AN INVESTIGATION OF THE NUMBER AND VOLUME OF AQUATIC INSECTS IN PONDS IN RELATION TO THE USE OF FERTILIZER

Thesis for the Degree of M. S.

MICHIGAN STATE COLLEGE

Dale Frank Bray

1949

This is to certify that the

thesis entitled

[illegible]

presented by

[illegible]

has been accepted towards fulfillment
of the requirements for

[illegible] degree in [illegible]

Ray Hutson
Major professor

Date [illegible]

AN INVESTIGATION OF THE NUMBER AND VOLUME OF AQUATIC INSECTS IN PONDS IN RELATION TO THE USE OF FERTILIZER

By

Dale Frank Bray

A THESIS

Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Department of Entomology

1949

ACKNOWLEDGMENTS

The writer wishes to express his thanks to Professor Ray Hutson for advice and guidance during the preparation of this thesis. Acknowledgment is also extended to Mr. Alan Stone of the U. S. National Museum for the determination of adult Chironomidae, and to Doctors Robert C. Ball and Peter I. Tack of the Michigan State College Zoology Department for their kindly suggestions.

Finally, grateful appreciation is extended to Professor Walter F. Morofsky, under whose encouragement and consideration this investigation was made possible. To him the writer is especially indebted.

TABLE OF CONTENTS

	PAGE
INTRODUCTION	1
LITERATURE REVIEW	2
OBJECTIVES	3
EQUIPMENT AND METHODS	4
Description of the ponds	4
Sampling of bottom fauna	6
Collecting terrestrial insects emerging from the ponds	7
Laboratory equipment and methods	8
NOMENCLATURE	12
A LIST OF INSECTS RECOVERED FROM BOTTOM SAMPLES FROM THE FERTILIZED AND UNFERTILIZED POND	13
TABLES 1 THROUGH 28	17 through 54
DISCUSSION	55
Numbers	57
Volumes	62
Seasonal variation in population	64
Key for identifying the larvae of Chironomidae found in the fertilized and unfertilized ponds under study	67
SUMMARY	69
BIBLIOGRAPHY	72
KEY TO PLATES	Plates No. 1 and 2

INTRODUCTION

During the summers of 1947 and 1948, at the Michigan State College Lake City Experiment Station, Lake City, Michigan, a detailed study was made upon the effect on aquatic insects of fertilizer application in experimental ponds.

Field work began on June 10, 1947, and was carried on through to September 20, 1947. Work was resumed on June 25, 1948 and concluded on September 10, 1948.

LITERATURE REVIEW

The use of fertilizer in the production of fish and fish foods in ponds has been practiced in various countries of Europe and Asia. This practice is not entirely new in the United States, but within the past decade it has become the subject of considerable study.

Extensive investigation on this problem has been carried on in the southern states, especially Alabama, Smith and Swingle (17, 18, 19), Swingle and Smith (27), Howell (6), and Swingle (21).

Tack and Morofsky (22) began an investigation of this problem in Michigan to determine if fertilizer, in a cooler climate, produced similar results to those in the south. They advanced the hypothesis that proper fertilizer will increase production of plankton, which in turn increases the numbers of insects (fish food).

In these past studies the insects were considered by families and genera. The present study is concerned with the quantitative relationship of the various species present in the ponds.

OBJECTIVES

These studies are designed to:

1. Determine, as far as possible, the species of insects in two ponds, one fertilized, the other unfertilized;
2. Determine the numbers and volumes of these species;
3. Determine the seasonal variation of the volumes and numbers of these species, and the numbers of all the species as a whole;
4. Correlate these findings, if possible, with the effects of the application of fertilizer to one of the ponds;
5. Present a key to the larvae of the Chironomidae (DIPTERA) found in the two ponds.

EQUIPMENT AND METHODS

Description of the Ponds

The ponds in this investigation were constructed at the Michigan State College Lake City Experiment Station. This station is located in the west-central portion of Missaukee County, about 15 miles northeast of Cadillac. They were completed in June, 1945, and fertilizer first applied to one.

Each application of fertilizer consisted of 5 pounds of 7.5-15-3.75 N-P-K-mixture. That was at the rate of 100 pounds per acre, and applications were made at intervals of three weeks during summer. The above mixture was the result of greenhouse trials on water from the ponds, Tack and Morofsky (22). When the present investigation was made the mixture in use was 5 pounds of 10-6-4 N-P-K, applied at intervals of three weeks. The pond with the fertilizer application was designated "D" and the unfertilized pond as "C" by Tack and Morofsky (22).

The ponds have a surface area of approximately 1,500 square feet, and an average depth of one and one-half feet. There is neither an inlet nor an outlet to either pond. The water levels are maintained by pumping or seepage. The shores of the ponds are sandy with a dense covering of grass, sedge, clover, and a few small willow trees. The bottoms are sand, but when this investigation was begun, the fertilized pond had a

bottom deposit of organic ooze.

These ponds originally were planned to have no fish in them. However, both ponds contained some stickle backs Eucalia inconstans (Kirtland). The unfertilized pond had some fathead minnows Pimephales promelas promelas (Raf.). It was found that the pump used to fill the ponds in 1945 was capable of carrying minnows through the pipe, and discharging some of them uninjured. This probably explains how these fish got into the ponds.

Except for cattails, rooted vegetation did not occur in either pond. The cattails that had invaded the ponds were cut each year, but their roots persisted. Neither pond had any Chara sp. or Nitella sp., which were abundant in other ponds on the station. The fertilized pond had a few small patches of duckweed, Lemna sp.

The water in the fertilized pond was a deep green color, while that of the unfertilized pond was brown. Objects, such as caddis fly cases, could be seen at a depth of 4 inches in the fertilized pond. Similar objects could not be seen in the unfertilized pond if deeper than 2 inches.

Chemical tests, made by Doctor Peter I. Tack of the Michigan State College Zoology Department, revealed that the water of the ponds was slightly alkalin.

In early May, 1947, the fertilized pond was drained by

pump. It refilled by seepage. This factor may have had an important bearing on the populations of different species of insects, as will be shown later.

Sampling of Bottom Fauna

The equipment used in taking bottom samples consisted of a $1/4^{th}$ square foot Ekman dredge, a 30-mesh sieve, tweezers, vials containing pickling solution, and a cloth aquatic net.

Three bottom samples were taken in each pond each week. No set stations were used. In order to obtain a representative sample of the insects, the 3 samples were taken in 3 depth zones in each pond. The first zone was along the shore at a depth of approximately 3 inches. The second zone was at a depth of 1 foot. The third zone was at a depth of approximately 2 feet. It was considered essential to have one of the zones close to the shore, for as Welch (25) has shown, greatest productivity of life is found there.

Before a dredge sample was drawn out of the water, the 30-mesh sieve was placed beneath it. As Ball (1) has shown, this procedure avoids the loss of specimens which might flow out of the dredge with the water. The dredge contents were dumped into the sieve, and the sand and organic ooze sifted out. The sieve was examined carefully, and any organisms present were picked out with tweezers and dropped into a vial of pickling solution. The

pickling solution consisted of formalin, alcohol, and distilled water in a mixture of 1-10-10. It was found that nymphs of Odonata would feed on each other and other organisms if placed in a vial of water. Therefore, it seemed advisable to place all specimens directly into the pickling solution. No attempt was made to keep the samples from the different depth zones separate, because the study was concerned with each pond as a unit. When the organisms from the three bottom samples were all in one vial, a date and pond label was applied to the vial and it was set aside for later examination. All bottom samples were taken in the day time.

General aquatic insect collections were made with the cloth net to determine whether the dredge bottom samples represented all the species in the ponds or not. A list of those species found by general collecting, but not represented in the bottom samples, is given in Table 25 for the fertilized pond, and Table 26 for the unfertilized pond.

Collecting Terrestrial Insects Emerging from the Ponds

Because some aquatic insects have a terrestrial stage in their life cycle, and because the terrestrial stage of such insects offers a check on the identification of the aquatic stage, an attempt was made to collect samples of them. The equipment used to collect them consisted of one quart Mason

jars, cheesecloth, an aspirator, cyanide bottles, and a light trap.

Mason jars were used to rear adults from the ponds in the following manner: Each jar was half filled with pond water. Organisms from the pond bottom were introduced to each jar. Cheesecloth was used to cover each jar to retain emerging adults, and the jars placed in about 3 inches of water in the ponds. The jars were inspected daily, and if any adults were present, the aspirator was used to remove them from the jars. Adults collected were killed in a cyanide bottle, pinned, labeled, and set aside for later identification. The results of these identifications were used as checks against larval and nymphal identifications, and are not included in this report. This equipment and procedure was applied to both ponds.

Light traps were operated in the pond area as often as possible. Light trap collections were not considered as necessarily representing members of either of the ponds, and identifications of specimens from the light trap collections are not included in this report. Collected material was saved in pill boxes, with labels of date and locality.

Laboratory Equipment and Methods

Two groups of equipment were used in the laboratory work. The first group was used in preparing specimens for identifica-

tion and their subsequent identification. This equipment consisted of microscopes, dissecting scopes, dissecting tools, glass slides and cover slips, absolute ethyl alcohol, eugenol, and Canada balsam. The second group of laboratory equipment was used to determine the volume of the specimens.

Identification of some specimens required the preparation of glass-slide mounts. In preparing the Chironomidae and Ceratopogonidae for glass slide mounts, the specimens were pricked several times along the body with a number 1 pin to hasten the dehydration process. The specimens were then placed in absolute ethyl alcohol for one-half hour to dehydrate. Following this they were transferred to eugenol for fifteen minutes to clear. From the eugenol the specimens were placed on a glass slide where they were decapitated, and the head split into dorsal and ventral halves. The body and the head were covered with Canada balsam, and a cover slip placed over each. Specimens made into slide mounts were chosen from each bottom sample, and were picked in such a manner that all size classes from every bottom sample were represented on a slide.

Slide mounts were made for other families than the Chironomidae and Ceratopogonidae. The procedure followed for them was the same as outlined above, but did not require dissection.

When slides were dry enough to handle, the specimens were identified under a microscope. After all slide specimens were

identified, enough facility was gained to identify the remaining specimens, primarily, under a dissecting scope. Identifications were listed by volume and number, by pond, and by year, and are shown in Tables 1 through 26.

The equipment used to determine the volume of the organisms consisted of a burette, a graduated centrifuge tube, a millimeter rule, and tissue paper. The procedure followed was essentially the same as that outlined by Tester (23) and used by Ball (1). Before any volumes were obtained, the graduated centrifuge tube was calibrated against the burette of the same graduations. The organism to be measured was placed on the tissue paper long enough to allow the surface liquid on the organism to be absorbed. It was then placed in the centrifuge tube and enough liquid allowed to run from the burette into the centrifuge tube to cover the organism. The difference between the reading on the burette and on the centrifuge tube was the volume of the organism. The volumes were recorded according to species, year and pond, and are shown in Tables 1 through 26.

Volumes for single small specimens could not be obtained in the manner outlined above. Instead, the small specimens were identified and measured for length. When all specimens of one species and one length were placed together, their total volume was obtained as outlined above. Knowing the total volume and the number of specimens, the volume of a single specimen was

calculated. These volumes were recorded as above. All volumes are expressed in cubic centimeters.

