A PRE-IMPOUNDMENT BOTTOM-FAUNA STUDY OF WATTS BAR RESERVOIR AREA (TENNESSEE)[1]

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ABSTRACT

Pre-impoundment bottom-fauna data are presented for the Watts Bar Reservoir area (Tennessee). A salting-out technique is described which was used to facilitate the separation of organisms from debris. In deep water four major taxonomic groups made up 98.93 per cent of the total number and practically 100 per cent of the total volume. Nymphs of *Hexagenia bilineata* (Say) composed 82.43 per cent of the total volume. This species probably has a 1-year life cycle in Tennessee. Production was highest on the muddy bottom and lowest on sand. Data on depth distribution showed the first 10 feet to be most productive. The seasonal peak of production was reached during September and October. This maximum was due almost entirely to mayflies. The rate of growth of *Hexagenia* nymphs was most rapid during August and September or immediately following hatching. The riffles and flats at the shallow-water station were less productive than the mud-sand bottom of the deep water. The fauna of the riffles and flats will probably not survive impoundment; however, the fauna of the deep-water area will survive.

INTRODUCTION

A series of studies aimed at learning what changes occur in basic fertility, fish food, fish population, and fishing with transformation of the Tennessee River and many of its tributaries from streams to reservoirs is being conducted. The present study was undertaken to determine the relative amount of bottom fauna potentially available for fish food prior to impoundment in that portion of the original river channel now included by Watts Bar Reservoir. A concurrent bottom-fauna study was made in the original river channel of that part of the Holston River which is now flooded by Cherokee Reservoir. Cherokee is a storage reservoir and Watts Bar is a run-of-the-river reservoir; the two types differ decidedly as habitats for fish and fish food. A comparison of the bottom fauna in the two reservoir areas before and after impoundment is planned.

Watts Bar Reservoir (Table 1) is located on the Tennessee River 530 miles above the mouth, between Chickamauga and Fort Loudoun Reservoirs. It is the second of a series of nine reservoirs which impound the entire length of the Tennessee River from its source to within about 20 miles of its mouth (Ohio River).

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Table 1.—Morphometric data on Watts Bar Reservoir, Tennessee. All elevations are in feet above sea level. (Data from Watts Bar Project, T.V.A. Water Control Planning Department, December 1938.)

Original river area (acres)	10,700
Reservoir:	
Area (acres)	
maximum, at elevation 745	41,500
minimum, at elevation 735	32,200
Length (miles)	72.4
Shoreline (miles) normal pool at elevation 741	543.0
Average width (miles) at elevation 741	0.82

ing technique; and to Alden M. Jones for aid in collecting and sorting samples.

Stations

Station I, for deep-water (1-30 feet) samples, was chosen near the center of the reservoir area just below Long Island between miles 569 and 570. In this area the bottom was composed primarily of mud and sand. The mud and sand bottom was the predominant type of habitat along the channel of the Tennessee River in the Watts Bar Reservoir area. In this type of habitat, current, except during periods of flood, was for the most part negligible. The bottom was arbitrarily classified as either mud, sand, muddy sand (sand predominating), or sandy mud (mud predominating).

Station II, for shallow-water (2-18 inches) samples, was selected in the same general locality near the upper end of Ebben Island which was located to the left and approximately 1 mile above the lower end of Long Island. In this area the water flowed over a bottom consisting of rocks and gravel. Here the current was relatively strong and in certain places produced riffles. For this reason samples were collected from an area where the water surface was classified as flat or riffled. Whether or not the surface of the water is flat or riffled depends upon some combination of the following factors: character of bottom surface, slope of bottom, size of stones, depth of water, and rate of current.

Methods

Collecting at Station I was accomplished with an unweighted Petersen dredge which covered an area of 0.82 square feet. Within the station area samples were taken at random from various depths and kinds of bottom. Usually three hauls comprised one sample from any given depth. The range of depth for all samples taken was 1.5-30.0 feet. A 30-mesh screen was used in the field for washing and concentrating samples. The residue, including the organisms, was preserved with 10 per cent formalin.

