Presented at Michigan Acad. Sci., Arts and Letters, 1955.
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Original: Fish Division
cc: Education-Game
Inst. for Fish. Res.
F. F. Hooper
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INSTITUTE FOR FISHERIES RESEARCH
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October 27, 1955

Report No. 1460

SEASONAL ABUNDANCE OF FISH-FOOD ORGANISMS IN SUGARLOAF LAKE, WASHTENAW COUNTY, MICHIGAN[1]

Richard O. Anderson and Frank F. Hooper

Michigan Department of Conservation, Ann Arbor, Michigan

ABSTRACT

A study of the bottom fauna of Sugarloaf Lake was undertaken as a step in analysis of factors influencing fish production of this lake. Samples of the benthos were collected at intervals of approximately 30 days from three stations from April, 1953 through April, 1954. Two stations were located in shallow water (3-4 feet) and the third station was at the deepest portion of the basin (18 feet). The midge, *Tanytarsus jucundus*, and the amphipod, *Hyalella azteca*, made up 74 percent of the total number and 54 percent of the total volume of organisms collected during the period of study at the two shallow-water stations. *Chaoborus punctipennis* was the predominant form at the deep-water station. The standing crop of bottom fauna was much greater in the spring of 1953 than in the spring of 1954. This difference was due to the larger number of *Tanytarsus jucundus* larvae collected in 1953. The size frequency distribution of this midge at each collecting period shows that it emerges in the spring and has one generation per year. The theoretical

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[1] Contribution from the Michigan Institute for Fisheries Research

net production for Tanytarsus jucundus for the 1953-1954 generation was 67.2 pounds per acre. Mortality of larvae from all causes amounted to 72.5 percent of the net production. Observations of changes in the size frequency of Hyalella azteca during the period of study indicate that the reproducing population is replaced approximately twice during the reproductive period (May through September). Uncorrected productivity for this species in 1953-1954 was estimated to be 47.3 pounds per acre.

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INTRODUCTION

Sugarloaf Lake is one of a series of lakes in southern Michigan used by the Institute for Fisheries Research for experimental studies in fish management. Estimates of the fish population of this lake have been made periodically since 1948 (Cooper, 1952; Cooper, 1953; Cooper and Latta, 1954) and creel census data have been collected since 1946. These data have given an estimate of the lake's yield of fish to the angler (Christensen, 1953). To provide data on the factors underlying fish production, a quantitative study of the fish food organisms was started early in 1953. During the initial year of the study (1953-1954), a marked change occurred in the quantity of bottom fauna which could be interpreted in terms of population changes of the midge *Tanytarsus jucundus*. The purpose of this paper is to give results of the first year of the study and to present data on life history, growth, population dynamics and production of the predominant species of bottom animals.

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[1] Contribution from the Michigan Institute for Fisheries Research.

DESCRIPTION OF STATIONS AND METHODS

Sugarloaf Lake is located in the northwest corner of Washtenaw County (T. 1 S., R. 3 E., Sec. 31, 32) and is glacial in origin. It has a surface area of 180 acres and a maximum depth of 18 feet. Approximately 87 percent of the surface area is less than 5 feet deep; 11 percent is between 5 and 10 feet deep. Only 1.3 percent of the basin is deeper than 10 feet. Aquatic vegetation is abundant between the 1-foot and 10-foot contours. A hydrographic map of the lake has been published (Cooper, 1952; Christensen, 1953). The lake is of the hard water type. Methyl orange alkalinity of the surface water ranged from 127 to 171 p.p.m. during the period of study.

Sampling Stations and Methods

Samples were taken at three stations on a transect extending from the east shore of the lake to the maximum depth. Station 1 was located 100 yards offshore. The depth at this station was 3 feet. Station 2, located 300 yards offshore, was 4 feet deep. At Station 3 samples were taken at depths of 15 to 18 feet.

Stations 1 and 2 appeared to be typical of a large percentage of the lake bottom between the 2- and 5-foot contours. Both stations had moderate stands of _Chara_. The bottom soil at these two locations was a mixture of marl and organic matter. A thermocline developed during the summer of 1953 at 13 feet. As a result of stagnation the dissolved oxygen at Station 3 (16 feet) fell below 2.0 p.p.m. on July 10. On August 13, no oxygen could be detected in water of this depth. The bottom soil at this station consisted of a finely divided dark-brown ooze.

At approximately monthly intervals from April 25, 1953 to April 20, 1954, four samples were taken at each station with a 6-inch Ekman dredge.

Each sample was washed in a 30-mesh screen and the residue containing organisms and debris was placed in a one-quart jar and preserved with formalin. At Stations 1 and 2 it was frequently necessary to make several dredge hauls to collect a single suitable sample. The Chara often prevented the dredge from closing completely. When this happened, material and animals were lost from the dredge while it was being drawn to the surface. To remedy this, a seven-foot handle was attached to the dredge, making it possible to force the jaws of the dredge through the surface layer of plants. Once this layer was penetrated, the jaws closed completely in the underlying ooze. The modified dredge was first used in the September 4 collections, 1953. To determine if there was a difference in the efficiency of the two methods, 4 samples were collected at Stations 1 and 2 using the dredge with, and without, the handle. It can be seen from table 1 that the difference in the total number of animals collected with each method are small. The mean number of Hyalella and Tanytarsus jucundus collected with the modified dredge was compared with the mean number collected with the conventional dredge. Comparisons were made by a t-test for Stations 1 and 2. The t-values were not significant for either species. Thereafter samples at these two stations were collected with the modified dredge.

After collecting a series of samples, the jars were brought to the laboratory, the organisms were removed by careful picking, and were sorted to the smallest identifiable taxonomic group. Each group was then counted and measured volumetrically. Ball (1948) discussed the advantage of volumetric over gravimetric methods. The advantages are: considerable time is saved, the equipment used is not elaborate, and volume in milliliters can be converted directly to weight in grams with negligible error. The organisms are not destroyed in making volume measurements and can be further used for taxonomic and seasonal growth studies.

