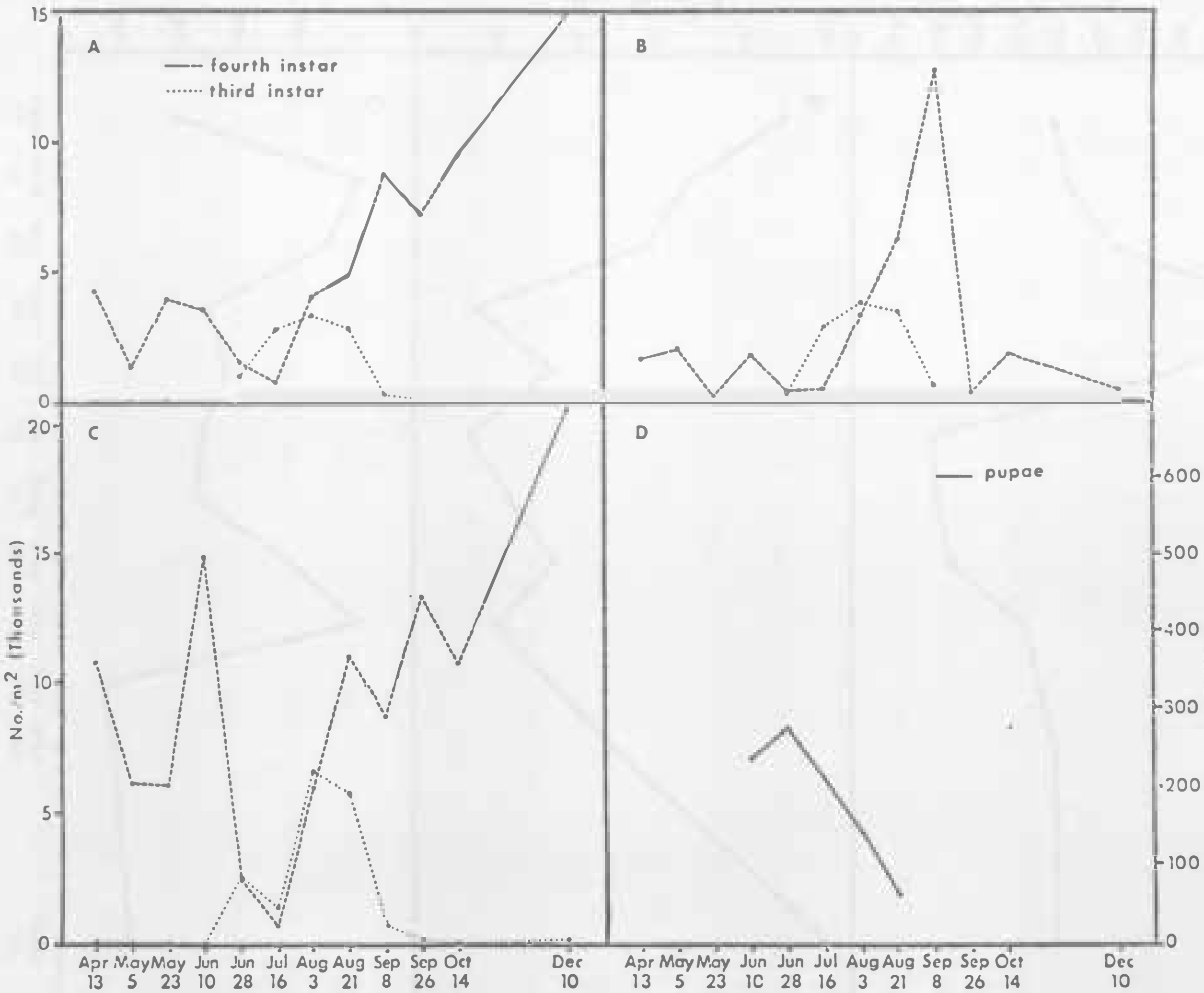

Figure 12. Seasonal variations in Chaoborus punctipennis populations, (A) Station 1; (B) Station 2; (C) Station 3; (D) Mean pupal numbers from all stations