In the rocky to gravelly shallow area at Station II, where a relatively strong current was present and where use of a Petersen dredge was impracticable, a Surber sampler (Surber, 1937) with a 24-mesh cloth screen bag was used. This sampler was designed to cover an area of 1 square foot. The washed residue was preserved with 10 per cent formalin. The depth range for these samples was 2 to 18 inches.

A total of 228 bottom samples was secured, 122 from Station I and 106 from Station II. Sampling was done from July to December 1941 (for exact dates see Fig. 1).

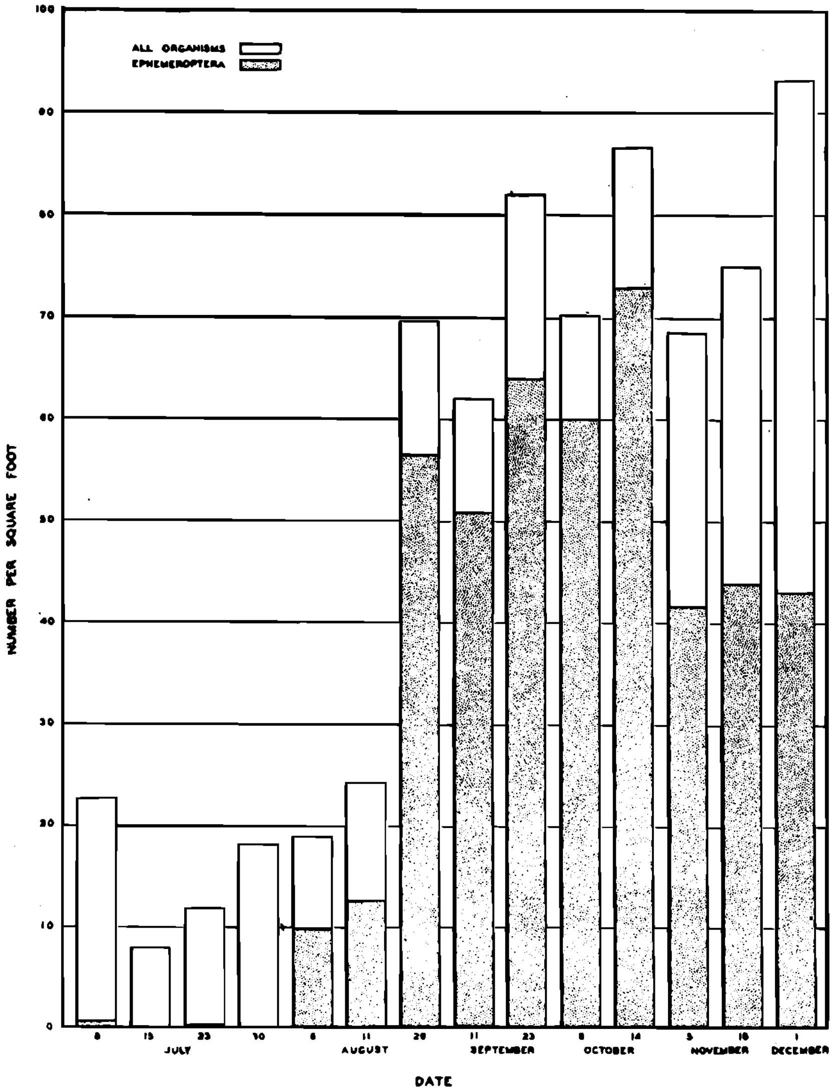

FIGURE 1.—Seasonal distribution (1941) at Station I, Tennessee River, Watts Bar Reservoir area, Tennessee, of all organisms as compared with the Ephemeroptera on the basis of numbers.

In order to separate the organisms from the debris, a technique involving the use of a saturated salt (NaCl) solution was used in the laboratory to concentrate the organisms further before finally picking the sample. The preserved field residue was placed in a screen and thoroughly rewashed. If no large stones or other bulky debris were present in the sample the salting-out process proceeded immediately from this point. However, if numerous large stones or other bulky debris were present, the sample was washed into a large pan which in turn was placed in the screen. A strong stream of water was used to agitate and wash out of the pan all of the lighter-weight material which included most of the organisms, thus leaving behind only the heavier residue. This coarse residue could then be examined quickly for stray organisms. Seldom were any found. That material which had been washed into the screen was then transferred to a pan and the excess water, required to wash off the screen, was poured through a screen cup to catch any floating organisms. The residue caught by the screen cup was later added to the main residue of concentrated organisms obtained by salting. The drained residue left in the pan was flooded with a saturated salt solution and stirred vigorously. This stirring caused most of the organisms to float to the surface. The salt solution, carrying with it the floating organisms, was poured into a funnel covered by grit cloth of proper mesh to retain all specimens. Alternate flooding with the salt solution and floating off the organisms was repeated on the residue until no more could be secured. Three to five times was usually sufficient. The salted residue was examined for any organisms that had not floated out. The organisms in the concentrated residue on the funnel were then separated from the small amount of debris which had floated over with them.