Volumes were not recorded for caddis fly cases, though Ball (1) found that certain cases of the Leptoceridae are digestible. It is not known how much nutritional value such cases have.

Volumes were considered important because numbers alone are often misleading concerning the amount of fish food present. Table 9 shows a total of 160 Chironominae larvae constitute a volume of only 1.156 cubic centimeters, whereas Table 17 shows that only 36 nymphs of Plathemis lydia constitute a volume of 3.500 cubic centimeters.

NOMENCLATURE

The most familiar nomenclature was used in this report. This is not meant to indicate a disregard for priority. Rather, it is felt that for an ecological investigation such a policy is appropriate on the grounds of workability.

The sources of nomenclature follow:

DIPTERA (except Ceratopogonidae) -----
Johannsen (9, 10, 11, 12)

CERATOPOGONIDAE --------- Thomsen (24)

COLEOPTERA (except Haliplidae) -------
Blatchley (2)

HALIPLIDAE ---------- Matheson (13)

EPHEMERIDA ---------- Needham, Traver,
and Hsue (15)

HEMIPTERA (except Corixidae) ---------
Hungerford (7)

CORIXIDAE ---------- Hungerford (8)

ODONATA ---------- Garman (3)

TRICHOPTERA ---------- Ross (16)

The list of authorities was also the source of most identification. Larvae of Haliplidae were identified according to Hickman (5). Larvae of Gyrinidae were identified according to Hatch (4), and larvae of other Coleoptera were identified according to Needham and Needham (14).

A LIST OF INSECTS RECOVERED FROM BOTTOM SAMPLES FROM THE FERTILIZED AND UNFERTILIZED POND

COLEOPTERA

Dytiscidae

Acilius semisulcatus Aube.

Canthydrus bicolor Say

Coelambus inaequalis Fab.

Coptotomus interrogatus Fab.

Coptotomus sp.

Hydrovatus sp.

Laccophilus maculosus Say

Gyrinidae

Dineutus assimilis Aube.

Haliplidae

Haliplus ruficollis DeG.

Hydrophilidae

Berosus striatus

Berosus sp.

Tropisternus mixtus Lec.

Tropisternus nimbatus Say

Tropisternus sp.

DIPTERA

Ceratopogonidae

Palpomyia flavipes (Meig.)

Chironomidae

Chironomus (*Glyptotendipes*) *lobiferus* Say

Chironomus (*Endochironomus*) *nigricans* Joh.

Chironomus (*Microtendipes*) *peddelus* DeG.

Chironomus (*Chironomus*) *plumosus* L.

Chironomus (*Cryptochironomus*) sp.

Chironomus (*Polypedilum*) sp.

Cricotopus trifasciatus (Panzer)

Pentaneura monilis (L.)

Procladius culiciformis (L.)

Culicidae

Chaoborus punctipennis (Say)

Tabanidae

Chrysops sp.

Tabanus sp.

Tipulidae

Unclassified

EPHEMERIDA

Baetidae

Caenis sp.

Callibaetis sp.

HEMIPTERA

Belostomatidae

Belostoma flumineum Say

Corixidae

Hesperocorixa vulgaris (Hungfd.)

Sigara (Vermicorixa) alternata (Say)

Gerridae

Gerris marginatus Say

Hydrometridae

Hydrometra martini Kirk.

Nepidae

Ranatra americana Montd.

Notonectidae

Notonecta undulata Say

ODONATA

Aeshnidae

Anax junius (Drury)

Libellulidae

Libellula pulchella (Drury)

Libellula sp.

Plathemis lydia (Drury)

Sympetrum spp.

Gomphidae

Gomphus spicatus Hagen

Coenagrionidae

Enallagma sp.

TRICHOPTERA

Leptoceridae

Oecetis sp.

Table 1. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of *Berosus* sp.

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	*		No	Data			No	Data
June 19 - 20			No	Data			No	Data
June 25 - 28								
July 1 - 5					1	.010	1	.020
July 8 - 12					2	.020	1	.010
July 15 - 19							2	.020
July 22 - 26					1	.020	1	.010
July 29 - Aug. 2								
Aug. 5 - 9								
Aug. 12	No	Data**			No	Data		
Aug. 18 - 20								
Aug. 26 - 27								
Sept. 5			No	Data			No	Data
Sept. 10 - 13							1	.020
Sept. 20			No	Data			No	Data
TOTAL	0	0	0	0	4	.050	6	.080

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 2. Seasonal variation of population by volume and number per 3/4th wquare foot, 1947-1948, of Coelambus inaequalis Fab.

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	*		No	Data			No	Data
June 19 - 20			No	Data			No	Data
June 25 - 28								
July 1 - 5								
July 8 - 12								
July 15 - 19								
July 22 - 26							1	.010
July 29 - Aug. 2								
Aug. 5 - 9							1	.010
Aug. 12	No	Data**			No	Data		
Aug. 18 - 20	1	.010			3	.030		
Aug. 26 - 27							1	.010
Sept. 5			No	Data			No	Data
Sept. 10 - 13					9	.090	20	.200
Sept. 20	1	.010	No	Data	12	.120	No	Data
TOTAL	2	.020	0	0	24	.240	23	.230

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 3. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of Haliplus ruficollis DeG.

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	*		No	Data			No	Data
June 19 - 20			No	Data			No	Data
June 25 - 28								
July 1 - 5								
July 8 - 12								
July 15 - 19							1	.001
July 22 - 26							1	.001
July 29 - Aug. 2					1	.010	①	.010
Aug. 5 - 9					5	.016	1	.010
Aug. 12	No	Data**			No	Data	1	.002
Aug. 18 - 20					② 3	.004 .030		
Aug. 26 - 27					①	.010	④	.024
Sept. 5			No	Data			No	Data
Sept. 10 - 13					①	.002	②	.020
Sept. 20			No	Data			No	Data
TOTAL	0	0	0	0	12	.072	11	.068

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

① A circled digit indicates an adult while an uncircled digit indicates a larva

Table 4. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of Palpomyia flavipes (Meig.)

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	2	.003	No	Data	6	.035	No	Data
June 19 - 20	*		No	Data	5	.008	No	Data
June 25 - 28	3	.004			1	.001	5	.009
July 1 - 5	8	.012					2	.003
July 8 - 12							10	.016
July 15 - 19			3	.004	4	.013	2	.003
July 22 - 26					2	.003		
July 29 - Aug. 2			2	.003			4	.006
Aug. 5 - 9					1	.001	4	.006
Aug. 12	No	Data**			No	Data	3	.005
Aug. 18 - 20			1	.001			23	.036
Aug. 26 - 27			1	.001	1	.001	9	.014
Sept. 5			No	Data	1	.001	No	Data
Sept. 10 - 13			1	.001	2	.003		
Sept. 20			No	Data	5	.008	No	Data
TOTAL	13	.019	8	.010	28	.068	62	.098

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 5. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of *Chironomus* (*Glyptotendipes*) *lobiferus* Say

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	*		No	Data	1	.008	No	Data
June 19 - 20			No	Data			No	Data
June 25 - 28								
July 1 - 5								
July 8 - 12					1	.010		
July 15 - 19							1	.015
July 22 - 26								
July 29 - Aug. 2								
Aug. 5 - 9					4	.028		
Aug. 12	No	Data**					1	.007
Aug. 18 - 20					1	.020	5	.050
Aug. 26 - 27					4	.030	1	.013
Sept. 5			No	Data	1	.008	No	Data
Sept. 10 - 13					2	.009		
Sept. 20			No	Data	19	.171	No	Data
TOTAL	0	0	0	0	33	.284	8	.085

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken on that day

Table 6. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of *Chironomus (Endochironomus) nigricans* Joh.

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	*		No	Data			No	Data
June 19 - 20			No	Data			No	Data
June 25 - 28								
July 1 - 5					3	.024		
July 8 - 12					9	.070		
July 15 - 19					7	.056	2	.020
July 22 - 26					17	.170		
July 29 - Aug. 2					9	.085		
Aug. 5 - 9	No	Data**			17	.136		
Aug. 12	No	Data			No	Data	1	.009
Aug. 18 - 20					2	.014	17	.174
Aug. 26 - 27					3	.027		
Sept. 5			No	Data	2	.009	No	Data
Sept. 10 - 13								
Sept. 20			No	Data	2	.016	No	Data
TOTAL	0	0	0	0	71	.607	20	.203

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 7. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of Chironomus (Chironomus) plumosus L.

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	*		No	Data	1	.027	No	Data
June 19 - 20			No	Data	1	.027	No	Data
June 25 - 28			9	.250				
July 1 - 5			4	.108			1	.007
July 8 - 12	3	.081	2	.054				
July 15 - 19			6	.260				
July 22 - 26			3	.100			2	.014
July 29 - Aug. 2			1	.030				
Aug. 5 - 9					2	.014	2	.016
Aug. 12	No	Data**			No	Data		
Aug. 18 - 20					4	.028	1	.015
Aug. 26 - 27					3	.025		
Sept. 5			No	Data			No	Data
Sept. 10 - 13								
Sept. 20			No	Data	16	.272	No	Data
TOTAL	0	0	25	.802	27	.393	6	.152

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 8. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of Chironomus (Cryptochironomus) sp.

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	1	.010	No	Data			No	Data
June 19 - 20	*		No	Data			No	Data
June 25 - 28								
July 1 - 5			1	.006	3	.018		
July 8 - 12			5	.020	3	.012	2	.018
July 15 - 19			5	.020	6	.024	3	.018
July 22 - 26			1	.004			2	.006
July 29 - Aug. 2					5	.020		
Aug. 5 - 9			2	.014	6	.030	1	.001
Aug. 12	No	Data**	1	.007	No	Data		
Aug. 18 - 20					2	.014	1	.006
Aug. 26 - 27					1	.007		
Sept. 5			No	Data			No	Data
Sept. 10 - 13					1	.007		
Sept. 20			No	Data			No	Data
TOTAL	1	.010	15	.071	27	.132	9	.055

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 9. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of Chironominae*

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	**		No	Data	90	.525	No	Data
June 19 - 20			No	Data	15	.210	No	Data
June 25 - 28					8	.066	4	.015
July 1 - 5	1	.028			15	.166	13	.039
July 8 - 12			3	.009	3	.027	3	.006
July 15 - 19							25	.097
July 22 - 26	1	.010			7	.003	9	.051
July 29 - Aug. 2	1	.006	1	.002	4	.083	11	.076
Aug. 5 - 9					4	.028	4	.021
Aug. 12	No	Data***			No	Data	2	.004
Aug. 18 - 20					5	.025	22	.115
Aug. 26 - 27					2	.010		
Sept. 5			No	Data	3	.011	No	Data
Sept. 10 - 13								
Sept. 20	1	.010	No	Data	4	.002	No	Data
TOTAL	4	.054	4	.011	160	1.156	93	.424

* Exclusive of the following genera and species: Chironomus plumosus L., Chironomus lobiferus Say., Chironomus nigricans Joh., and the group Cryptochironomus of Chironomus. This table includes those specimens which could not be classified further than the subfamily and the following genera and species: Chironomus (Microtendipes) peddelus DeG., Chironomus (Polypedilum) sp., a species which, except for the lack of gills on the eleventh abdominal segment, resembles Chironomus decorus Joh., and an unknown species which fits the description of Chironomus (Einfeldia) insolita Kieff, of Europe.