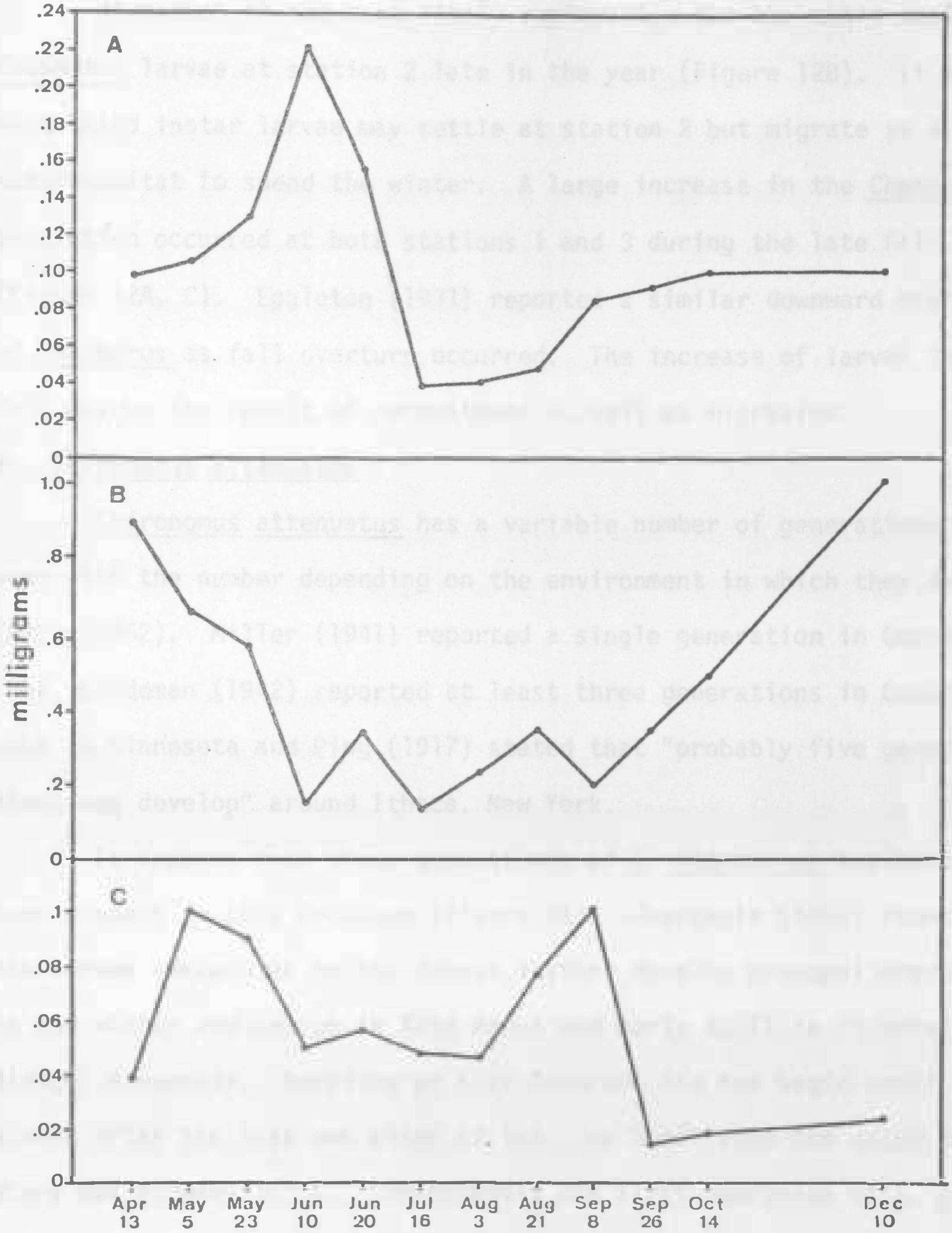

Figure 13. Mean individual larval weights of (A) Chaoborus punctipennis; (B) Chironomus attenuatus; (C) Harnischia.

Migration is the most likely explanation for the sharp decline in Chaoborus larvae at station 2 late in the year (Figure 12B). It appears that third instar larvae may settle at station 2 but migrate to a deeper water habitat to spend the winter. A large increase in the Chaoborus population occurred at both stations 1 and 3 during the late fall (Figure 12A, C). Eggleton (1931) reported a similar downward migration of Chaoborus as fall overturn occurred. The increase of larvae in the fall may be the result of recruitment as well as migration.