At times the routine method had to be modified slightly to meet the circumstances. For example, when masses of filamentous algae occurred in the sample, many organisms became entangled and could be obtained only by hand picking. The salting method not only shortened the total time involved, but it undoubtedly reduced the number of smaller organisms inevitably missed by ordinary hand picking.

All specimens were finelly sorted to major taxonomic groups and counted; the volume of each group was measured by displacement in alcohol. Various volumetric measuring devices were used according to the size and number of organisms to be measured. Centrifuge tubes of assorted sizes graduated to 0.01 or 0.1 cubic centimeters were found convenient for the determination of the smaller volumes, and cylinders graduated to 0.1 or 1.0 cubic centimeters were used to determine larger volumes. The numbers given for the Oligochaeta are only approximations, since many of the smaller specimens became fragmented and could be counted accurately; however, volume measurements for this group are reliable. All specimens were placed on an absorbent paper to remove excess moisture before they were measured for volume.

Abundance of Major Taxonomic Groups

In the deep-water samples taken at Station I, 12 principal taxonomic groups[2] were represented (Table 2). Of these 12 groups, 4 (Ephemeroptera, Diptera, Oligochaeta, Anisoptera) made up 98.93 per cent of the total number. These same four groups comprised for all practical purposes 100 per cent of the total volume since all other groups were represented by immeasurable traces.

Table 2.—Average numbers and volumes (cubic centimeters) per square foot of bottom organisms at Station I, Tennessee River, Watts Bar Reservoir area, Tennessee. Based on 122 bottom samples (average of 2.9 hauls per sample) taken in deep water with a Petersen dredge, 1941

Organisms	Number	Percentage of total number	Volume	Percentage of total volume
Nematoda (Roundworms)	0.07	0.14	Trace	Trace
Oligochaeta (Earthworms)	7.01	13.86	0.08	10.81
Hirudinea (Leeches)	0.01	0.02	Trace	Trace
Decapoda (Crayfish)	Trace	Trace	Trace	Trace
Hydracarina (Water mites)	0.04	0.08	Trace	Trace
Sialidae (Alder flies)	0.01	0.02	Trace	Trace
Ephemeroptera (Mayflies)	32.42	64.10	0.61	82.43
Anisoptera (Dragonflies)	0.78	1.54	0.04	5.41
Zygoptera (Damselflies)	0.01	0.02	Trace	Trace
Coleoptera (Beetles)	0.30	0.59	Trace	Trace
Trichoptera (Caddisflies)	0.10	0.20	Trace	Trace
Diptera (True flies)	9.83	19.43	0.01	1.35
Total	50.58	100.00	0.74	100.00

In the shallow-water samples from Station II, 12 major taxonomic groups (Table 3) were also present with only minor differences in the groups represented as compared with the deep-water fauna of Station I. The Hirudinea and Hydracarina at Station I were not present in the Station II fauna; likewise, the Turbellaria and Plecoptera of the Station II samples were not found among the Station I fauna. Of the 12 groups, 4 (Ephemeroptera, Trichoptera, Diptera, Oligochaeta) made up 86.27 per cent of the total numbers. Four of the groups (Oligochaeta, Sialidae, Decapoda, Ephemeroptera) comprised 90.24 per cent of the total volume. It may be noted that while Trichoptera and Diptera were significant as to numbers, the Sialidae and Decapoda were more important from the standpoint of volume. Likewise, the Ephemeroptera which composed 33.61 per cent of the total numbers of all organisms, formed only 4.88 per cent of the total volume. This group was not as important at Station II as it was at Station I. However, these facts may be viewed from a different angle with regard to their importance in the light of available fish food. It would seem that smaller fish would be benefited more by the large number of small organisms, whereas, only the larger fish would be benefited by the small number of larger organisms.