** A blank indicates that a bottom sample was taken but no specimens recovered

*** "No Data" indicates that a bottom sample was not taken that day

Table 10. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of Procladius culiciformis (L.)

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	10	.090	No	Data	5	.030	No	Data
June 19 - 20	3	.030	No	Data	1	.006	No	Data
June 25 - 28	4	.040					5	.045
July 1 - 5	*		1	.007	2	.010	7	.061
July 8 - 12			2	.012			2	.016
July 15 - 19					4	.032	11	.098
July 22 - 26					8	.048	6	.051
July 29 - Aug. 2					1	.001	9	.080
Aug. 5 - 9					1	.002	2	.006
Aug. 12	No	Data**	1	.008	No	Data	21	.169
Aug. 18 - 20					2	.009	10	.061
Aug. 26 - 27					1	.008	6	.054
Sept. 5			No	Data			No	Data
Sept. 10 - 13								
Sept. 20			No	Data			No	Data
TOTAL	17	.160	4	.027	25	.146	79	.631

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 11. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of *Chaoborus punctipennis* (Say)

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	*		No	Data			No	Data
June 19 - 20			No	Data			No	Data
June 25 - 28							3	.012
July 1 - 5								
July 8 - 12								
July 15 - 19			2	.006				
July 22 - 26			1	.004				
July 29 - Aug. 2			1	.001			1	.003
Aug. 5 - 9			5	.023				
Aug. 12	No	Data**	3	.014	No	Data	5	.025
Aug. 18 - 20					2	.010	2	.009
Aug. 26 - 27					1	.004	6	.030
Sept. 5			No	Data	12	.060	No	Data
Sept. 10 - 13			15	.070			33	.132
Sept. 20			No	Data	16	.064	No	Data
TOTAL	0	0	27	.118	31	.138	50	.211

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 12. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of *Chrysops* sp.

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	*		No	Data			No	Data
June 19 - 20			No	Data	3	.140	No	Data
June 25 - 28					1	.010		
July 1 - 5					3	.120		
July 8 - 12					1	.100		
July 15 - 19					1	.020		
July 22 - 26			1	.030	1	.030		
July 29 - Aug. 2					6	.120		
Aug. 5 - 9					14	.042	3	.065
Aug. 12	No	Data**			No	Data	1	.010
Aug. 18 - 20					6	.180	4	.120
Aug. 26 - 27					4	.090	6	.150
Sept. 5			No	Data	4	.120	No	Data
Sept. 10 - 13					6	.150		
Sept. 20			No	Data	5	.090	No	Data
TOTAL	0	0	1	.030	55	1.212	14	.345

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 13. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of *Caenis* sp.

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	*		No	Data			No	Data
June 19 - 20			No	Data			No	Data
June 25 - 28							2	.007
July 1 - 5							1	.003
July 8 - 12					1	.005		
July 15 - 19							11	.033
July 22 - 26							18	.060
July 29 - Aug. 2					4	.012	1	.004
Aug. 5 - 9					2	.006	5	.015
Aug. 12	No	Data**			No	Data	11	.033
Aug. 18 - 20					4	.012	3	.009
Aug. 26 - 27							2	.005
Sept. 5			No	Data			No	Data
Sept. 10 - 13					2	.006	3	.009
Sept. 20			No	Data	1	.003	No	Data
TOTAL	0	0	0	0	14	.044	57	.176

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 14. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of Corixidae*

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	**		No	Data			No	Data
June 19 - 20			No	Data			No	Data
June 25 - 28								
July 1 - 5	1	.030			1	.010		
July 8 - 12	2	.010			1	.010		
July 15 - 19	2	.020						
July 22 - 26	1	.010			3	.100		
July 29 - Aug. 2					1	.007		
Aug. 5 - 9			7	.035	1	.006	2	.017
Aug. 12	No	Data***	1	.001	No	Data	1	.007
Aug. 18 - 20	2	.090	1	.010				
Aug. 26 - 27			1	.010	1	.005		
Sept. 5	1	.070	No	Data			No	Data
Sept. 10 - 13			2	.020	3	.120	2	.028
Sept. 20	1	.050	No	Data	5	.035	No	Data
TOTAL	10	.280	12	.076	16	.293	5	.052

* Two species were determined in this family and are listed in order of their frequency of occurrence: Sigara (Vermicorixa) alternata (Say), Hesperocorixa vulgaris (Hungfd.). Most of the specimens taken in the bottom samples were immature and could not be identified accurately.

** A blank indicates that a bottom sample was taken but no specimens recovered

*** "No Data" indicates that a bottom sample was not taken that day

Table 15. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of *Enellagma* sp.

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	*		No	Data			No	Data
June 19 - 20			No	Data			No	Data
June 25 - 28								
July 1 - 5								
July 8 - 12								
July 15 - 19								
July 22 - 26					1	.005		
July 29 - Aug. 2								
Aug. 5 - 9					2	.080	2	.060
Aug. 12	No	Data**			No	Data		
Aug. 18 - 20			1	.006	8	.160	2	.016
Aug. 26 - 27			2	.005	2	.016	1	.006
Sept. 5			No	Data			No	Data
Sept. 10 - 13			3	.070	16	.128	7	.049
Sept. 20			No	Data	9	.360	No	Data
TOTAL	0	0	6	.081	38	.749	12	.131

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 16. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of Gomphus spicatus Hagen

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	*		No	Data			No	Data
June 19 - 20			No	Data			No	Data
June 25 - 28								
July 1 - 5							1	.350
July 8 - 12								
July 15 - 19								
July 22 - 26							2	.400
July 29 - Aug. 2					1	.350	1	.350
Aug. 5 - 9								
Aug. 12	No	Data**			No	Data		
Aug. 18 - 20			1	.008			2	.507
Aug. 26 - 27							2	.310
Sept. 5			No	Data			No	Data
Sept. 10 - 13					2	.030	2	.400
Sept. 20			No	Data	1	.050	No	Data
TOTAL	0	0	1	.008	4	.430	10	2.317

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 17. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of *Plathemis lydia* (Drury)

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	*		No	Data			No	Data
June 19 - 20			No	Data			No	Data
June 25 - 28								
July 1 - 5								
July 8 - 12								
July 15 - 19								
July 22 - 26								
July 29 - Aug. 2								
Aug. 5 - 9								
Aug. 12	No	Data**			No	Data		
Aug. 18 - 20					2	.300		
Aug. 26 - 27					16	.700		
Sept. 5			No	Data	11	.750	No	Data
Sept. 10 - 13					4	.900		
Sept. 20			No	Data	3	.850	No	Data
TOTAL	0	0	0	0	36	3.500	0	0

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 18. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of *Sympetrum* spp.

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	*		No	Data			No	Data
June 19 - 20			No	Data			No	Data
June 25 - 28								
July 1 - 5					1	.030	1	.035
July 8 - 12								
July 15 - 19							1	.200
July 22 - 26							4	.800
July 29 - Aug. 2								
Aug. 5 - 9								
Aug. 12	No	Data**			No	Data		
Aug. 18 - 20								
Aug. 26 - 27					2	.070		
Sept. 5			No	Data			No	Data
Sept. 10 - 13							1	.035
Sept. 20			No	Data	1	.250	No	Data
TOTAL	0	0	0	0	4	.350	7	1.075

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 19. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of Miscellaneous Insects

	UNFERTILIZED POND			FERTILIZED POND		
	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)
COLEOPTERA						
Dytiscidae						
Acilius semisulcatus	8-20-48	1	.230			
Canthydrus bicolor				9-10-48	2	.010
Coptotomus interrogatus	8-26-48	1	.080			
Coptotomus sp.				7-5-47	1	.027
Hydrovatus sp.					1	.010
Laccophilus maculosus					2	.020
Unclassified					1	.008
					1	.050
					4	.016
					2	.006
					2	.006
					1	.003
					1	.009
Total Misc. Dytiscidae		2	.310		18	.169
Gyrinidae						
Dineutus assimilis				8-2-47	1	.100
				7-8-48	1	.010
Total Gyrinidae		0	0		2	.110

Table 19. (Continued)

	UNFERTILIZED POND			FERTILIZED POND		
	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)
Hydrophilidae						
Tropisternus nimbatus				9-13-47	1	.100
				9-20-47	2	.150
Tropisternus mixtus				9-10-48	2	.160
Tropisternus				7-26-47	1	.030
				8-9-47	1	.020
				7-29-48	1	.004
				8-5-48	4	.080
Unclassified				8-2-47	6	.150
Total Misc. Hydrophilidae					18	.649
DIPTERA						
Chironomidae						
Cricotopus trifasciatus				8-9-47	15	.075
				9-20-47	4	.020
				6-25-48	1	.004
				8-20-48	1	.006
Pentaneura monilis				7-19-47	1	.007
				8-27-47	1	.007
				7-15-48	1	.009

Table 19. (Continued)

	UNFERTILIZED POND			FERTILIZED POND		
	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)
				8-5-48	1	.008
				8-12-48	1	.007
				8-20-48	1	.009
Total Misc. Chironomidae		0	0		27	.152
Tabanidae						
Tabanus sp.				8-18-47	1	.900
Total Misc. Tabanidae		0	0		1	.900
Tipulidae						
Unclassified				7-12-47	1	.020
Total Misc. Tipulidae		0	0		1	.020
EPHEMERIDA						
Baetidae						
Callibaetis				9-13-47	2	.015
				9-20-47	3	.024
				8-5-48	2	.010
				8-12-48	1	.005

Table 19. (Continued)

	UNFERTILIZED POND			FERTILIZED POND		
	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)
Total Misc. Baetidae		0	0		8	.054
HEMIPTERA						
Belostomatidae						
Belostoma fluminium				8-9-47	1	.050
				9-20-47	1	.350
Total Misc. Belostomatidae		0	0		2	.400
Gerridae						
Gerris marginatus				8-2-47	2	.040
Total Misc. Gerridae					2	.040
Hydrometridae						
Hydrometra martini				8-26-48	1	.001
Total Misc. Hydrometridae					1	.001
Nepidae						
Ranatra americana	8-2-47	1	.290	8-18-47	1	.350
	9-5-47	1	.290	8-26-48	1	.200
	9-10-48	1	.300			
Total Misc. Nepidae		3	.880		2	.550

Table 19. (Continued)

	UNFERTILIZED POND			FERTILIZED POND		
	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)
Notonectidae						
Notonecta undulata				7-5-47	1	.020
				7-19-47	2	.140
				8-2-47	1	.020
				8-9-47	1	.005
				8-18-47	1	.150
				8-27-47	2	.300
				9-13-47	1	.200
				9-20-47	2	.200
Total Notonectidae					11	1.035
ODONATA						
Aeshnidae						
Anax junius	8-26-48	1	1.250	7-15-48	1	.750
				8-20-48	1	.250
Total Aeshnidae		1	1.250		2	1.000
Libellulidae						
Libellula pulchella				6-27-47	1	.500
				7-20-47	1	.400
				9-10-47	1	.350

Table 19. (Continued)