The following materials were used in making the volumetric determinations: a supply of a heavy grade blotting paper, a polyethylene wash bottle with a fine delivery tube, a graduated cylinder, a 1.0-milliliter pipette calibrated into 0.01 milliliter and fitted with a rubber bulb, and a burette stand with clamp to support the pipette. The graduated cylinder was made from a burette which was calibrated to 0.05 milliliter and had an inside diameter of one-fourth inch. A 3-inch section was cut from this burette and flame sealed at one end. The graduated cylinder and pipette were periodically treated with Beckman's "Desicote." This eliminated the meniscus and made a sharp horizontal air-water interface. More precise readings of the water level were thus made possible. "Desicote" also prevented a film of water or water droplets from adhering to the inside of the tube, and thus eliminated an important source of error in volume measurements.

The organisms to be measured were placed on a piece of the blotting paper and allowed to dry for 20 to 30 seconds. While they were drying, the graduated tube was filled to a given level with water from the wash bottle. The organisms were then placed in the tube. The displaced water was drawn into the pipette where the volume could be accurately read. With this technique, the volume of a sample could be quickly and easily determined with a minimal amount of error.

QUALITATIVE DETERMINATION OF BOTTOM FAUNA

A list of invertebrates collected during the period of study is given below. Nomenclature used for the Tendipedini is that given by

Townes (1945). Numbers in parentheses following each group indicate the station at which the species was collected.

Oligochaeta

Lumbriculidae (1, 2, 3)

Tubificidae (1, 2, 3)

Hirudinea (1, 2)

Ostracoda (1, 2)

Amphipoda - Hyalella azteca (Saussure) (1, 2)

Decapoda - Orconectes rusticus (Girard)[2] (1, 2)

Hydracarina (1, 2)

Ephemeroptera

Ephemeridae - Hexagenia sp. (1, 2)

Baetidae - Ephemerella sp. (1)

Caenis sp. (1, 2)

Callibaetis sp. (1)

Siphlonurus sp. (2)

Odonata

Libellulidae - Tetragoneuria sp. (1, 2)

Coenagrionidae - Enallagma sp. (1, 2)

Trichoptera

Phryganeidae - Banksiola selina (Betten) (1, 2)

Hydroptilidae - Oxyethira sp. (2)

Leptoceridae - Oecetis sp. (1, 2)

Leptocella sp. (2)

Psychomyiidae - Polycentropus sp. (1, 2)

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[2] This species was not included in the quantitative data.

Diptera

Culicidae - *Chaoborus punctipennis* (Say) (1, 2, 3)

Tendipedidae (= Chironomidae)

Pelopiinae (= Tanypodinae)

Pentaneura sp. (1, 2, 3)

Procladius spp. (1, 2, 3)

Clinotanypus sp. (1, 2)

Hydrobaeninae (= Orthocladiinae) (1, 2, 3)

Tendipedinae (= Chironominae)

Calopsectra gregarius (Kieffer) (1, 2)

Lauterborniella sp. (2)

Microtendipes pedellus (De Geer) (1, 2)

Polypedilum (*Polypedilum*) *nubeculosum* (Meigen) (1, 2)

Polypedilum (*Polypedilum*) sp. (1, 2)

Tanytarsus (*Endochironomus*) *nigricans* (Johannsen) (1, 2)

Tanytarsus (*Tribelos*) *jucundus* (Walker) (1, 2)

Tanytarsus (*Stictochironomus*) sp. (2)

Cryptochironomus digitatus (Malloch) (1, 2, 3)

Tendipes (*Limnochironomus*) *fumidus* (Johannsen) (1, 2)

Tendipes (*Limnochironomus*) *nervosus* (Staeger) (1, 2)

Tendipes (*Tendipes*) spp. (1, 2, 3)

Harnischia (*Harnischia*) *tenuicaudata* (Malloch) (3)

Heleidae (= Ceratopogonidae) (1, 2, 3)

SEASONAL CHANGES IN THE QUANTITY OF BOTTOM FAUNA

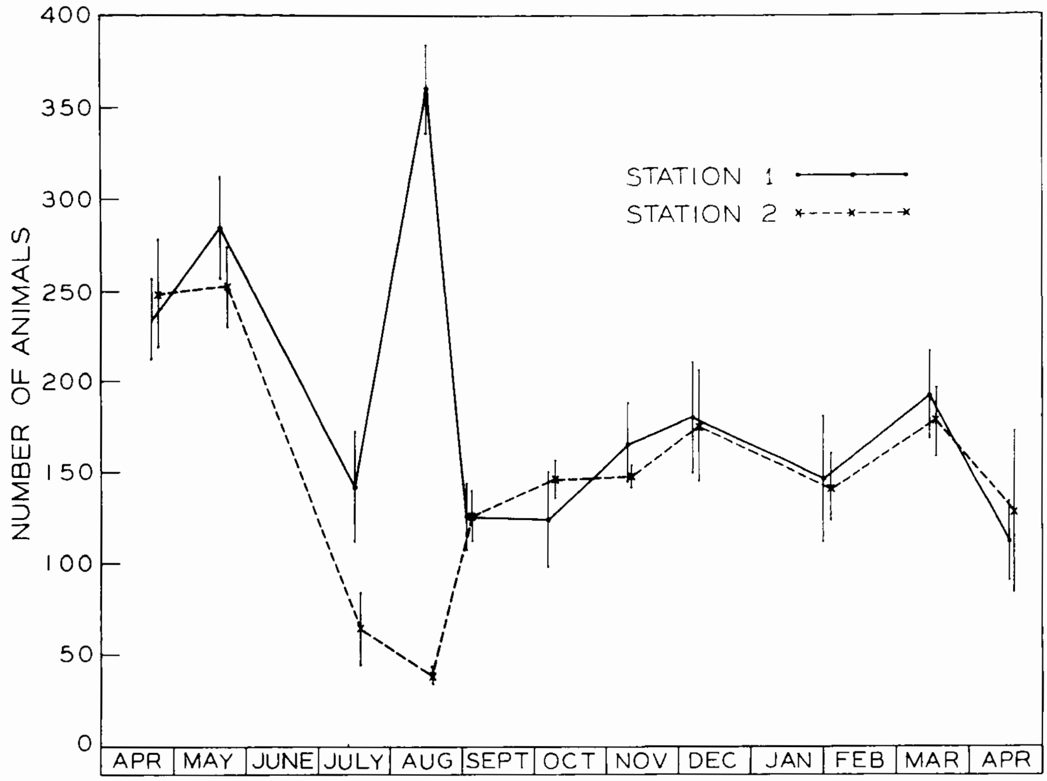
Both annual and seasonal fluctuations in the standing crop are large (Fig. 1). The total volume of organisms found at Stations 1 and 2 in April, 1953, was approximately three times the volume found in April, 1954.