Although the higher taxonomic categories, such as, family, order,

[2]Exclusive of the Mollusca.

Table 3.—Average numbers and volumes (cubic centimeters) per square foot of bottom organisms at Station II, Tennessee River, Watts Bar Reservoir area, Tennessee. Based on 106 square-foot bottom samples taken in shallow water with a Surber sampler, 1941

Organisms	Number	Percentage of total number	Volume	Percentage of total volume
Turbellaria (Flatworms)	0.20	0.45	Trace	Trace
Nematoda (Roundworms)	0.62	1.39	Trace	Trace
Oligochaeta (Earthworms)	5.79	12.98	0.15	36.59
Decapoda (Crayfish)	0.03	0.07	0.07	17.07
Sia idae (Dobson-flies)	1.04	2.33	0.13	31.70
Ephemeropte a (Mayflies)	15.00	33.61	0.02	4.88
Anisoptera (Dragonflies)	0.38	0.85	0.01	2.44
Zygopte a (Damselflies)	1.34	3.01	0.01	2.44
Plecoptera (Stoneflies)	0.17	0.38	0.01	2.44
Coleoptera (Beetles)	2.34	5.25	Trace	Trace
T ichoptera (Caddisflies)	9.96	22.33	0.01	2.44
Diptera (True flies)	7.74	17.35	Trace	Trace
Total	44.61	100.00	0.41	100.00

and class may be the same for the two general habitats, it is not to be concluded that the specific or generic groups were identical. For example, the Sialidae in the Station I fauna belonged to the genus *Sialis* while those in the Station II fauna were *Corydalus*. The Ephemeroptera of the Station I fauna were *Hexagenia* while those of Station II habitat belonged to various genera from the families Heptageniidae and Baetidae.

The data (Tables 2 and 3) show that the average number of deep-water organisms (Station I) per square foot was 50.58, with an average volume per square foot of 0.74 cubic centimeters, as compared with an average number of 44.61 and an average volume of 0.41 cubic centimeters for the shallow-water area (Station II).

Distribution on the Bottom

Table 4 shows that of the four types of bottom (mud, sandy mud, muddy sand, and sand) mud was the most productive as to both number and volume. This production can be traced primarily to the abundance of Ephemeroptera in both number and volume since this

Table 4.—Abundance of bottom organisms per square foot and average size of organisms on four types of bottom at Station I, Tennessee River, Watts Bar Reservoir area, Tennessee. Based on 122 bottom samples (average of 2.9 hauls per sample) taken in deep water with a Petersen dredge between July and December, 1941. Volume in cubic centimeters.

Item	Mud (60 samples)		Sandy mud (26 samples)		Muddy sand (21 samples)		Sand (15 samples)	
	Number	Volume	Number	Volume	Number	Volume	Number	Volume
All organisms	81.91	1.60	38.84	0.36	32.82	0.22	7.86	0.03
Ephemeroptera	57.85	1.44	20.89	0.22	19.24	0.12	2.06	0.01
Average size, exclusive of mayflies	....	0.007	....	0.008	....	0.007	....	0.004
Average size of mayflies	....	0.025	....	0.011	....	0.006	....	0.005

group formed between 53 and 70 per cent of the total number and between 54 and 90 per cent of the total volume of all organisms on all types of bottom except sand.

A study of the distribution of forms with relation to depth (Table 5) shows that the first 10 feet are the most productive in both volume and number. This region produced over 64 per cent of the total number and over 80 per cent of the total volume found at all depths. It is significant to note that the upper 10 feet of bottom is the area most affected by changes in water level.

A comparison of productiveness of the flats and riffles at Station II is shown in Table 6. Riffles were somewhat more productive in number and volume.

Table 5.—Average numbers and volumes (cubic centimeters) per square foot of bottom organisms according to depth at Station I, Tennessee River, Watts Bar area, Tennessee.