	UNFERTILIZED POND			FERTILIZED POND		
	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)
Unclassified				8-18-47	2	.300
				8-27-47	2	.030
				9-20-47	1	.030
				9-10-48	2	.035
Total Misc. Libellulidae					11	1.645
TRICHOPTERA						
Leptoceridae						
Oecetis sp.				7-26-47	1	.020
				8-2-47	1	.020
				8-9-47	2	.040
				7-8-48	3	.050
				7-22-48	1	.020
				9-10-48	1	.020
Total Leptoceridae					9	.170

Table 20. Total numbers and volumes of families of insects, 1947

FAMILY	UNFERTILIZED POND		FERTILIZED POND	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
AESHNIDAE	0			
BAETIDAE			19	.083
BELOSTOMATIDAE			2	.400
CERATOPOGONIDAE	13	.109	28	.068
CHIRONOMIDAE	12	.224	370	2.849
COENAGRIONIDAE			38	.749
CORIXIDAE	10	.280	16	.293
CULICIDAE			31	.138
DYTISCIDAE	2	.020	36	.366
GERRIDAE			2	.040
GOMPHIDAE			4	.430
GYRINIDAE			1	.100
HALIPLIDAE			12	.072
HYDROMETRIDAE				
HYDROPHILIDAE			15	.455
LEPTOCERIDAE			3	.060
LIBELLULIDAE			48	5.460
NEPIDAE	2	.580	1	.350
NOTONECTIDAE			11	1.035
TABANIDAE			56	2.112
TIPULIDAE			1	.020
TOTAL	39	1.213	684	15.060

Table 21. Total numbers and volumes of families of insects, 1948

FAMILY	UNFERTILIZED POND		FERTILIZED POND	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
AESHNIDAE	1	1.250	2	1.000
BAETIDAE			60	.193
BELOSTOMATIDAE				
CERATOPOGONIDAE	8	.010	62	.093
CHIRONOMIDAE	48	.911	227	1.619
COENAGRIONIDAE	6	.081	12	.131
CORIXIDAE	12	.076	5	.052
CULICIDAE	27	.118	50	.211
DYTISCIDAE	2	.310	29	.279
GERRIDAE				
GOMPHIDAE	1	.008	10	2.317
GYRINIDAE			1	.010
HALIPLIDAE			11	.068
HYDROMETRIDAE			1	.001
HYDROPHILIDAE			12	.324
LEPTOCERIDAE			5	.090
LIBELLULIDAE			10	1.110
NEPIDAE	1	.300	1	.200
NOTONECTIDAE				
TABANIDAE	1	.030	14	.345
TIPULIDAE				
TOTAL	107	3.094	512	8.043

Table 22. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of Clams and Snails

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	*		No	Data			No	Data
June 19 - 20			No	Data			No	Data
June 25 - 28							1	.007
July 1 - 5							7	.052
July 8 - 12							4	.030
July 15 - 19							11	.082
July 22 - 26					3	.132	20	.150
July 29 - Aug. 2					17	.029	5	.037
Aug. 5 - 9					42	.350	8	.059
Aug. 12	No	Data**			No	Data	4	.030
Aug. 18 - 20					27	.202	5	.037
Aug. 26 - 27					28	.210	7	.052
Sept. 5			No	Data	13	.100	No	Data
Sept. 10 - 13					11	.082	2	.015
Sept. 20			No	Data	29	.217	No	Data
TOTAL	0	0	0	0	171	1.322	74	.551

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 23. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of Oligochaeta

DATE	UNFERTILIZED POND				FERTILIZED POND			
	1947		1948		1947		1948	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
June 10	*		No	Data	1	.001	No	Data
June 19 - 20	2	.001	No	Data	10	.200	No	Data
June 25 - 28							2	.001
July 1 - 5	4	.003			4	.070	6	.010
July 8 - 12							4	.003
July 15 - 19					1	.001		
July 22 - 26					2	.020	3	.002
July 29 - Aug. 2								
Aug. 5 - 9							2	.001
Aug. 12	No	Data**			No	Data		
Aug. 18 - 20					2	.020		
Aug. 26 - 27								
Sept. 5			No	Data			No	Data
Sept. 10 - 13			9	.050	2	.010	1	.001
Sept. 20			No	Data	1	.001	No	Data
TOTAL	6	.004	9	.050	23	.323	18	.018

* A blank indicates that a bottom sample was taken but no specimens recovered

** "No Data" indicates that a bottom sample was not taken that day

Table 24. Seasonal variation of population by volume and number per 3/4th square foot, 1947-1948, of Miscellaneous fauna

SPECIES	UNFERTILIZED POND			FERTILIZED POND		
	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)
Caddisfly cases				9-5-47	1	
				6-25-48	5	
				7-8-48	13	
				7-15-48	9	
				7-22-48	4	
				7-29-48	9	
				8-5-48	2	
				8-12-48	2	
				8-20-48	5	
				8-26-48	9	
Crayfish				7-5-48	1	1.600
Fat-head minnow	9-10-48	1	1.630			
Leech	8-1-48	1	.130	7-5-47	1	1.000
	8-26-48	1	.280	7-22-48	1	2.550
Mite				8-2-47	1	)
				7-22-48	2	).001
				7-29-48	1	)

Table 24. (Continued)

SPECIES	UNFERTILIZED POND			FERTILIZED POND		
	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)	DATE OF APPEARANCE IN BOTTOM SAMPLE	NO.	VOL. (C.C.)
OSTRACHODA				7-22-48	4	
Stickle Back	8-2-47	1	.190	7-15-48	3	1.500
	8-18-47	1	.170	7-22-48	2	.400
				8-20-48	1	.300
				9-10-48	1	.200
Tadpoles	8-10-48	3	.060			

Table 25. A list of insects collected from fertilized pond which were not represented in bottom samples

COLEOPTERA

Dytiscidae

Acilius semisulcatus Aube.

Coptotomus interrogatus Fab.

Dytiscus fasciventris Say

Dytiscus hybridus Aube.

Dytiscus marginalis L.

Gyrinidae

Gyrinus fraternus Coup.

Haliplidae

Haliplus cribrarius Lec.

Haliplus connexus Math.

Peltodytes sp.

Hydrophilidae

Hydrochus sp.

DIPTERA

Tetanoceridae

Sepedon sp.

HEMIPTERA

Belostomatidae

Lethocerus americanus Leidy

Table 25. (Continued)

Notonectidae

Plea striola Fieber

ODONATA

Libellulidae

Leucorrhinia intacta Hagen

TRICHOPTERA

Limnephilidae

Polycentropus radiatus (Say)

Table 26. A list of insects collected from unfertilized pond which were not represented in bottom samples

COLEOPTERA

Dytiscidae

Dytiscus fasciventris Say

Dytiscus marginalis L.

Gyrinidae

Dineutus assimilis Aube.

Gyrinus fraternus Coup.

Haliplidae

Haliplus ruficollis DeG.

Hydrophilidae

Tropisternus mixtus Lec.

DIPTERA

Chironomidae

Chironomus (*Endochironomus*) *nigricans* Joh.

Pentaneura monilis (L.)

EPHEMERIDA

Baetidae

Caenis sp.

HEMIPTERA

Belostomatidae

Belostoma fluminium

Table 26. (Continued)

Notonectidae

Notonecta undulata

Gerridae

Gerris marginatus Say

ODONATA

Libellulidae

Libellula pulchella Drury

Plathemis lydia (Drury)

Sympetrum spp.

Table 27. Numbers and volumes per square foot of insects and bottom fauna found in both ponds, 1947

SPECIES	UNFERTILIZED POND		FERTILIZED POND	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
COLEOPTERA				
Coelambus inaequalis	.190	.002	2.286	.023
Haliplus ruficollis			1.140	.007
Berosus sp.			.380	.005
Misc.			2.190	.049
DIPTERA				
Palpomyia flavipes	1.243	.002	2.667	.006
Chironomus lobiferus			3.143	.017
Chironomus nigricans			6.762	.058
Chironomus plumosus			2.571	.037
Chironomus Cryptochironomus sp.	.096	.001	2.571	.012
Chironominae spp. (in part)	.381	.005	15.138	.110
Procladius culiciformis	1.619	.015	2.381	.014
Chaoborus punctipennis			2.952	.013
Chrysops sp.			5.238	.115
Misc.			2.190	.098
EPHEMERIDA				
Caenis sp.			1.343	.004
Callibaetis sp.			.476	.003
HEMIPTERA				
Corixidae	.952	.027	1.524	.028
Notonecta undulata			1.048	.099
Misc.	.190	.055	.476	.075
ODONATA				
Gomphus spicatus			.381	.041
Plathemis lydia			3.428	.333
Sympetrum spp.			.381	.033
Enellagma spp.			3.619	.071
Misc.			.762	.153

Table 27. (Continued)

SPECIES	UNFERTILIZED POND		FERTILIZED POND	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
TRICHOPTERA				
Oecetis sp.			.381	.007
TOTAL INSECTS	4.671	.107	65.418	1.111
Clams and Snails			16.280	.125
Oligochaeta	.571	.001	2.190	.031
Miscellaneous organisms	.190	.034	.190	.095
TOTAL	.761	.035	18.660	.251
GRAND TOTAL	4.432	.142	84.078	1.362

Table 28. Numbers and volumes per square foot of insects and bottom fauna found in both ponds, 1948

SPECIES	UNFERTILIZED POND		FERTILIZED POND	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
COLEOPTERA				
Coelambus inaequalis			2.788	.028
Haliplus ruficollis			1.333	.008
Berosus sp.			.727	.009
Misc.	.242	.037	1.697	.036
DIPTERA				
Palpomyia flavipes	.969	.001	7.515	.011
Chironomus lobiferus			.969	.010
Chironomus nigricans			2.424	.024
Chironomus plumosus	3.030	.097	.727	.018
Chironomus Cryptochironomus sp.	1.818	.008	1.091	.006
Chironominae spp. (in part)	.484	.001	11.327	.051
Procladius culiciformis	.484	.003	9.578	.077
Chaoborus punctipennis	3.272	.014	6.061	.025
Chrysops sp.	.121	.004	1.696	.042
Misc.			.727	.005
EPHEMERIDA				
Caenis sp.			6.909	.021
Callibaetis sp.			.363	.002
HEMIPTERA				
Corixidae	1.454	.034	.606	.006
Notonecta undulata				
Misc.	.121	.036	.242	.024
ODONATA				
Gomphus spicatus	.121	.001	1.212	.281
Plathemis lydia				
Sympetrum sp.			.848	.130
Enellagma spp.	.727	.009	1.454	.091
Misc.	.121	.151	.363	.004

Table 28. (Continued)

SPECIES	UNFERTILIZED POND		FERTILIZED POND	
	NO.	VOL. (C.C.)	NO.	VOL. (C.C.)
TRICHOPTERA				
Oecetis sp.			.606	.011
TOTAL INSECTS	12.964	.396	58.973	.910
Clams and Snails			8.969	.066
Oligochaeta	1.091	.006	2.181	.008
Miscellaneous organisms	.727	.254	1.939	.794
TOTAL	1.818	.260	13.089	.868
GRAND TOTAL	14.782	.656	71.062	1.778

DISCUSSION

A total of 150 one-fourth square foot bottom samples were made in the two ponds over the two year period. Thus, a total of 18.75 square feet was sampled in each pond during the seasons of 1947 and 1948. Forty-two one-fourth square foot bottom samples were made in each pond in 1947. This represents 10.50 square feet of bottom sampled. Thirty-three one-fourth square foot bottom samples were made in each pond in 1948. This represents 8.25 square feet of bottom sampled.