2. Chironomus attenuatus

Chironomus attenuatus has a variable number of generations per year with the number depending on the environment in which they develop (Darby 1962). Miller (1941) reported a single generation in Costello Lake, Lindeman (1942) reported at least three generations in Cedar Bog Lake in Minnesota and Ping (1917) stated that "probably five generations may develop" around Ithaca, New York.

It appears that three generations of C. attenuatus may have been present in Lake Cochrane (Figure 14). Heuschele (1969) found that the larvae overwinter in the fourth instar, develop prepupal characters in the winter and emerge in late March and early April in Pickerel Slough, Minnesota. Sampling at Lake Cochrane did not begin until over a week after the lake was clear of ice. On April 13th the water temperature was already 10° C. Consequently the first emergence of C. attenuatus may have been missed. Larval populations decreased sharply in April and May indicating either emergence or heavy mortality (Figure 14A, B, C). Pupae were not collected on April 13th but they were present on May 5th (Figure 14D). This pupation may represent the first emergence

of the season if an emergence had not occurred before sampling began.

Recruitment of offspring from the May emergence caused a population peak on June 10th at stations 1 and 2 (Figure 14A, B). A peak at station 3 was not observed until June 28th (Figure 14C). The presence of many small larvae caused a minimum to occur in the mean individual larval weight on June 10th (Figure 13B).

Life history curves during the summer months are hard to interpret because of rapid growth and development of the larvae during this time. Ping (1917) found that at 18° to 19° C, C. attenuatus larvae emerged 32 days after hatching from the eggs. The temperature of the water in Lake Cochrane ranged from 20° to 24° C from June 10th to September 8th. Assuming that adequate food was available to the larvae, major population changes would have been occurring between sampling dates that were not detected.

Based on the presence of pupae, an emergence was occurring in late June (Figure 14D). When sampled on July 16th, fourth instar larval numbers were very low at all stations (Figure 14A, B, C). Mean weight of individual larvae was also at a low point on July 16th (Figure 13B). This indicates almost complete emergence of the offspring from the spring reproductive period by July 16th.

Pupae were again collected on August 21st and on September 8th (Figure 14D). Another mimimum in the mean weight of individual larvae occurred on September 8th (Figure 13B). This may indicate both a loss of large fourth instar larvae and the presence of third and small fourth instar larvae.