[Based on 122 bottom samples (average of 2.9 hauls per sample) taken in deep water with a Petersen dredge, 1941]

Depth	Number of samples	Number	Volume
1-5	25	76.87	1.50
6-10	40	78.80	1.43
11-15	33	38.44	0.39
16-20	15	20.78	0.16
21-25	6	11.25	0.05
26-30	3	16.26	0.06

Table 6.—Abundance of bottom organisms per square foot on riffles and flats at Station II, Tennessee River, Watts Bar Reservoir area, Tennessee. Based on 106 square-foot bottom samples taken in shallow water with a Surber sampler, 1941.

[Volume in cubic centimenters.]

Riffle (46 samples)		Flat (60 samples)	
Number	Volume	Number	Volume
54.28	0.44	35.18	0.37

Seasonal Distribution

The numbers and volumes of the fauna at Station I were low during early summer and gradually became higher in late summer (Figs. 1 and 2). The importance of mayflies as a component of this fauna is clearly shown by the graphs. The maximum number of Ephemeroptera was present during September and October (Table 7). The reason for the distinct decline in November is not apparent. However, the total number of all organisms was maintained more or less constant during November and December due to the increase in the number of organisms other than mayflies. Figure 2 shows that mayflies play an even more important role from the standpoint of volume. Over the 6-month period from July to December no very consistent change occurred in that portion of the volume made up of organisms other than mayflies (Table 7). During July and August the volume of mayflies was very low or nil. This scarcity was caused by the early-summer

Table 7.—Seasonal distribution of bottom organisms in average numbers and volumes (cubic centimeters) per square foot at Station I in the Watts Bar Reservoir area of one Tennessee River, 1941.

[Based on 122 bottom samples (average of 2.9 hauls per sample) taken in deep water with a Petersen dredge. T=trace.]

	Ephemeroptera		Other organisms		Total	
Date	Number	Volume	Number	Volume	Number	Volume
July 8	0.52	T	21.89	0.17	22.41	0.17
July 15	....	....	7.86	0.04	7.86	0.04
July 23	0.20	T	11.41	0.12	11.61	0.12
July 30	....	....	18.04	0.20	18.04	0.20
August 6	9.84	0.03	8.99	0.10	18.83	0.13
August 11	12.43	0.05	11.64	0.12	24.07	0.17
August 29	56.20	0.61	13.39	0.09	69.59	0.70
September 11	50.58	0.86	11.12	0.13	61.70	0.99
September 23	63.82	1.22	17.79	0.13	81.61	1.35
October 6	59.89	1.42	10.11	0.08	70.00	1.50
October 14	72.67	2.10	13.88	0.09	86.55	2.19
November 5	41.42	1.06	26.93	0.15	68.35	1.21
November 18	43.59	1.15	31.08	0.18	74.67	1.33
December 1	42.71	1.00	50.35	0.21	93.06	1.21

emergence of this group. In late August the eggs laid earlier began to hatch so that from this time on the volume due to mayflies became increasingly important and reached a maximum in October. Corresponding with the drop in numbers (Fig. 1), the volume was reduced by about one half in November. This level would probably be maintained throughout the winter with some increase in late spring due to growth just before emergence.

It appears that the length of the life cycle of the mayfly, *Hexagenia bilineata* (Say), at least in the Tennessee area, is 1 year rather than 2 years. Needham (1920) concluded that this species has a 2-year cycle in the northern reaches of the Mississippi River. Certain other species of *Hexagenia* in the region of the Great Lakes have a 2-year life cycle (Lyman, 1940, MS.). If *Hexagenia bilineata* had a 2-year cycle in Tennessee, specimens should have been present in greater numbers during July and August. There should also have been two distinct size and age groups present during September; only one group was found. The increase in volume and number (Table 7) that occurred in late summer and early fall was evidently due entirely to hatching of eggs and growth of the young nymphs.