The weekly bottom samples represent $3/4^{th}$ square foot of bottom sampled. No corrections were made to adjust weekly numbers and volumes to the more common square foot.

Though no corrections were made to adjust the weekly numbers and volumes to a square foot basis, the total numbers and volumes of the species of insects and all organisms were adjusted to a square foot basis. From Tables 1 through 19, the totals can be divided by the square feet of bottom sampled, and the results will be the numbers or volumes of insect species per square foot. From Tables 22 through 24 the totals can be treated in a similar manner, giving the numbers and volumes of miscellaneous organisms per square foot. Adding these two gives the numbers or volumes of all organisms per square foot. The numbers and volumes of insect species and miscellaneous organisms are given in Tables

27 and 28.

From Table 27 it can be seen that the approximate number of insects in the fertilized pond in 1947 was 65.4 per square foot. The approximate volume of insects for the fertilized pond in 1947 was 1.1 c.c. per square foot. The same year there were approximately 4.6 insects per square foot in the unfertilized pond, representing a volume of 0.1 c.c. per square foot. This indicates that the fertilized pond produced approximately 15 times as many insects as the unfertilized pond, and a volume of approximately 10 times as great as the unfertilized pond. The number of miscellaneous organisms was approximately 25 times greater in the fertilized pond in 1947 than in the unfertilized pond. The volume of miscellaneous organisms in the fertilized pond for 1947 was approximately 7 times greater than in the unfertilized pond.

From Table 28 it can be seen that the trend in 1948 was similar to that of 1947, but not so pronounced. The fertilized pond in 1948 produced approximately 59 insects per square foot, representing a volume of 0.9 c.c. per square foot. The unfertilized pond, in 1948, produced approximately 13 insects per square foot, representing a volume of 0.4 c.c. per square foot. Thus the fertilized pond produced 4 times as many insects per square foot as the unfertilized pond in 1948. Approximately twice the volume of insects were produced in the fertilized pond

in 1948 as compared to the unfertilized pond in the same year. Approximately 7 times as many miscellaneous organisms per square foot were produced in the fertilized pond as the unfertilized pond in 1948, with a volume 3 times as great as in the unfertilized pond.

The differences in the numbers and volumes of insects and miscellaneous organisms in the two ponds are assumed as being the result of adding fertilizer, because other conditions were similar. The above figures doubtless were affected by the presence of stickle backs Eucalia inconstans, but since both ponds supported a population of these fish, the relative nature of the figures is considered reasonably accurate. Since the fathead minnow, Pimephales promelas promelas, is herbivorous, the affect of this fish on insect populations is not considered important.

Numbers

Apparently significant differences were found in the populations of various species, genera, subfamilies and families. In every case except two, the populations of the insects, considered as families, were higher in the fertilized pond than in the unfertilized pond (Tables 20 and 21). From Table 20 it can be seen that a difference is found in the Chironomidae populations in the two ponds. In the fertilized pond 370 specimens of Chironomidae were recovered in the 1947 bottom samples, while

only 12 were recovered in the unfertilized pond. Thus the fertilized pond produced approximately 30 times as many Chironomidae as the unfertilized pond in 1947. In 1948, Table 21, the difference was not so great. The fertilized produced more than 4.5 times as many Chironomidae as the unfertilized pond.

The differences in the populations of Chironomidae in the two ponds are considered more important than differences in other families because of the great difference in actual numbers. However, the relative abundance in each pond is similar. The Chironomidae, in numbers, compose 39% of all fauna recovered in the fertilized pond bottom samples of 2 years (Fig. 1). They compose 36% of the number of all fauna recovered in the unfertilized pond bottom samples for 2 years (Fig. 2).

With the exception of Chironomus plumosus (Table 7), the species of Chironomidae which could be identified occurred in greater numbers in the fertilized pond than in the unfertilized pond (Tables 5, 6, 8 and 10). An explanation for the continuously high population of Chironomus plumosus in the unfertilized pond in 1948 could be regarded as the result of a lack of sufficient food to attain maturity, thus keeping individuals in the aquatic stage over a longer period of time. This supposition is supported by the fact that in the fertilized pond, where food is considered sufficient, there appeared to be a definite break between the emergence of the one generation and the reappearance

FIGURE 1. PERCENTAGE COMPOSITION OF BOTTOM FAUNA OF FERTILIZED POND, VOLUME AND NUMBER, 1947-1948.

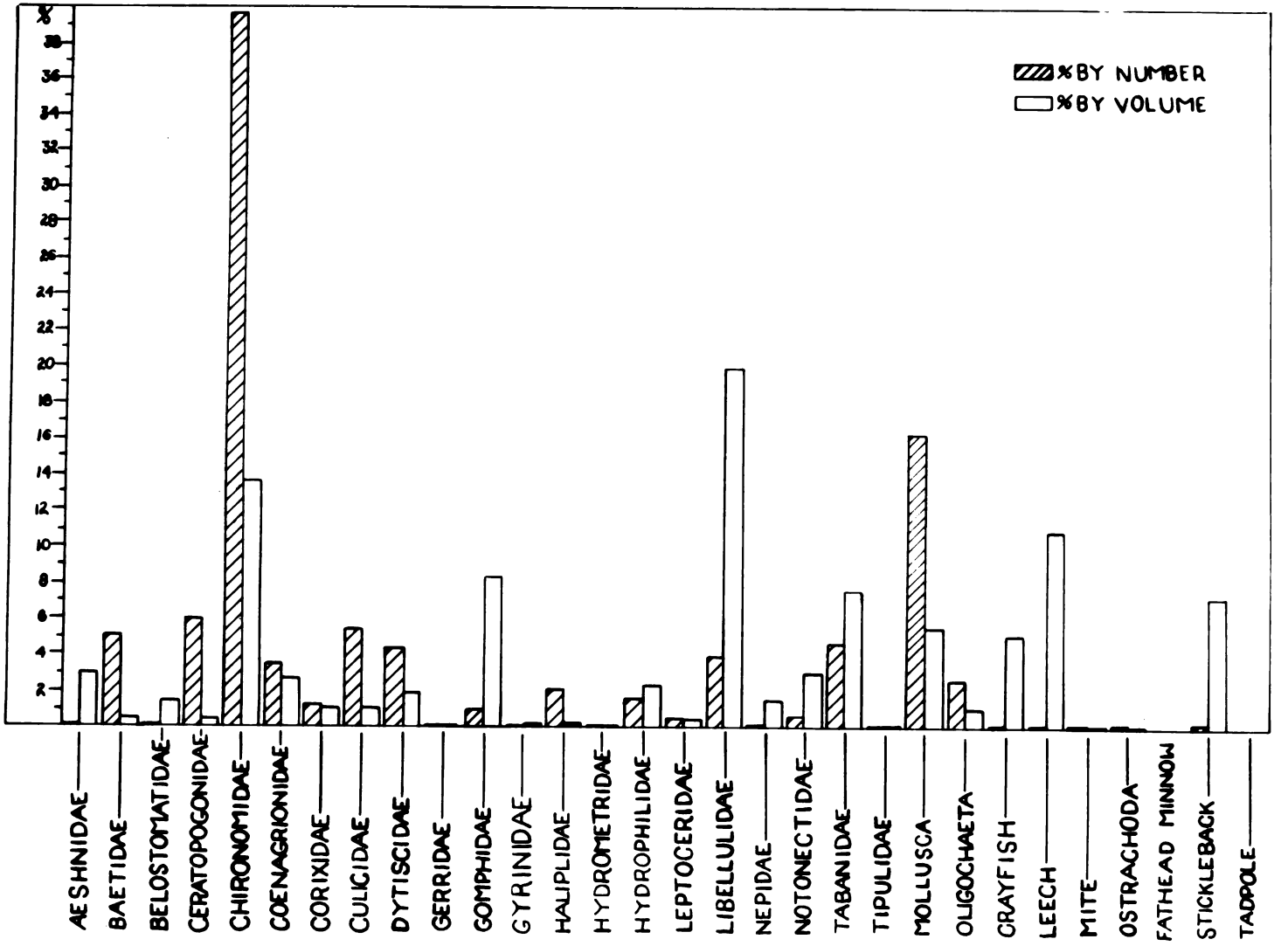
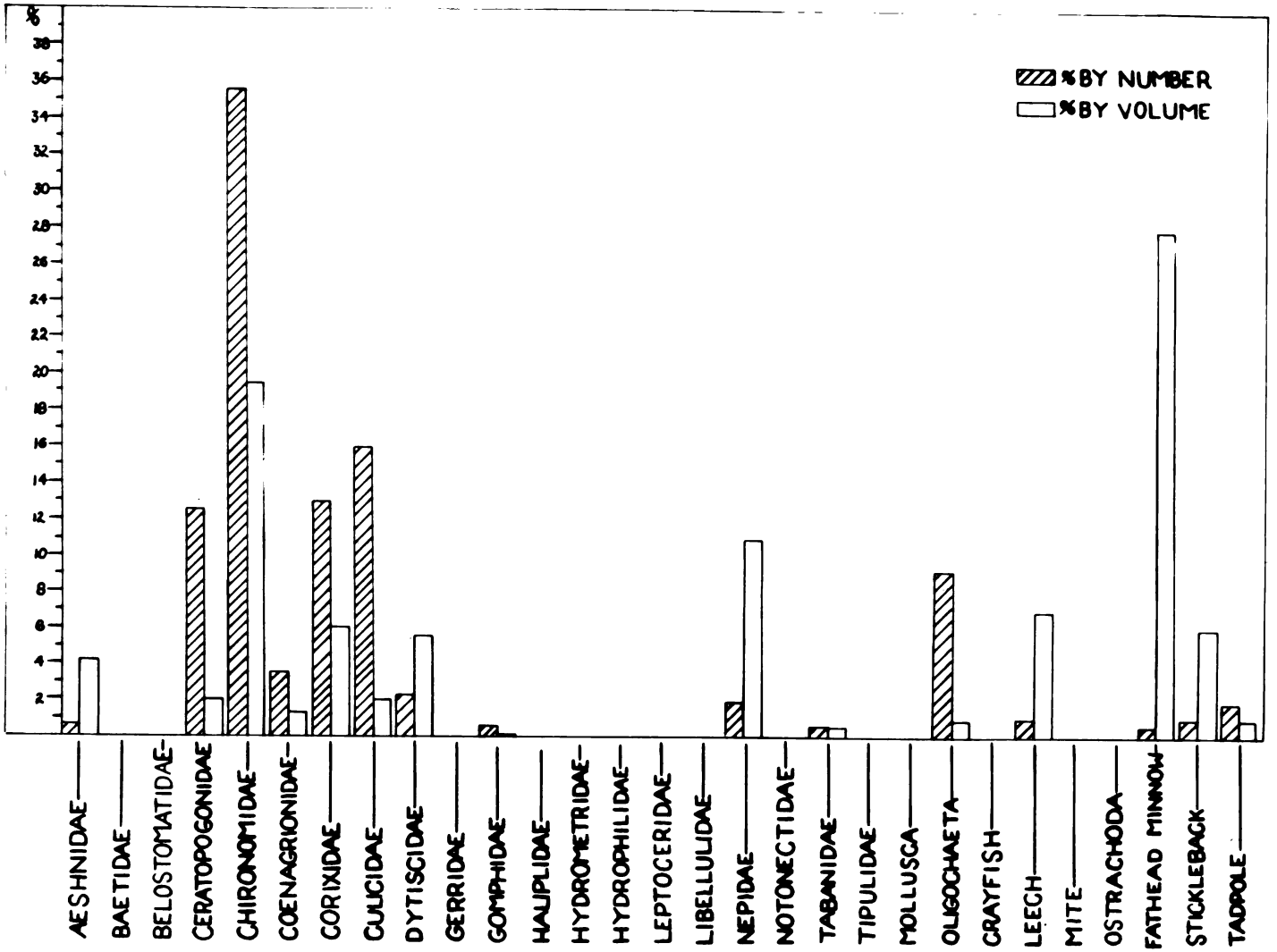


FIGURE 2. PERCENTAGE COMPOSITION OF BOTTOM FAUNA OF UNFERTILIZED POND, VOLUME AND NUMBER, 1947-1948.



of the new generation in both years (Table 7). However, there is no way of accounting for the complete absence of this species from the unfertilized pond in 1947.