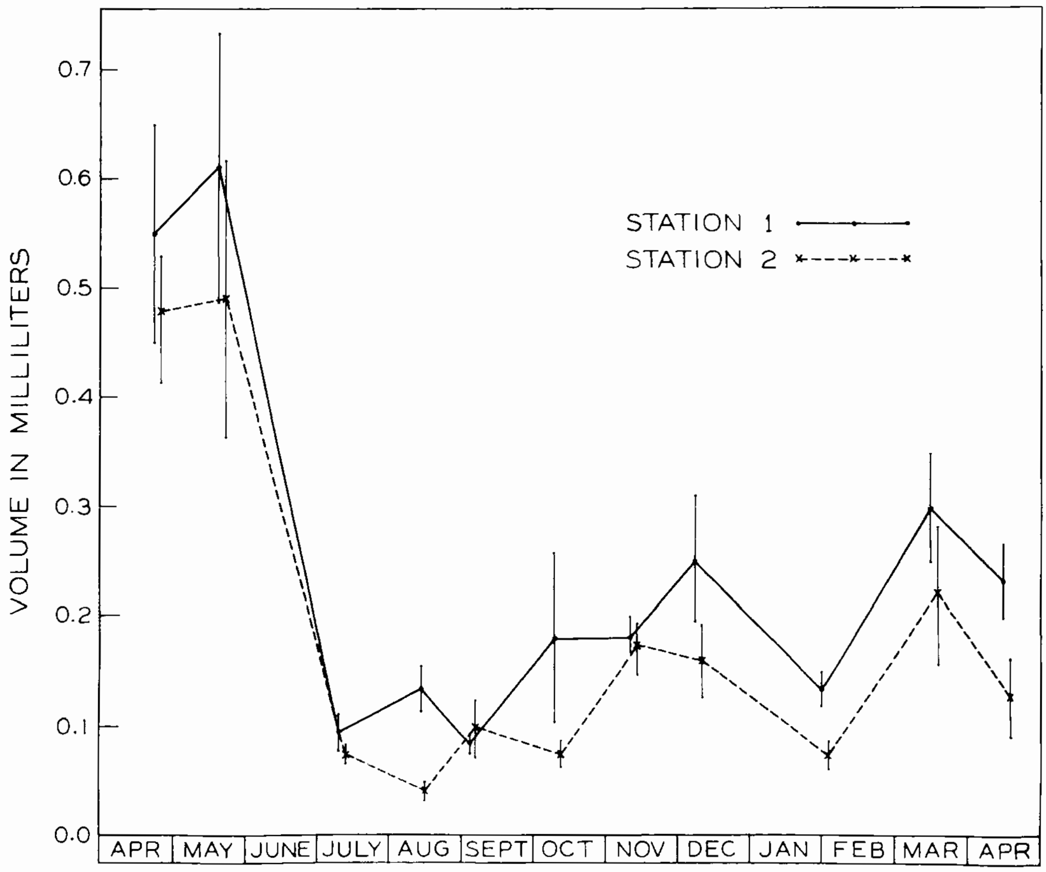
Similar large annual fluctuations have been observed in other waters. Lundbeck (1926) found that the total weight of fauna in a bay of Plöner See during the growing season 1924-1925 was almost twice as great as the total for 1923-1924. Working on Swedish lakes, Alm (1922) demonstrated a decrease of similar proportions in the total quantity of fauna between the seasons 1918-1919 and 1919-1920. During the period of study, Tanytarsus jucundus and Hyalella azteca made up, on the average, 76.6 percent of the mean number and 58.2 percent of the mean volume at Station 1, and 69.7 percent of the mean number and 51.7 percent of the mean volume at Station 2. Fluctuations in total standing crop of organisms to a large extent reflect population changes in these two species.

The greatest volume of invertebrates was found in the spring of 1953. On April 25, Tanytarsus made up 69.8 percent of the total volume and 49.9 percent of the total numbers of animals found at Stations 1 and 2. By May 22, the number of larvae of this midge had been reduced by approximately one-half, probably as a result of emergence and predation. However the total volume of botton fauna was maintained at a high level during this period by rapid growth of Hyalella.

By July 10 the Tanytarsus emergence was completed and a few newly hatched larvae were collected (Fig. 4). In collections between April 25 and July 10 the average combined number of Hyalella for Stations 1 and 2 remained nearly constant although the number of animals increased at Station 1 and decreased at Station 2 (Fig. 2). This suggests that there might have been a shoreward migration of this amphipod. Although the total number of Hyalella at Stations 1 and 2 was the same for June and July, there was a drop in the total volume of animals due to disappearance of the larger individuals. The emergence of Tanytarsus

Figure 1. The average number and volume of organisms per one-quarter square foot of bottom at Stations 1 and 2, Sugarloaf Lake, Michigan. The vertical lines represent the standard error of the mean for each collection.