The rate of growth of *Hexagenia* nymphs (Fig. 3) was most rapid during August and September or immediately following hatching. (Growth has been expressed in terms of the number of individuals per cubic centimeter, computed from data given in Table 7.) Growth was greatest on mud or sandy mud. Since by far the larger number and volume of mayfly nymphs occurred on the mud and sandy mud bottom, the growth curve represents essentially the rate of growth on these two types of bottom. The average size of an individual nymph on the various types of bottom is shown in Table 4. (From this same table comparisons may be made of the average size of individuals of all other organisms with that of an individual mayfly.) On mud and sandy mud the mayfly nymphs averaged much larger than on the

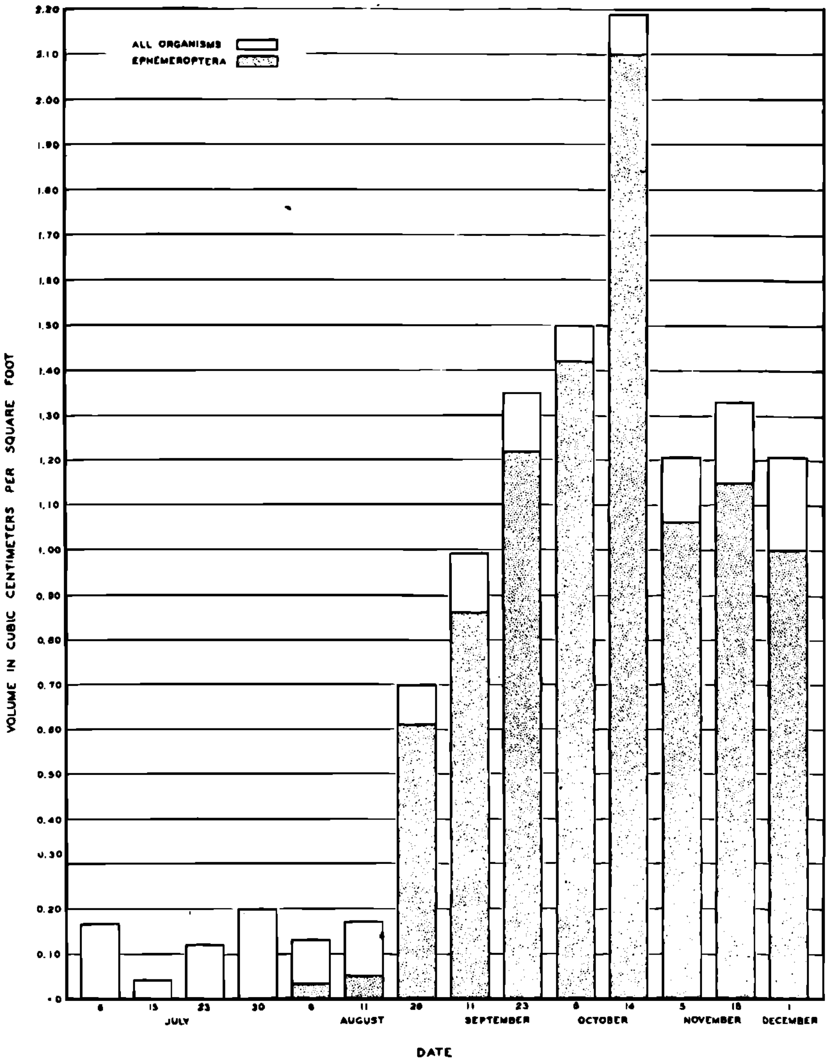

FIGURE 2.—Seasonal distribution (1941) at Station I, Tennessee River, Watts Bar Reservoir area, Tennessee, of all organisms as compared with the Ephemeroptera on the basis of volumes.