The fall emergence that occurred seems to represent only part of

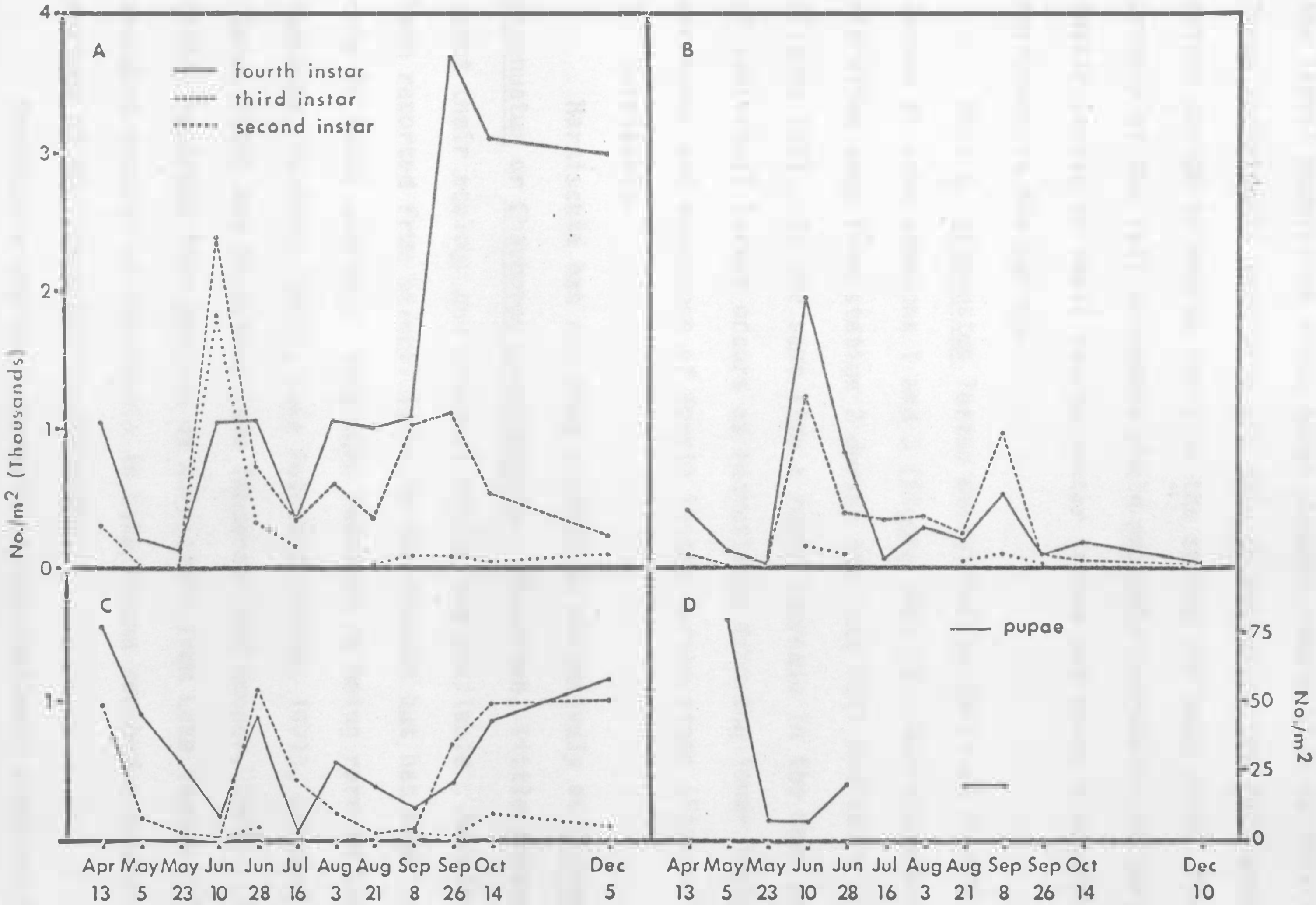

Figure 14. Seasonal variations in <u>Chironomus attenuatus</u> populations, (A) Station 1; (B) Station 2; (C) Station 3; (D) Mean pupal numbers from all stations

the larval population since total numbers remain high at this time. Those individuals that were not able to emerge in the fall would be mature enough to emerge early in the spring the next year. The progeny of the fall emergence would probably overwinter as large third instar larvae or small fourth instar larvae and cause a second late emergence in the spring.

Most C. attenuatus larvae overwinter as third or fourth instar larvae at both stations 1 and 3 (Figure 14A, C). There appears to be a migration away from station 2 during the late fall and early winter (Figure 14B). At the same time a rapid increase in the mean weight of individual larvae occurs as recruitment from the lower instars decreases and emergence of fourth instar larvae stops (Figure 13B).

3. Harnischia

Harnischia has not been studied as extensively as Chironomus attenuatus or Chaoborus punctipennis. Therefore, little information about their ecology and seasonal habits are available. Harnischia has been reported from several lakes in the Midwest but has been found only in small numbers. They were reported as being rare in Lake Kampeska (Hartung, 1968), Lake Poinsett (Smith, 1971), Lizzard Lake (Tebo, 1955) and Sugarloaf Lake (Anderson and Hooper, 1965). Sublette (1957) reported four species of harnischia from Lake Texoma. The most abundant species of harnischia in Lake Texoma reached a seasonal maximum of 80 larvae per square meter.

Harnischia was most abundant at the shallower stations 1 and 2 in Lake Cochrane but had low numbers throughout most of the study at

station 3 (Figure 15). Harnischia appears to have at least three generations per year in Lake Cochrane. Many of the larvae spend the winter in the third instar. It is not known how many larvae spend the winter in the second instar since they were not retained quantitatively in the samples. The larvae require growth and development prior to emergence. This is indicated by a rise in the mean weight of individual larvae between April 13th and May 5th (Figure 13C). After the first emergence fourth instar numbers dropped to near zero at stations 2 and 3 (Figure 15B, C) but remained high at station 1 (Figure 15A). The fourth instar larvae that were present were small as shown by the low mean larval weight. This may indicate recruitment from larvae that had hatched earlier resulting in the overlap of generations.