400
350
300
250
200
150
100
50
0
NUMBER OF ANIMALS
STATION 1
STATION 2
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR


0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
VOLUME IN MILLILITERS
STATION 1
STATION 2
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR

and other insects together with the decrease in average size of Hyalella resulted in a sharp decline in the volume of the standing crop between May 22 and July 10. The decrease in total volume of Hyalella azteca continued into August at which time this species was at its lowest level of abundance for the year.

In the August samples collected at Station 1, small Tanytarsus larvae numbered 1,114 per square foot. This is in contrast to Station 2 where only 18 larvae per square foot were recorded. By September the concentration of larvae at Station 1 was reduced to 231 per square foot. Such a great reduction in numbers may be somewhat abnormal. Over 600 larvae per square foot in the previous generation had survived until spring.

From September to December there was an increase in number and volume of bottom animals. Hyalella contributed heavily to this increase. In late January there was a decrease in the number and volume of bottom fauna. This was followed by an increase in March. The decrease in January appears to be a systematic error in sampling of Hyalella which was perhaps caused by a change in habits of this animal under ice cover. The reduction in total number and volume of Hyalella from March to April may have been the result of predation.

The mean number and volume of the organisms for the year at Station 1 and Station 2 are in good agreement (Table 1). The greatest difference is the higher number of Tanytarsus larvae found at Station 1. Such good agreement between separate sampling stations suggests that much of the lake bottom has a fauna of similar quantitative characteristics.

At Station 3, Chaoborus punctipennis made up 97.5 percent of the mean number and 89.2 of the mean volume of bottom fauna for the entire sampling period. The annual minimum for this species occurred in July when 92 larvae, which had a total volume of 0.185 milliliter were found

Figure 2. The average number and volume of Hyalella azteca per one-quarter square foot of bottom at Stations 1 and 2, Sugarloaf Lake, Michigan. The vertical lines represent the standard error of the mean for each collection.

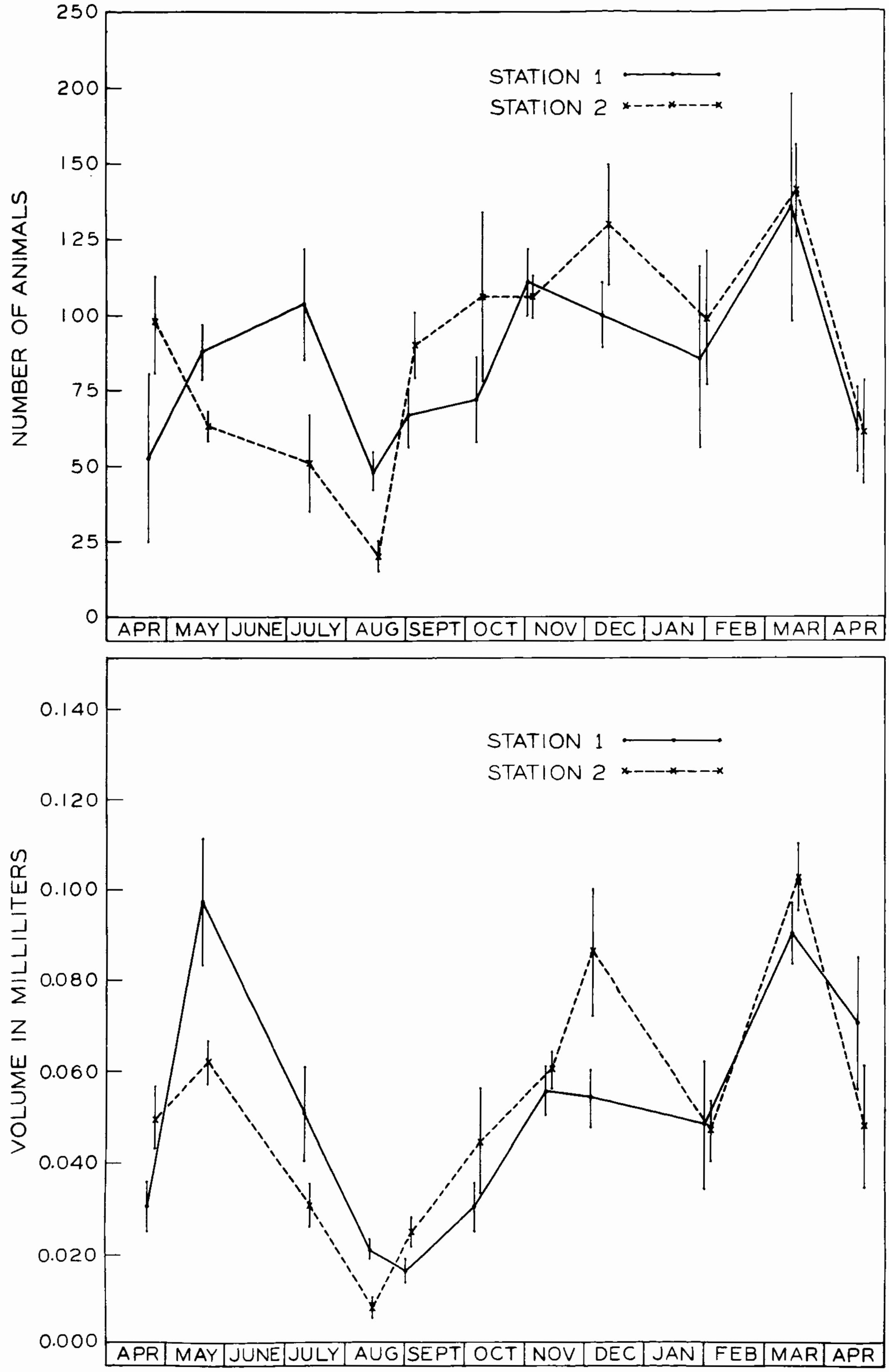

250
200
150
125
100
75
50
25
0
NUMBER OF ANIMALS
STATION 1
STATION 2
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
VOLUME IN MILLILITERS
STATION 1
STATION 2
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR

Table 1.—Numbers and volumes (in milliliters times 1,000) of organisms per square foot at Stations 1 and 2

Date of Collection	Hyalella azteca		Caenis		Hexagenia		Tanytarsus jucundus		Other Tendipedinae		Pelopiinae		All others		Totals	
Station 1	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.
1953																
April 25	212	125	13	30	...	...	609	1,820	44	100	14	45	46	85	938	2,205
May 22	353	410	84	275	8	310	279	1,030	368	225	84	60	53	135	1,229	2,445
July 10	419	205	4	10	...	...	61	5	10	5	44	85	30	65	568	375
Aug. 13	193	85	...	...	...	...	1,114	280	43	15	21	25	66	105	1,437	510
Sept. 4	254	70	2	...	...	...	231	65	29	15	6	10	35	90	557	250
Sept. 4*	282	65	2	5	2	190	138	30	13	5	5	5	13	65	455	365
Oct. 7	288	120	83	145	7	315	28	10	19	...	32	65	42	45	499	700
Nov. 11	445	225	4	5	3	325	22	15	107	15	36	50	48	100	665	735
Dec. 9	400	220	9	15	1	240	117	240	89	25	40	125	62	140	718	1,005
1954																
Jan. 29	343	190	...	...	...	...	94	235	117	45	16	30	12	25	582	525
March 16	542	365	...	...	3	485	70	240	116	65	13	20	23	35	767	1,210
April 20	248	285	...	...	...	...	50	190	58	55	44	120	51	250	451	900
Mean	332	197	17	40	2	155	234	347	84	48	30	53	40	95	739	935
Station 2																
1953																
April 25	389	195	58	95	3	165	352	1,050	124	170	20	50	43	180	989	1,905
May 22	252	250	140	540	2	175	171	535	229	100	110	95	105	260	1,009	1,955
July 10	203	125	1	...	1	85	8	...	3	5	24	40	16	40	256	295
Aug. 13	80	30	2	5	...	...	18	...	15	10	3	5	31	100	149	150
Sept. 9	362	110	6	10	2	205	55	15	30	5	29	55	27	55	511	455
Sept. 9*	361	95	10	15	2	85	50	10	31	5	32	65	23	50	509	325
Oct. 7	426	175	10	15	...	...	30	10	51	5	21	40	46	55	584	300
Nov. 11	424	240	7	15	3	225	4	...	75	15	29	45	49	140	591	680
Dec. 9	520	345	6	20	1	80	5	10	102	20	30	50	36	125	700	650
1954																
Jan. 29	397	185	4	10	...	...	1	...	116	30	30	35	20	25	568	285
March 16	566	415	1	...	2	325	3	10	94	30	19	30	22	75	707	885
April 20	247	195	3	10	...	...	6	20	179	115	49	110	29	65	513	515
Mean	352	197	21	61	1	112	59	138	87	42	33	52	37	98	590	700

*Samples collected with modified Ekman dredge. For explanation see text.

per square foot. In late summer and early fall a rapid increase in the population occurred and in October the sampling showed 3,900 larvae totaling 6.590 milliliters per square foot. The samples during winter and early spring showed a steady decline in numbers. On April 20, 1954, 322 larvae (0.610 milliliter) were found per square foot. This general pattern of seasonal variation is similar to that found by Eggleton (1931) in the profundal region of Third Sister Lake.

SEASONAL CHANGES IN SIZE FREQUENCY OF *Hyalella azteca*

The length-frequency distribution of Hyalella at each collecting period has been plotted (Figure 4). All measurements of *Hyalella* were made under a binocular dissecting microscope with a magnification of 8.4 diameters. The curved shape of the preserved specimens made it necessary to straighten them in order to determine total lengths. This was done with a thin plate of glass 2 1/2 inches by 3 inches, two 1-inch by 3-inch glass slides, stop cock grease, and a millimeter rule which was attached to the stage of the microscope. One surface of the glass plate was coated with a thin layer of grease and then the two slides were pressed into position to form a shallow rectangular groove. By moving the slides closer together or farther apart, the width of the groove could be readily adjusted to accommodate individuals of various sizes. A series of animals were placed in the groove, straightened to the desired position and measured under the microscope. With this technique it was possible to measure the length of a number of animals quickly and accurately to the nearest 0.5 millimeter. For each collecting date, all the animals in at least two, 1/4-square-foot samples, from each station were measured. There was no indication of differences in the size frequency between samples or between stations on any given date.

Increasing water temperature from April 25 to May 22 seemed to provide conditions favorable for growth. Examination of the brood pouches of the females collected on April 25 failed to show a single specimen carrying eggs. On May 22 most females over 3.0 millimeters long were carrying eggs or young animals in their brood pouches. No young were collected on May 22 because few individuals less than 1.5 millimeters in length were retained by the sieve. The small, newly hatched animals found in the brood pouches on May 22 were all approximately 1.0 millimeter in length. By July 10, some of the young apparently had grown to mature size and many other small individuals were collected. The largest animals present in the May 22 collection had disappeared.

In August, the standing crop of *Hyalella* was at its lowest level. Two conditions seem to have brought about this minimum. First, there are comparatively few sexually mature individuals in the population during mid-summer and second, the reproductive population at this time is made up of young, born in spring and early summer, which have just reached maturity. These animals have a smaller average size than adults found early in the season and tend to have small broods (Gaylor, 1922).