Most of the Chironomidae could not be identified. Those of the subfamily Chironominae which could not be identified, and a few which were identified, are grouped together in Table 9. Here, again, the fertilized pond was much more productive than the unfertilized pond. Cricotopus trifasciatus, and Pentaneura monilis, are listed in Table 19, and they also occurred in greater numbers in the fertilized pond.

The Coenagrionidae, represented by the one genus, Enallagma, composed approximately 3.5% in numbers of the total populations of all fauna in both ponds for 2 years (Figs. 1 and 2). From Table 15 it can be seen that this genus was 8 times as abundant in the fertilized pond as in the unfertilized pond for 2 years.

Individuals of the genus Chrysops were 69 times as abundant in the fertilized pond as in the unfertilized pond for 2 years (Table 12). The relative abundance of Chrysops was not the same in the two ponds, (Figs. 1 and 2).

Palpomyia flavipes (Table 4) was approximately 4 times as abundant in the fertilized pond bottom samples as in the unfertilized pond bottom samples for 2 years.

Three times as many specimens of Chaoborus punctipennis (Table 11) were found in the bottom samples of the fertilized pond as in the bottom samples of the unfertilized pond.

Though no specimens of the genus Caenis were recovered in the bottom samples from the unfertilized pond (Table 13), it was represented in the general collections from that pond (Table 26). Therefore its absence from the bottom samples of the unfertilized pond cannot be attributed entirely to chance egg-laying by adults of this genus. Table 13 shows that 71 specimens of Caenis sp. were recovered from bottom samples of the fertilized pond during the 2 year period.

Berosus sp. (Table 1), Coelambus inaequalis (Table 2), and Haliplus ruficollis (Table 3) were all more abundant in the bottom samples of the fertilized pond than in the unfertilized pond during the 2 years. Examination of Table 3 indicates that the larvae of Haliplus ruficollis appear, in the locality of Lake City, during early July, and that the adults appear in late July through August. This agrees with the life history of this species as outlined by Hickman (5).

Gomphus spicatus was more abundant in the bottom samples of the fertilized pond than in those of the unfertilized pond (Table 16). This species was approximately 3 times as abundant in 1948 as in 1947 in the fertilized pond (Tables 27 and 28). This might be significant because the populations of most of the

Chironomidae were less abundant in 1948 than in 1947 in the fertilized pond (Tables 27 and 28). It is possible that the population of Gomphus spicatus was reduced in the draining of the fertilized pond in 1947. If this important predator of the Chironomidae was reduced in numbers, the Chironomidae might tend to build up a higher population. This is only a possibility, and before accepting or rejecting this supposition a thorough investigation of the problem would have to be made.

Neither Plathemis lydia nor Sympetrum spp. were found in the bottom samples of the unfertilized pond (Tables 17 and 18). However, both were found in general collections of the unfertilized pond (Table 23). It can be seen from Tables 17 and 18 that these two were important in the fertilized pond. No explanation can be given for the absence of Plathemis lydia in the fertilized pond's bottom samples in 1948.

Eleven specimens of Notonecta undulata (Table 19) were recovered in the bottom samples of the fertilized pond in 1947. When the agility and speed of this insect are considered, it seems highly unusual for any of them to be caught in an Ekman dredge. The appearance of this species in the bottom samples of 1947 indicates that its population must have been comparatively very high in that year.

The above differences in numerical populations of insects in the two ponds are regarded as being the result of the appli-

cation of fertilizer.

No explanation for the similarity of numerical populations of the Corixidae (Table 14) in the two ponds can be made. The population of Ranatra americana (Table 19) is greater in the unfertilized pond, but is apparently too small to be significant, as is the case of Coptotomus interrogatus and Acilius semisulcatus (Table 19).

No snails or clams were recovered in the bottom samples of the unfertilized pond during either year. In the fertilized pond, 244 snails and clams were recovered in the bottom samples (Table 22). This difference is regarded as resulting partly from the application of fertilizer, but no explanation is apparent for the complete absence of snails and clams in bottom samples from the unfertilized pond.

Oligochaeta were more than 2.5 times as abundant in the bottom samples from the fertilized pond as from the unfertilized pond during the 2 years (Table 23).

Table 24 lists the volumes and numbers of miscellaneous fauna, excluding insects. The numbers and volumes of these animals are greater in the fertilized pond. These differences are regarded as the result of the application of fertilizer.

Volumes

In general, a volumetric comparison of species from the

two ponds would duplicate the numerical comparison. Tables 27 and 28 show that volumes of insects from the fertilized pond are greater than those from the unfertilized pond.

Volume can be used to compare species within a pond. Thus Fig. 1 shows that the most important insects, listed in descending order of their numerical importance, for the fertilized pond were the Chironomidae, the Ceratopogonidae, the Baetidae, and the Tabanidae. Volumetrically, the most important insects from the fertilized pond, listed in descending order of their importance, were the Libellulidae, the Chironomidae, the Gomphidae, and the Tabanidae. It can be seen that only the Chironomidae and the Tabanidae produce consistently high numbers and volumes. Therefore, they probably can be regarded as the most important insects as sources of fish food in the fertilized pond. Tables 27 and 28 indicate that the most important species of the Chironomidae, volumetrically and numerically, was Chironomus nigricans. However, such is not necessarily the truth because this species may have a life cycle of more than one generation per year, while such a species as Chironomus plumosus has a one year life cycle, leaving very few specimens in the aquatic stage during summer.

The most important insects of the unfertilized pond, numerically listed in descending order of their importance, were the Chironomidae, the Culicidae, the Corixidae and the Ceratopogon-

idae (Fig. 2). Volumetrically the most important insects in the unfertilized pond, listed in descending order of their importance, were the Chironomidae, the Nepidae, the Corixidae, and the Dytiscidae (Fig. 2). It can be seen that only the Chironomidae and the Corixidae are important both numerically and volumetrically. Therefore these 2 families probably represent the most important source of insect fish-food in the unfertilized pond.

From the above it can be seen that the Chironomidae are probably the most important insects as a source of fish food in either pond.

Seasonal Variation in Population

Curves representing the seasonal variation of insect populations for the ponds are shown in Figs. 3 and 4. The curves are based on numbers, and not volumes, of insects. Seasonal variation of populations cannot be completely accurate if expressed in volume because of such insects as the dragonflies whose body volumes increase rapidly as the season advances.

The curves in Figs. 3 and 4 represent the average number of insects in three successive weekly bottom samples. For example, on June 10, 1947, 103 insects were recovered in the bottom samples in the fertilized pond. On June 19, 25 insects were recovered, and on June 28, 22 insects were recovered. The average of these three numbers was 46, and this average was

FIGURE 3. SEASONAL VARIATION OF INSECT POPULATIONS IN FERTILIZED POND

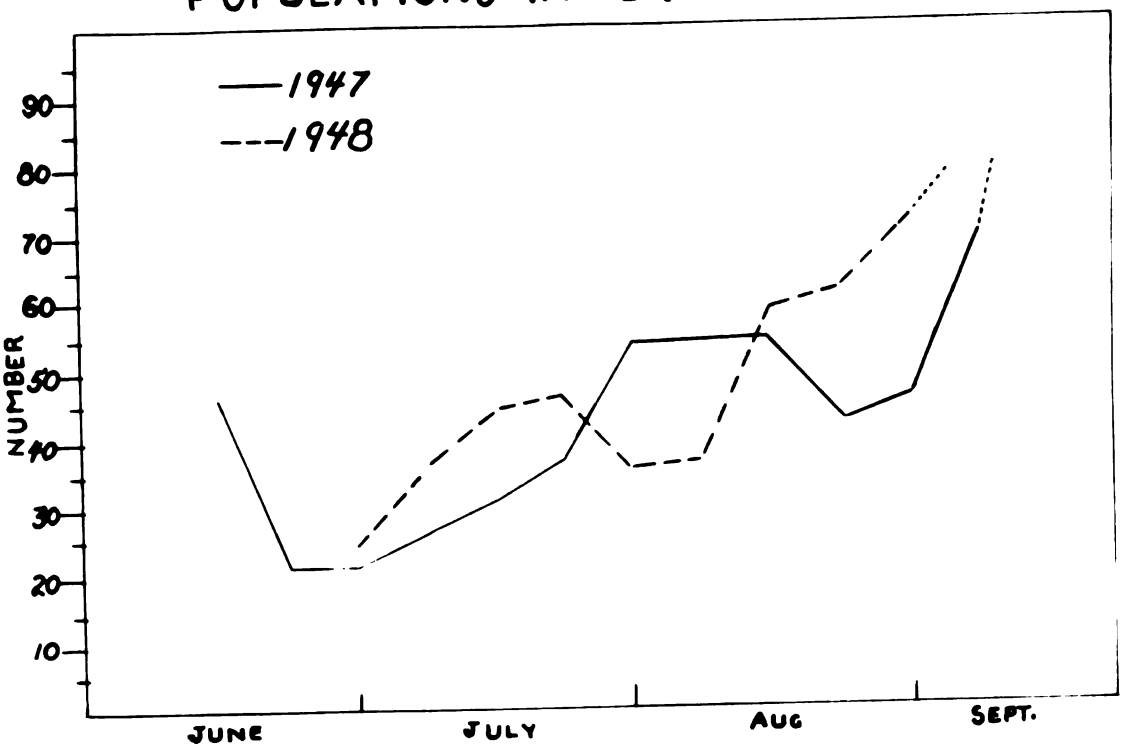
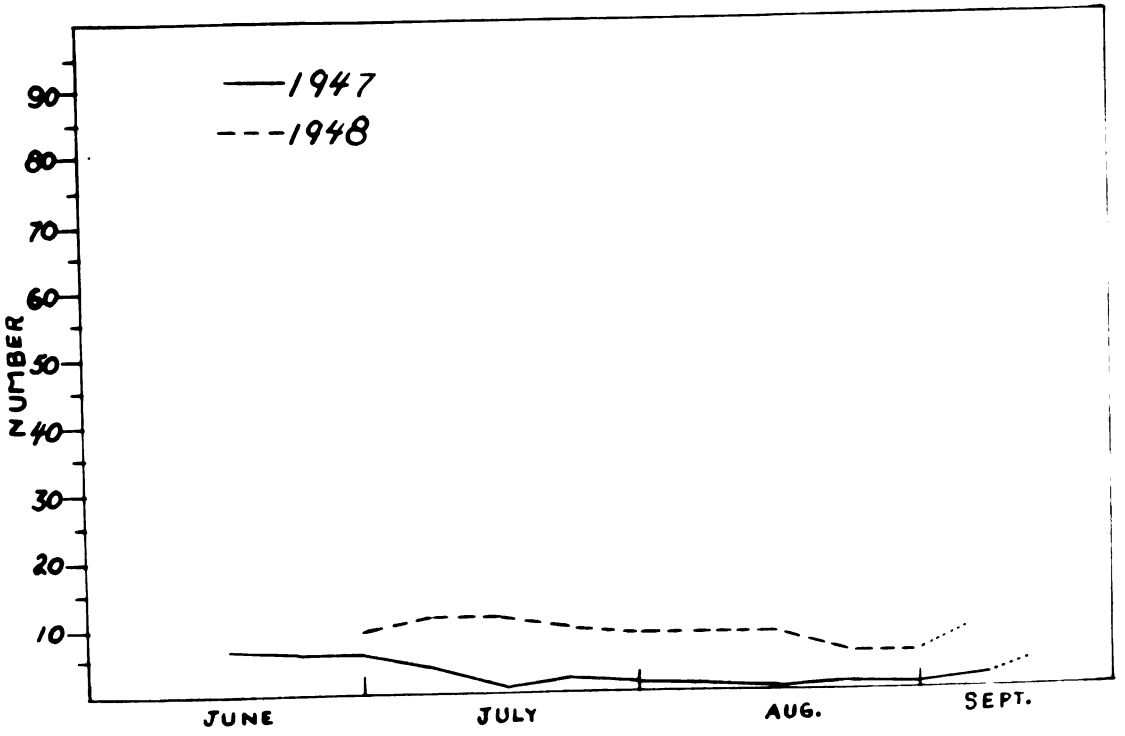