As with C. attenuatus large population changes may be occurring between sampling dates and are therefore not detected. The length of each stadium in the harnischia life cycle is not known, however. Low numbers of third instar larvae and relatively high numbers of fourth instar larvae during the warmer months may indicate that the third stadium is short. The reasoning is that the less time spent in a particular instar the smaller the portion of the population that will be made up by that instar. Low numbers of third instar larvae could also indicate that they were not sampled quantitatively; however, large numbers collected in the Fall would suggest that they were retained quantitatively. Further evidence of a short third instar is that large populations of third instar larvae do not occur until after development to the fourth instar stops in the Fall (Figure 15A, B, C).

Although the presence of pupae is continuous throughout the summer, the peak on June 28th indicated that a second major emergence was occurring (Figure 15D). It seems likely that this was the beginning of the emergence since fourth instar numbers were high at all stations on June 28th and then decreased over the next few sampling dates (Figure 15A, B, C). The numbers of pupae also declined during the same period until they reached a low on August 3rd (Figure 15D). Mean individual larval weight did not reach a very large peak at the beginning of the second emergence as would be expected when large numbers of mature larvae are present (Figure 13C). This indicates the presence of many small larvae which is further evidence of overlapping generations.

Large numbers of pupae were again collected on August 21st and September 8th (Figure 15D). The individuals emerging at this time are probably the first offspring from the emergence that began on June 28th. On September 8th, the last date that pupae were collected, larval weight had reached a maximum, indicating that the larvae that were present were mostly mature larvae in the fourth instar (Figure 13C).

After September 8th large numbers of third instar larvae began to appear. As winter approaches the larvae apparently develop to the third instar and then stop development. Numbers of larvae that over-winter in the first two instars is not known since they were too small to be retained in the samples. The larvae spend at least part of the winter in an inactive state. Specimens taken in December were found to be enclosed in tight fitting cases that had both ends sealed. The posterior end of each larvae was doubled back on itself with the