Wienert[3] found that reproduction in *Hyalella* ceased for the year in September. The reduced number of animals found in the 1.5 millimeter class in October supports this observation. The increase in average size of individuals during the fall indicates that the animals probably continue to grow until November. There was no evidence of growth during the period of ice cover. In fact, a slight decrease in average size

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[3] Wienert, K. 1940. Biology of the Amphipoda of Michigan. 168 pp. Ph.D. thesis, University of Michigan.

during the January-to-March period is suggested. From March 16 to April 20, growth was apparently resumed and the length-frequency distribution of the specimens collected on April 20, 1954 was almost identical to that found the previous April.

SEASONAL CHANGES IN THE SIZE FREQUENCY OF *Tanytarsus jucundus*

The length-frequency distributions of *Tanytarsus jucundus* larvae at each collecting period clearly indicate that this species has a one-generation-per-year life cycle (Figure 4). The larvae reach an average size of 12 millimeters before the adults emerge in the spring. Only small numbers of young larvae were found in samples collected on July 10. By August 11, most of the young larvae had hatched and grown to an average size of 5 millimeters. Growth was slow between August 13 and October 7 but was rapid between October 7 and November 11. Growth continued at a slower rate during the period of ice cover. By April of 1954 the larvae had again attained an average size of 12 millimeters, the same average size observed during April of the previous year.

BOTTOM FAUNA PRODUCTIVITY

Measurement of the standing crop of bottom fauna at any one time is not a measure of production. Production as defined by Clarke (1946) must be expressed in terms of rate, *e.g.*, in units of weight, volume or energy per unit area per unit time. Since many of the bottom fauna organisms have a yearly life cycle, it is logical to use a year as the unit of time. The weight of animals in the standing crop may be increased by growth of the individuals or by recruitment of new animals into the population. Obviously, if the weight of new protoplasm produced over a period of time is greater than the amount lost through mortality, emergence, or migration, the standing crop will be increased. Conversely, if the amount of material lost is greater than that gained, the standing crop will be reduced. Total production of bottom fauna depends upon the rate of change of the standing crop of each species in the community. To make an exact measurement of production, it is necessary to study the dynamics of each species of animal during a given period.

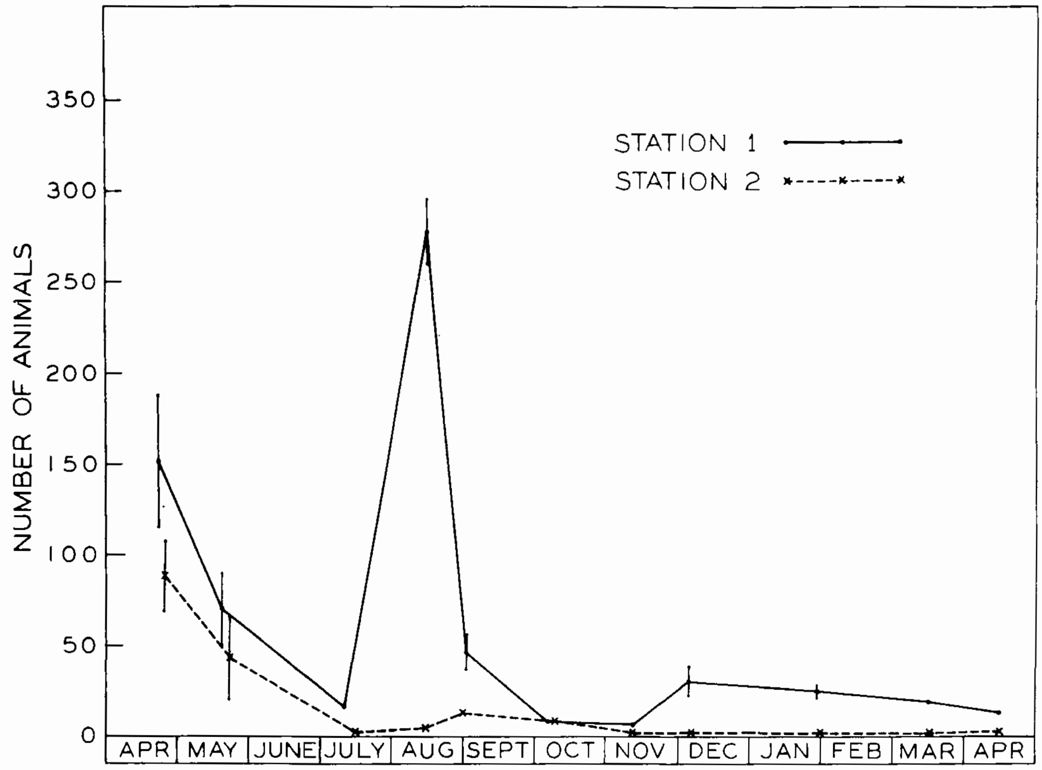
Calculation of the productivity of the midge, *Tanytarsus jucundus*, in Sugarloaf Lake is a relatively simple problem because this species occurred in large numbers and was apparently randomly distributed over a given area. Since there is only one generation per year, growth of individuals and population size can be followed from hatching to emergence. Figure 3 shows that there was a slight increase in the number of larvae between November 11 and December 9. Since there was no reproduction during this period, the low numbers during October and November probably reflect a systematic error in sampling. In order to calculate the production for this period, it is assumed that the population decreased at a constant rate between September 4 and December 9.