FIGURE 4. SEASONAL VARIATION OF INSECT POPULATIONS IN UNEERTILIZED POND



used to designate the insect population on June 19. All subsequent population figures for the curve were obtained in this manner.

The population curves of the insects (Fig. 3) agree with that found by Ball (1), which represented populations of aquatic organisms inhabiting Potamogeton amplifolius. They do not agree, however, with his curve representing variation in populations of bottom fauna.

Unfortunately, the field work was not started early enough either year to obtain bottom samples before the first period of emergence of insects, which probably occurs in late May. However, the curve for both years, in the fertilized pond, does show the second period of emergence from the pond. In 1947 and 1948 the minimum population by number was reached in late June. The second period of insect emergence occurred during the middle of August in 1947, but in late July in 1948. After the second period of emergence there was a gradual increase in the population into September, when observations were concluded.

The population curves for the unfertilized pond (Fig. 4) vary from those of the fertilized pond. The minimum population for the unfertilized pond in 1947 appeared in the middle of July, with the second period of emergence occurring in the middle of August. In the 1948 population curve for the unfertilized pond, indications were that a minimum was reached sometime in June,

and that the second period of emergence lasted over a long period from the middle of July through late August.

It is possible that the late period of the first emergence in the unfertilized pond in 1947 was the result of insufficient food for insects to complete their normal development. It is also possible that the prolonged period of the second emergence in the unfertilized pond in 1948 was the result of insufficient food for insects to complete their normal developments. If such possibilities were true, the differences in the population curves for the two ponds could be regarded as the result of the application of fertilizer to one pond.

Key for Identifying the Larvae of Chironomidae Found in the Fertilized and Unfertilized Ponds Under Study

A. Labial plate soft and colorless; hypopharynx with well developed supporting frame, and in the center with a five-toothed lingua (Plate I, 9)

B. Segments of the body with only a few scattered bristles; antennae slightly more than half as long as head ..... Pentaneura monilis (L.)

BB. Segments of the body with a hair fringe on each side; antennae at most one-fourth to one-third as long as head ..... Procladius culiciformis (L.)

AA. Labial plate hard and with most of the teeth brown to dark brown; hypopharynx without a central five-toothed lingua (Plate II, 1 and 2)

B. Middle teeth or section of the labial plate distinctly paler than the lateral teeth

C. Central portion of labial plate continuous without a notch; lateral teeth of labial plate long (Plate I, 1) .... Chironomus (Cryptochironomus) sp.

CC. Central portion of labial plate composed of two teeth, presenting a notched appearance; lateral teeth of labial plate moderately long (Plate I, 3)..... Chironomus (Microtendipes) pedellus DeGeer.

BB. Middle teeth or section of labial plate of the same shade as the laterals

C. Labial plate with an even number of teeth

D. Middle pair of teeth of labium distinctly shorter than the adjacent laterals (Plate I, 2) .... Chironomus (Endochironomus) nigricans Joh.

DD. Middle pair of teeth of labium distinctly longer than adjacent laterals (Plate I, 4) .... Chironomus (Polypedilum) sp.

CC. Labial plate with an odd number of teeth

D. Ventral gills on eleventh abdominal segment (Plate I, 6)

E. One pair of ventral gills on eleventh abdominal segment .. .. Unknown species.*

EE. Two pairs of ventral gills on on eleventh abdominal segment ..... Chironomus plumosus L.

DD. Without ventral gills on eleventh abdominal segment

E. Middle tooth of labium trilobed (Plate II, 1) .... Unknown species.**

EE. Middle tooth of labium simple (Plate I, 8)

F. Apex of mandible with four dark teeth (Plate I, 5) .. .. Chironomus lobiferus Say

FF. Apex of mandible with five dark teeth (Plate I, 7) .. .... Cricotopus trifasciatus (Pan.)

* This species fits the description of Chironomus (Einfeldia) insolita Kieff. of Europe

** This species, except for lack of ventral gills on the eleventh abdominal segment, resembles Chironomus decorus Joh.

SUMMARY

A detailed study was made upon the effect on aquatic insects of fertilizer application in two experimental ponds. The field work covered two successive summers at the Michigan State College Lake City Experiment Station, Lake City, Michigan.

Commercial fertilizer was applied to one pond at the rate of 100 pounds per acre at intervals of 3 weeks during summer. The mixture used was 10-6-4 N-P-K.

A total of 150 one-fourth square foot bottom samples was made in the two ponds over the two year period, with an Ekman dredge. This represents 18.75 square feet of bottom sampled in each pond in two summers.

A list of the species, genera, subfamilies and families of aquatic insects is presented. Volumes and numbers are given for each species, genus, subfamily or family. Weekly volumes and numbers are expressed per $3/4^{th}$ square foot. Annual total volumes and numbers are expressed per 1 square foot.

In every case except 5, the populations of all species, genera, subfamilies and families were higher in the fertilized pond than in the unfertilized pond. In the 5 cases where the unfertilized pond produced more than the fertilized pond, 3 were considered as probably insignificant because of the relatively

small numbers in question, and the slight differences.

During the summer of 1947 the fertilized pond produced approximately 15 times as many insects per square foot as the unfertilized pond. Approximately 10 times the volume of insects per square foot were produced in the fertilized pond as in the unfertilized pond in 1947. During 1948 the fertilized pond produced approximately 4 times as many insects per square foot with a volume twice as great as the unfertilized pond.

It is possible that draining of ponds in early spring may increase the population of the Chironomidae by removing some of their predators such as Gomphus spicatus.

Volumes and numbers per $3/4^{th}$ and 1 square foot of miscellaneous organisms are presented. These also showed greater numbers in the fertilized pond than in the unfertilized pond.

A population curve is presented and shows the seasonal variation of aquatic insect populations for each year in each pond. It is suggested that the application of fertilizer may increase the rate of development of aquatic insects by increasing the amount of insect food in ponds. A minimum insect population was reached in late June.

A key to the species of the larvae of Chironomidae (Diptera) is presented with 2 plates illustrating differences in the larval structure.

The differences in populations of insects, numerically

and volumetrically, are regarded as being the result of adding fertilizer. Differences in populations of all aquatic fauna in the two ponds is regarded as a result of adding fertilizer.

BIBLIOGRAPHY

1. Ball, Robert C., 1948. Relationships between available fish food, feeding habits of fish and total fish production in a Michigan lake. Michigan State College Agricultural Experiment Station, Technical Bulletin #206, pp. 1-59.

2. Blatchley, W. S., 1910. An Illustrated Descriptive Catalogue of the Coleoptera or Beetles Known to Occur in Indiana. The Nature Publishing Company, Indianapolis. Vol. 1.

3. Garman, P., 1927. The Odonata or Dragonflies of Connecticut. Connecticut Geological and Natural History Survey Bulletin #39.

4. Hatch, Melville H., 1925. An Outline of the Ecology of Gyrinidae. Bulletin Brooklyn Entomological Society. Vol. 20, pp. 101-114.

5. Hickman, Jennings R., 1930. Life Histories of Michigan Haliplidae (Coleoptera). Papers of the Michigan Academy of Science, Arts, and Letters. Vol. 11, pp. 399-424.

6. Howell, Henry H., 1941. Bottom organisms in fertilized and unfertilized ponds in Alabama. Transactions of the American Fisheries Society. Vol. 71, pp. 165-179.

7. Hungerford, H. B., 1919. The Biology and Ecology of Aquatic and Semi Aquatic Hemiptera. Kansas University Science Bulletin #11, pp. 3-341.

8. Hungerford, H. B., 1948. The Corixidae of the Western Hemisphere (Hemiptera). The University of Kansas Science Bulletin, Vol. 32, pp. 1-827.

9. Johannsen, O. A., 1944. Aquatic Diptera. Part I. Nemocera, Exclusive of Chironomidae and Ceratopogonidae. Cornell University Agricultural Experiment Station, Memoir 164, pp. 1-71.

10. Johannsen, O. A., 1935. Aquatic Diptera. Part II. Orthorrhapha-Brachycera and Cyclorrhapha. Cornell University Agricultural Experiment Station, Memoir 177, pp. 1-62.

11. Johannsen, O. A., 1937. Aquatic Diptera. Part III. Chironomidae: Subfamilies Tanypodinae, Diamesinae, and Orthocladinae. Cornell University Agricultural Experiment Station, Memoir 205, pp. 1-84.

12. Johannsen, O. A., 1937. Aquatic Diptera. Part IV. Chironomidae: Subfamily Chironominae. Cornell University Agricultural Experiment Station, Memoir 210, pp. 1-56.

13. Matheson, R., 1912. Haliplidae of North America (North of Mexico). Journal New York Entomological Society. Vol. 20, pp. 156-193.

14. Needham, J. G., and Needham, P. R., 1927. A Guide to the Study of Fresh Water Biology. The American Viewpoint Society. New York and Albany.