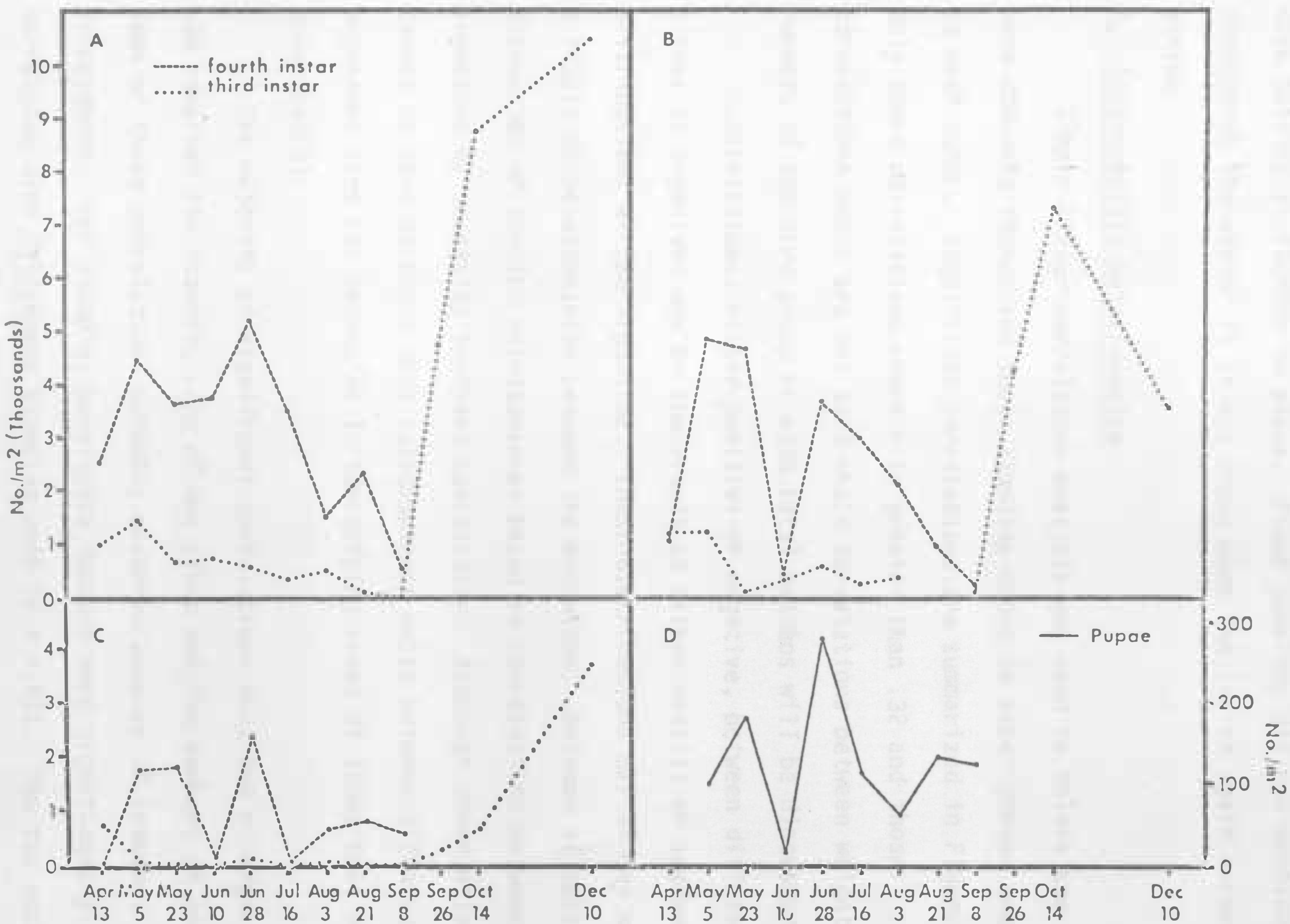

Figure 15. Seasonal variations in harnischia populations, (A) Station 1; (B) Station 2; (C) Station 3; (D) Mean pupal numbers from all stations

case holding it tightly in place. Since sampling did not continue throughout the winter it is not known when the larvae again became active.

F. Interspecific Relationships

Simple linear correlation analysis was used to relate the more abundant faunas and their standing crops to other groups and to each other. Significant correlations are summarized in Figure 16. Only those correlations where r is greater than .32 and those correlations which are not part-whole correlations between weights and numbers of the same group or with total benthos will be discussed.

Correlations, either positive or negative, between different groups of organisms may be the result of either spatial or seasonal distributions of the organisms. These distributions may or may not be a result of relationships between the organisms. Because of this, any discussion of implied relationships based on correlations between organisms by necessity involves speculation. Although correlations cannot be used to prove that relationships exist between different organisms they can be useful in identifying areas of study that may prove useful.

The majority of significant correlations that had r larger than .32 involved the standing crop of one group and the numbers of another. Some of these correlations probably occurred because of seasonal coincidence. For example, harnischia numbers were significantly correlated with *Chironomus* standing crop (r = +.53). The two events are probably not related but because of their life cycles harnischia numbers happen to be high when *Chironomus* standing crop is high and low

when Chironomus standing crop is low. Other correlations that may be coincidental include harnischia standing crop with Tanytarsini numbers (r = +.40) with large pupae numbers (r = +.36) and with Chaoborus numbers (r = -.45).

A correlation with harnischia standing crop that does not seem to be coincidental involves a positive correlation with samll pupae (r = +.43). Since small pupae are assumed to be harnischia pupae they would be expected to appear most often when the larvae are mature and large in size.

One set of positive correlations involving Procladius standing crop and the numbers of several small organisms may represent predator-prey relationships. Procladius standing crop is positively correlated with Harnischia numbers (r = +.37), Tanytarsini numbers (r = +.71), Ceratopogonid numbers (r = +.48) and Tubificid numbers (r = +.33). This might indicate that when prey populations are high Procladius prospers, resulting in a high standing crop. No quantitative food habit analysis was included in this study but there was evidence from mounted specimens that Procladius preyed on both harnischia and members of the tribe Tanytarsini. Roback (1969, 1976) reported that Tubificid worms were frequently utilized by members of the Tanypodinae. Although the predator-prey relationship may exist, positive correlations may also have been a result of spacial distribution since all of the forms involved except harnischia are most abundant at station 2. In that case the positive correlations would represent similar environmental requirements for the groups involved.