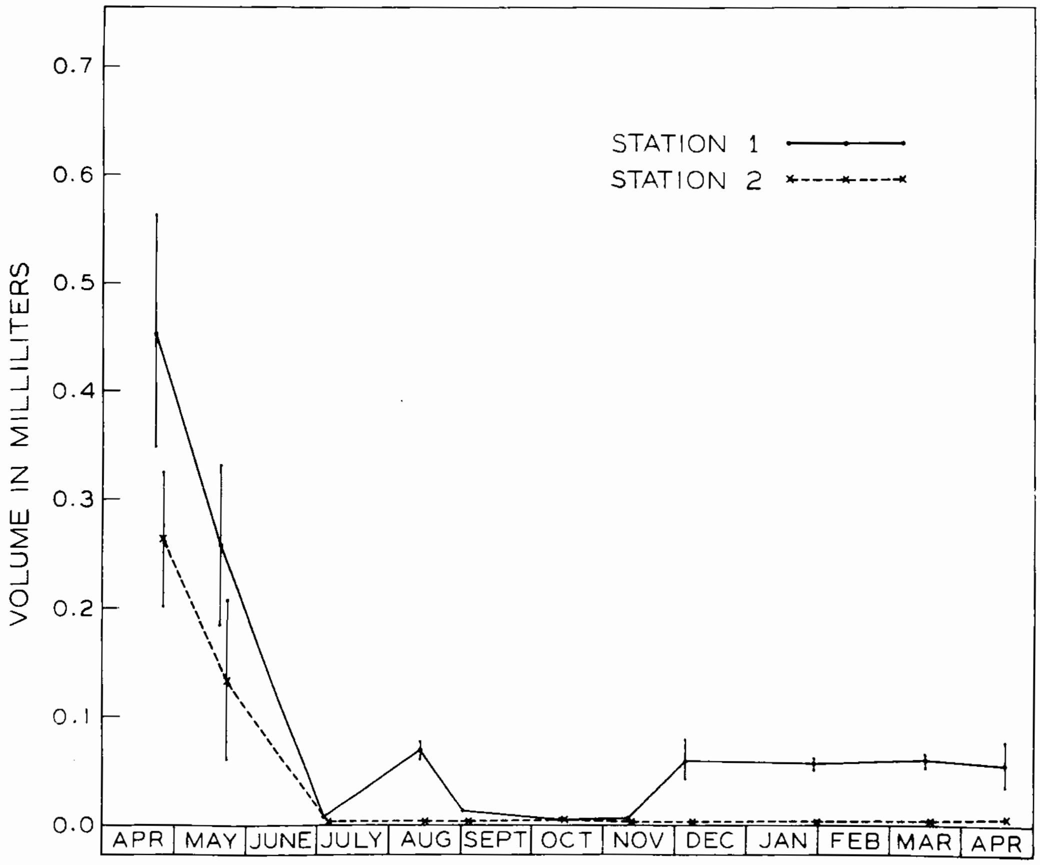
Production (P) is equal to the crop (C), *e.g.* the volume of animals which grow to emergence size, plus the volume of animals which die before reaching this size (M).

$$P = C + M$$

The quantity (P) is net production since no correction is made for respiratory loss (Clarke, 1946; Clarke, Edmondson and Ricker, 1946). The crop of animals for the 1953-1954 generation was considered to be the volume of animals found on April 20, 1954. The volume of animals lost between two collecting periods was calculated by multiplying the difference in numbers present in the two collections by the average size of larvae during this period. The total volume of animals which died before reaching emergence size (M) is equal to the sum of mortality between successive collections.

Figure 3. The average number and volume of Tanytarsus jucundus per one-quarter square foot of bottom at Stations 1 and 2, Sugarloaf Lake, Michigan. The vertical lines represented the standard error of the mean for each collection.


STATION 1
STATION 2
NUMBER OF ANIMALS
350
300
250
200
150
100
50
0
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR


STATION 1
STATION 2
VOLUME IN MILLILITERS
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
APR
MAY
JUNE
JULY
AUG
SEPT
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DEC
JAN
FEB
MAR
APR

Table 2.-Calculation of production of Tanytarsus jucundus for the year 1953-1954.

Date	Standing crop per one-quarter square foot: Mean number	Standing crop per one-quarter square foot: Mean volume in milliliters	Mean volume in milliliters of individuals ($\bar{V}$)	Difference in number of larvae per one-quarter square foot in succeeding samples $N_{T_1}-N_{T_2}$	Mean size of larvae in milliliters between collections $\frac{\bar{V}_{T_1} + \bar{V}_{T_2}}{2}$	Mortality of larvae in milliliters per one-quarter square foot (M)
1953						
Aug. 13	278.5	0.070	0.00025	...	...	...
Sept. 4	46.12	0.012	0.00026	232.38	0.00025	0.0581
Dec. 9	29.25	0.060	0.00205	16.87	0.00116	0.0196
1954						
Jan. 29	23.50	0.058	0.00247	5.75	0.00226	0.0130
Mar. 16	17.50	0.060	0.00343	6.00	0.00295	0.0177
Apr. 20	12.50	0.048	0.00384	5.00	0.00364	0.0182
		Total mortality in milliliters per one-quarter square foot				0.1266
		Volume of animals in milliliters growing to emergence size				0.0480
		Total production in milliliters per one-quarter square foot				0.1746
		Theoretical production in pounds per acre				67.2