15. Needham, J. G., Traver, J. R., and Hsue, Y. H., 1935. The Biology of Mayflies with a Systematic Account of North American Species. Comstock Publishing Company, Ithaca, New York.

16. Ross, Herbert H., 1944. The Caddis Flies or Trichoptera of Illinois. Illinois Natural History Survey Bulletin. Vol. 23.

17. Smith, E. V., and Swingle, H. S., 1939. The relationship between plankton production and fish production in ponds. Transactions of the American Fisheries Society. Vol. 68, pp. 309-315.

18. Smith, E. V., and Swingle, H. S., 1940. Effect of organic and inorganic fertilizers on plankton production and bluegill bream carrying capacity of ponds. Transactions of the American Fisheries Society. Vol. 69, pp. 257-262.

19. Smith, E. V., and Swingle, H. S., 1941. Winter and summer growth of bluegills in fertilized ponds. Transactions of the American Fisheries Society. Vol. 70, pp. 335-338.

20. Swingle, H. S., and Smith, E. V., 1939. Fertilizer for increasing the natural food for fish in ponds. Transactions of the American Fisheries Society. Vol. 68, pp. 126-135.

21. Swingle, H. S., 1947. Experiments on Pond Fertilization. Alabama Experiment Station, Alabama Polytechnical Institute, Bulletin #254, pp. 1-23.

22. Tack, Peter I., and Morofsky, W. F., 1946. A Preliminary Report on Farm Pond Management in Michigan. Michigan Agricultural Experiment Station Quarterly Bulletin, Vol. 28, No. 4.

23. Tester, A. L., 1932. Food of the Small-mouthed Black Bass (Micropterus dolomieu) in some Ontario waters. University of Toronto Studies #36. Publication Ontario Fisheries Research Laboratory, #46, pp. 171-203.

24. Thomsen, Lillian C., 1937. Aquatic Diptera. Part V. Ceratopogonidae. Cornell University Agricultural Experiment Station, Memoir 210, pp. 57-80.

25. Welch, Paul S., 1935. Limnology. McGraw-Hill Book Company.

KEY TO PLATE I

1. Labial plate of Chironomus (Cryptochironomus) sp.
2. Labial plate of Chironomus (Endochironomus) nigricans Joh.
3. Labial plate of Chironomus (Microtendipes) pedellus DeG.
4. Labial plate of Chironomus (Polypedilum) sp.
5. Apex of mandible of Chironomus (Glyptotendipes) lobiferus Say.
6. Eleventh and twelfth abdominal segment of Chironomus (Chironomus) plumosus L.
7. Apex of mandible of Cricotopus trifasciatus (Panzer).
8. Labial plate of Chironomus (Glyptotendipes) lobiferus Say.
9. Ventral view of head of Procladius culiciformis (L.).

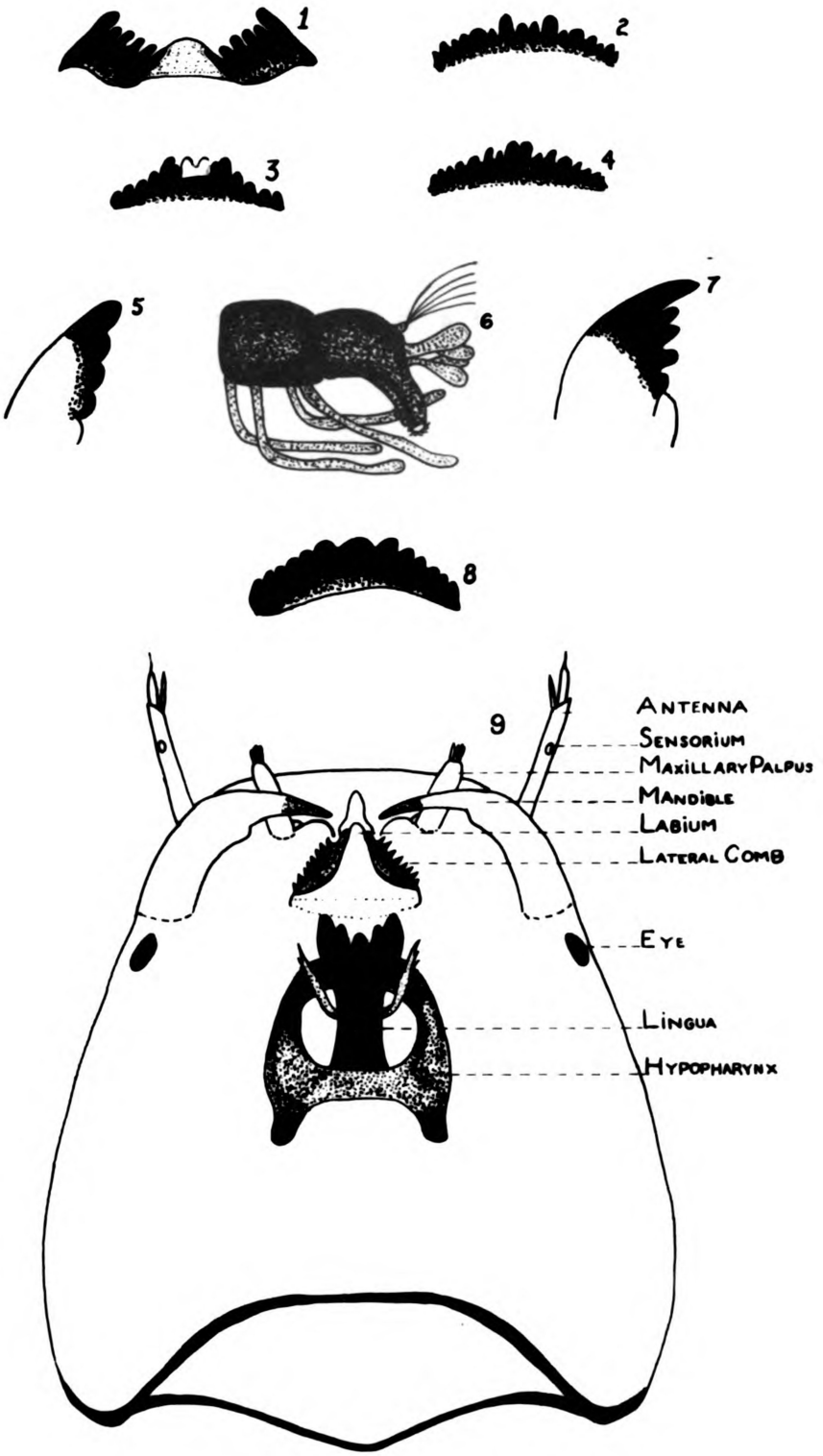
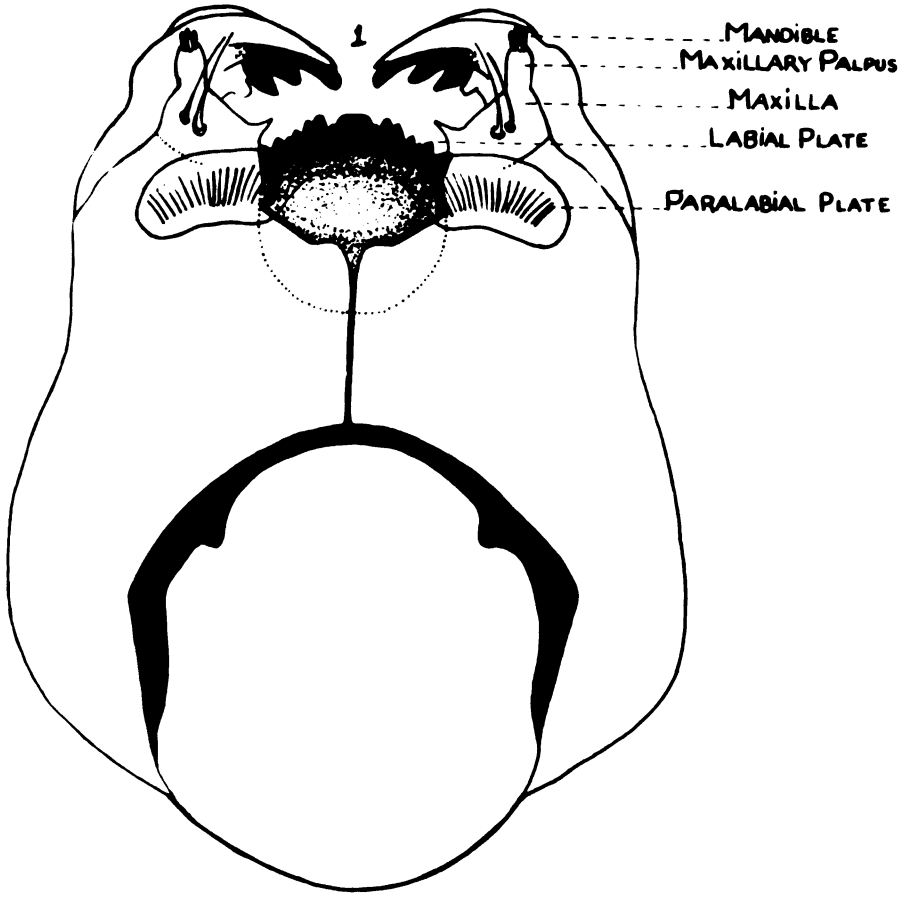

1
2
3
4
5
6
7
8
9
ANTENNA
SENSORIUM
MAXILLARY PALPUS
MANDIBLE
LABIUM
LATERAL COMB
EYE
LINGUA
HYPOPHARYNX

PLATE I

KEY TO PLATE II

1. Ventral view of ventral half of head of a typical Chironominae.
2. Ventral view of dorsal half of head of a typical Chironominae.


1
MANDIBLE
MAXILLARY PALPUS
MAXILLA
LABIAL PLATE
PARALABIAL PLATE

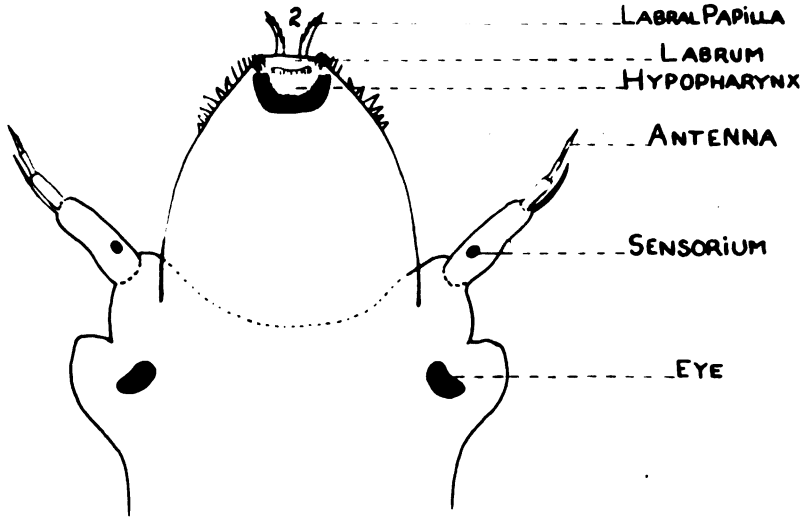

2
LABRAL PAPILLA
LABRUM
HYPOPHARYNX
ANTENNA
SENSORIUM
EYE

PLATE II