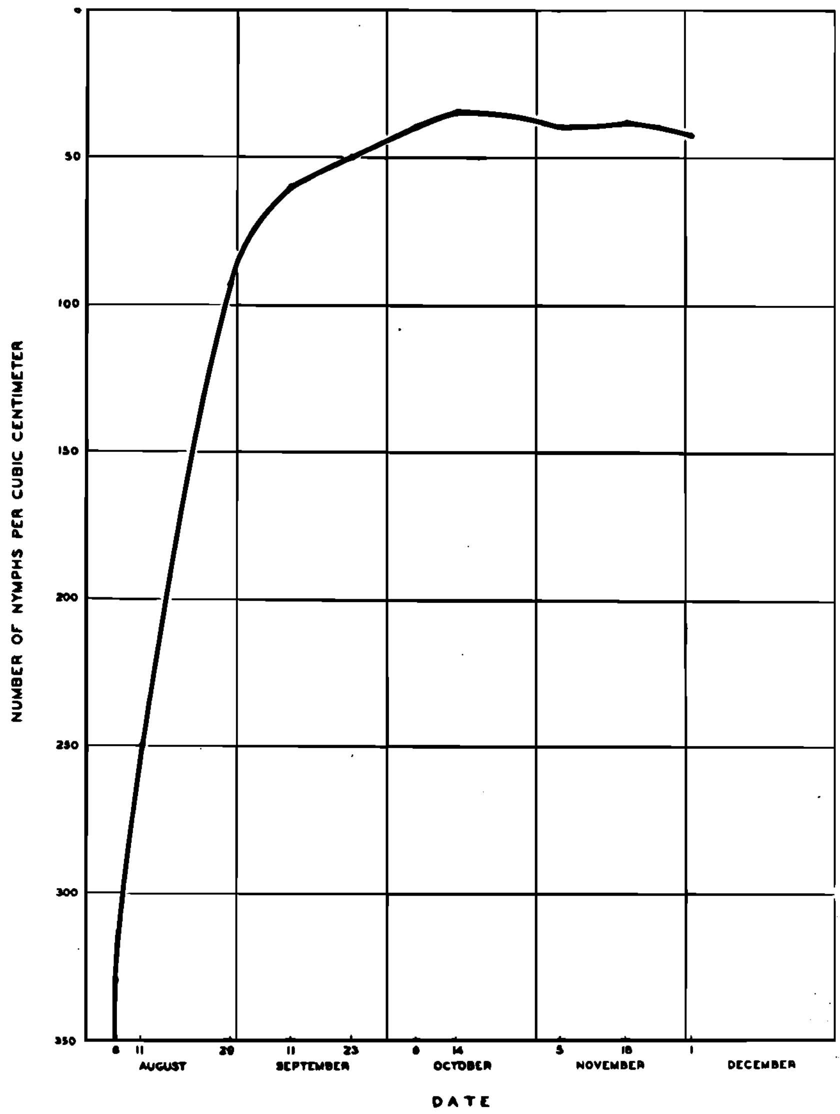

FIGURE 3.—Growth rate of *Hexagenia bilineata* (Say) nymphs averaged from all types of bottom as shown by number required to produce a volume of one cubic centimeter on various dates between August and December 1941, at Station I, Tennessee River, Watts Bar Reservoir area, Tennessee.

other two types of bottom. On muddy sand and sand the sizes were about equal.

The average size of organisms other than mayflies was smallest on sand, while the other three types of bottom produced individuals about twice as large.

Summary and Conclusions

The most important single component of the bottom fauna was the *Hexagenia bilineata* nymphs which were found to have the greatest growth and to be most abundant in the mud or sandy mud bottom of the Tennessee River. From the data presented it is concluded that the length of the life cycle of this species is one year. The peak volume per square foot for all organisms in the deep water (Station I) was reached in October; the lowest volume occurred in July and August. Mayflies were almost entirely responsible for the volume changes. Since Watts Bar Reservoir is of the run-of-the-river type, it may be stated almost with certainty that *Hexagenia* nymphs will not only survive impoundment but will reach even a greater production under the new and undoubtedly more favorable conditions.

The Station I (deep-water) habitat was more productive of bottom organisms than was the Station II (shallow-water) area, especially as to the volume. It is to be expected that most of the members belonging to the Station II fauna will not survive changes incurred by impoundment (silting in and lack of current). Since, however, most of the original river channel now included by Watts Bar Reservoir was composed of the type of habitat found at Station I, this probable loss in fauna will not be critical. Probably the numbers of many of the members of the deep-water fauna will increase with impoundment since it would seem that the new conditions brought about by impoundment will, at least, not become more unfavorable and it is to be expected that most changes will be for the better. The sandy areas of the original river channel which were the least productive will become covered by mud due to silting in and, therefore, will become more productive. Large shallow areas will be inundated which will increase fertility in general. The water level in the reservoir will fluctuate several feet (10 feet maximum). However, the fauna at Station I withstood even greater water-level changes in the original river and should, therefore, be able to cope with similar conditions in the reservoir. Later inquiries will demonstrate the extent to which the various organisms were able to adjust themselves to the new conditions.

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