Similar environmental requirements may also explain positive correlation between Procladius numbers and numbers of Tanytarsini (r = +.43), Procladius numbers and Caenis (r = .33) or Tanytarsini numbers and Ceratopogonid numbers (r - +.38). All of these groups are far more abundant at station 2 than at the other stations. Dissimilar environmental requirements may have resulted in the negative correlation between Procladius numbers and Chaoborus numbers since Chaoborus was most abundant at the deepest station (station 3) and Procladius was most abundant at the shallow station (station 2).

	Chaoborus punctipennis no./m²	*C. punctipennis* gm/m²	*Harnischia* no./m²	*Harnischia* gm/m²	*Chironomus attenuatus* no./m²	*C. attenuatus* no./m²	*Procladius* no./m²	*Procladius* gm/m²	Tanytarsini no./m²	Ceratopogonidae no./m²	*Caenis* no./m²	Tubificidae no./m²	large pupae no./m²	small pupae no./m²
C. punctipennis gm/m²	+.75***													
Harnischia no./m²	[illegible]													
Harnischia gm/m²	-.55***	-.26*	+.83***											
Chironomus attenuatus no./m²	+.18*	+.19*		-.26*										
C. attenuatus no./m²	+.29***	+.25***	+.53***	-.24*	+.60***									
Procladius no./m²	-.33***		+.31***		-.31***									
Procladius gm/m²			+.37*				+.94***							
Tanytarsini no./m²	-.25***	-.19*	+.23***	+.40***	-.23**	-.19*	+.43***	+.71***						
Ceratopogonidae no./m²							+.29***	+.48***	+.38***					
Caenis no./m²							+.33***							
Tubificidae no./m²					+.21*	+.18*		+.33*						
large pupae no./m²				+.36***										
small pupae no./m²	-.26**	-.29**		+.43***	-.20*	-.26**			+.19*					
total benthos no./m²	+.81***	+.65***	+.38***		+.42***	+.60***		+.33*						-.21*

Figure 16. Significant positive (+) or negative (-) correlations of numbers and standing crops of benthic organisms in Lake Cochrane, South Dakota

SUMMARY AND CONCLUSIONS

Benthos samples were collected from three stations in Lake Cochrane From April 1976 to December 1976. Analysis of variance showed that the stations differed from each other significantly in terms of the numbers of various organisms present and amount of standing crop; however, significant date by station interaction existed suggesting seasonal migration. Station 1 had the highest mean seasonal numbers (13,630.6/m^2) and mean seasonal standing crop (2.1227gm/m^2) for total macrobenthos. Station 2 had the lowest mean seasonal numbers (9618.1/m^2) and mean seasonal standing crop (.8858gm/m^2). Station 3 had seasonal means nearly as high as station 1 with numbers of 13,451.7/m^2 and a standing crop of 1.6743gm/m^2.

Three species dominated the benthos of Lake Cochrane and together made up 92.3% of the total numbers of benthos. They were in order of importance and numerically Chaoborus punctipennis (56.5%) harnischia (24.5%) and Chironomus attenuatus (11.3%) and gravimetrically C. punctipennis (42.3%), C. attenuatus (39.4%) and harnischia (9.8%).

The seasonal standing crop of benthic organisms in Lake Cochrane was 1.4609gm/m^2 and the seasonal density of organisms was 12,233/m^2. Benthos standing crops in Lake Cochrane are similar to other lakes in the area. The numerical density of organisms is much higher than other lakes with a similar standing crop, indicating a smaller average size per individual.

A study of the life cycles of the major species indicated that Chaoborus punctipennis had one generation per year, spent the winter

in the fourth instar and was most abundant at the deepest station. *Chironomus attenuatus* appears to have three generations with the fall emergence involving only part of the population. The majority of the larvae spend the winter in the fourth instar with greatest numbers at the station of the intermediate depth. Harnischia appears to have three generations per year. The larvae spend at least part of the winter in the third instar in an inactive state. They were most abundant at the station of intermediate depth but were also abundant at the shallower station.

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