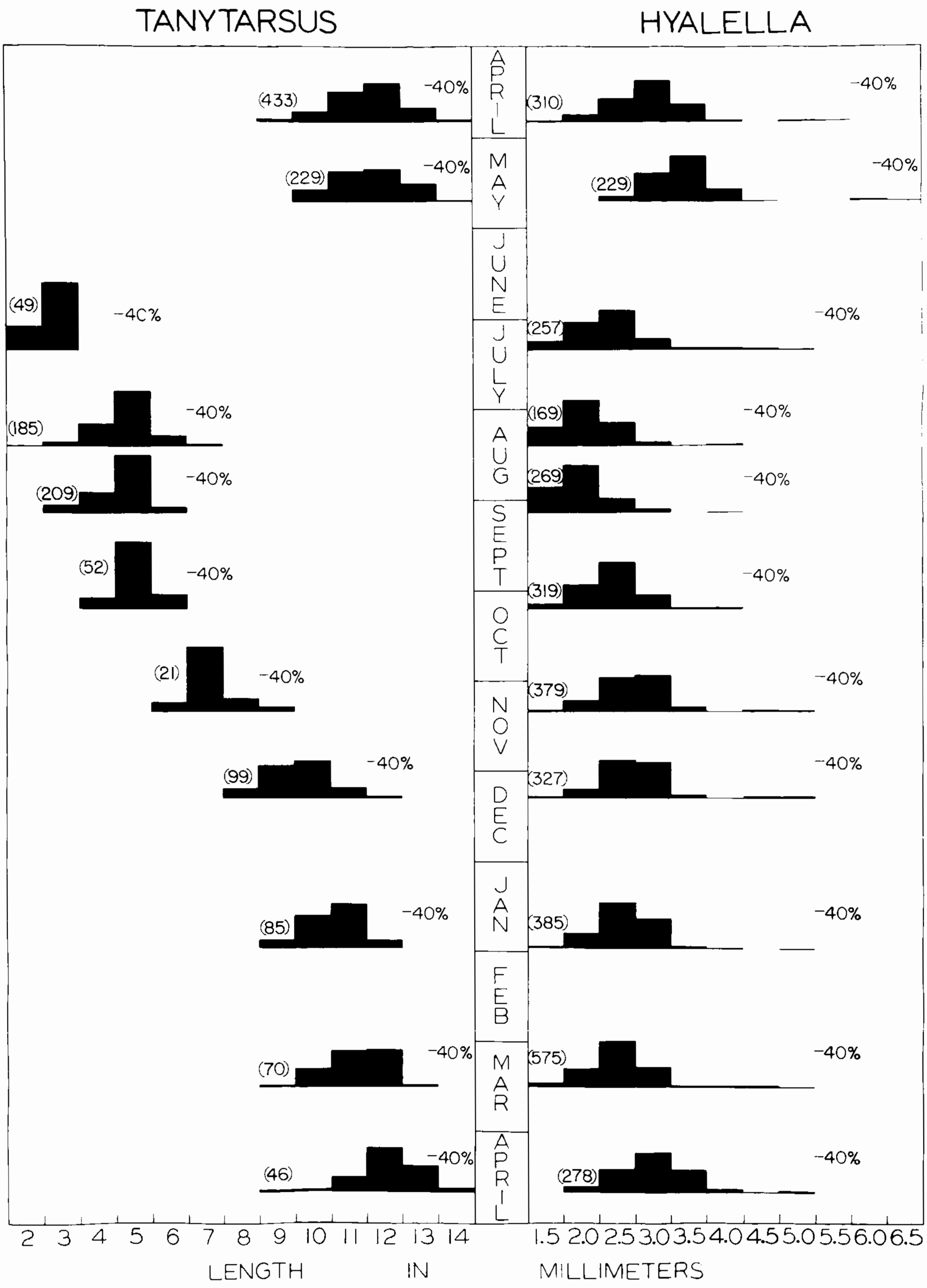
The annual production for the 1953-54 generation has been calculated to be 67.2 pounds per acre (Table 2). There was probably a great difference in the production of this species between 1952-1953 and 1953-1954. In comparing the crop alone, 18.5 pounds per acre were produced in 1954, and 175.0 pounds per acre in 1953.

Mortality of larvae from all causes from August 1953 to April 1954 amounted to 72.5 percent of the net production. This represents 2.64 times as great a volume of animals as that which lived to emergence. Since there is probably further predation on Tanytarsus at the time of emergence, this species is apparently utilized rather efficiently in the food chains and a large part of the energy fixed by this species passed on to higher trophic levels. The mortality rate was high compared to that of Chironomus plumosus larvae in Lake Beloie (15.4 percent) (Borutzky, 1939). This difference possibly reflects the greater vulnerability of a littoral species of midge (Tanytarsus jucundus) to predators as compared to a species found also on the sublittoral and profundal bottom.

Calculating productivity for Hyalella is more difficult than for Tanytarsus. With the present data, only an estimate of the uncorrected production can be made. To do this, it is necessary to know how long it takes the animals to reach maturity and give birth to young.

Geisler (1944) and Wilder (1940) have studied the reproduction and growth of Hyalella under laboratory conditions. Animals studied by Geisler were kept at 16°-18° C. (61°-64° F.) and Wilder's animals were raised at a mean temperature of 25° C. (77° F.). At the lower temperature it took approximately 83 days for the animals to grow to mature size and 22 to 24 additional days were required for the development and

Figure 4. Seasonal change in the length-frequency distribution of *Tanytarsus jucundus* and *Hyalella azteca*. The occurrence of individuals of various lengths is expressed as a percentage. The numbers in parentheses are the number of individuals measured.


TANYTARSUS
HYALELLA
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APRIL
(433)
(229)
(49)
(185)
(209)
(52)
(21)
(99)
(85)
(70)
(46)
(310)
(229)
(257)
(169)
(269)
(319)
(379)
(327)
(385)
(575)
(278)
-40%
2 3 4 5 6 7 8 9 10 11 12 13 14
1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5
LENGTH IN MILLIMETERS

shedding of young. At the higher temperature approximately 50 days were required to reach maturity and young were shed 7 to 9 days after oviposition. The mean surface temperature at Sugarloaf Lake during the reproductive season in 1953 (May through September) was approximately 22° C. (71.6° F.). If the laboratory data are interpolated, at 22° C. maturity may be reached in 62 days and young shed about 14 days later. Since the reproductive season is approximately 150 days long, the reproducing population may turn over twice during this period. The estimate for uncorrected productivity would then be the standing crop around the middle of July plus the standing crop the following May. These approximations are supported by the fact that there was approximately a 90 percent turnover in the population at Sugarloaf Lake between May 22 and July 10, 1953 (Fig. 4). Assuming that the standing crop in May 1953 is similar to that in May 1954, the uncorrected productivity for 1953-1954 is 47.3 pounds per acre.

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