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Aspects of insect populations of the Bitterroot River Montana

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ASPECTS OF INSECT POPULATIONS OF THE

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by

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INTRODUCTION

Past and Present Aims.

Few quantitative studies have been carried out on the bottom fauna of the upper Columbia River. Robeck (1954) reported quantitative data from the Columbia River and its tributaries near Hanford, Washington. Brunson (1956) took quantitative bottom samples from the Bitterroot River and its tributaries, the Blackfoot River, and Rock Creek during December 1955.

The original aims of this study on the Bitterroot River were to take quantitative bottom samples throughout a twelve-month period, and to determine population densities of all major groups of organisms. A time limit became evident, (as many other workers have noted), in the sorting and counting of the organisms. As a result, data are available for a period of nine months only; and quantitative results have been determined only for specific insect groups and organisms collected from cross-sectional samples.

Because there was limited time to complete the over-ambitious project by a deadline, emphasis was placed on the study of selected species. Two genera of the family Lepidostomatidae are described, *Theliopsyche* and *Lepidostoma*. According to Usinger (1956) the former occurs in the eastern United States, and the latter is found widespread in Canada and the entire United States. The genus *Lepidostoma* occurred in large numbers throughout the study area, and considerable information has been obtained in this work on population numbers and sizes of this genus throughout the nine-month sampling period.

Two genera of the family Pteronarcidae are recognized, Pteronarcys and Pteronarcella. Pteronarcys californica and Pteronarcella badia were found in the quantitative collections. Pteronarcys californica was absent from lower stations, and present in the remaining areas, whereas Pteronarcella badia occurred throughout the study area. The data on quantitative cross-sectional samples from the lower Bitterroot River and upper East Fork of the Bitterroot River show other aquatic forms which are characteristic of streams.

Review of Important Literature.

Large numbers of square-foot samples are needed to obtain averages of available bottom food, because of the variability in the amounts of food from place to place within a stream (Needham, 1934). Needham (1927) and Pate (1934) show that silt and mud type bottom are most productive in bottom food per unit area, followed by rubble, gravel, sand, hardpan, and bedrock. Life in the more sluggish parts of a river was not as evident as in riffles (Coker, 1954). Usinger (1956) also wrote that, in general, riffles were more productive than pools. Lastochkin (1945), however, indicated that biomass was greater in pool regions than in riffles.

Wide differences occur in both seasonal and yearly abundance of stream bottom organisms (Maciolek, 1951). Needham (1934) indicated that, in general, warm streams produced more bottom foods than cold ones. All of the above discussion points out the variability in the amount of stream fauna from place to place within a stream, time of year, and type of stream. (Many other chemical, physical, and biological factors affect the stream fauna, some of which are considered in the present study).

In the past, stream surveys emphasized the standing crop of bottom fauna. Stream productivity should be determined in terms of turnover rather than the standing crop (Ide, 1942). Hayne (1956) indicated that the true productivity of the biomass was the important aspect, rather than the size of the standing crop. From the latter work, it was concluded that fish predation reduced the standing crop of fish food organisms, but the production rate was increased.

Rounsefell (1953) indicated that in a stream survey, quantitative bottom samples required a great deal of time, and that the observer should estimate the productivity on the basis of (1) very rich, (2) average in richness, or (3) poor in food. This procedure has been followed by many workers in the field. Robeck (1954) found the Columbia River near Hanford, Washington, ranged from average to rich in fish food organisms, with larger numbers and weights occurring in the tributaries studied.

Other pertinant bibliographic references are referred to in the body of the thesis.

The Bitterroot River System.

The Bitterroot River in western Montana is a part of the Columbia River system. The Columbia River basin covers 259,000 square miles, of which 220,000 are in the United States (Robeck, 1954). The Bitterroot River flows through Ravalli and Missoula Counties before joining the Clark Fork River about five miles west of Missoula. The East Fork and the West Fork of the Bitterroot River are the two primary tributaries which form the main Bitterroot River and are permanent type streams.

The headwaters of the Bitterroot River drainage are located in high granite mountains of over 10,000 feet in elevation on the west side

(Bitterroot Mountains), and smaller, more timbered mountains of about 8,000 feet or more on the east side of the river (Sapphires). Snow fields remain on the higher peaks throughout the year, and many of the small high mountain lakes are frozen over eight to nine months of the year. These lakes, snowfields, and springs are the water source for the streams.

Logging, ranching, and farming are the major industries in the valley, with ranching in the higher elevations and farming in the valley proper. The Bitterroot River is generally free from pollution. A few small mines are located on some of its tributaries, but it is believed that these have little, if any, effect on the stream fauna. The stream flows clearly throughout the year, except during spring runoff, and after heavy showers. The Bitterroot River is not a stable river--it is continually changing its course, which is characteristic for most flowing streams.

Numerous tributaries empty into the Bitterroot throughout its course. These streams are primarily high mountain type torrential streams, while a few, such as Camp Creek and Cameron Creek on the East Fork, are meandering types.

No large dams are found on the East Fork or the main Bitterroot River, but the West Fork Dam stores a large supply of water which forms Painted Rocks Lake. Also many small dams are located on the main river and its tributaries to divert irrigation waters into ditches and canals. These dams block any upstream migrations of fish throughout the year. All of the water is diverted from some of the small streams for irrigation during the summer, destroying habitats and organisms along the stream-bed.

Most of the land on the headwaters of the Bitterroot River and its tributaries is controlled by the U. S. Forest Service. An extensive control project against the spruce budworm was launched on the East Fork and West Fork of the Bitterroot by the U. S. Forest Service early in the summer of 1955. Aerial spraying was employed in the control work using one pound of DDT in one gallon of fuel oil per acre (Park, 1956). To check possible effects of spraying, Brunson (1956) made a reconnaisance of the bottom fauna of the Bitterroot River and the East Fork of the Bitterroot River. Dr. Oliver B. Cope, U. S. Fish and Wildlife Service, reviewed Dr. Brunson's report, and stated that he believed that numbers of bottom organisms present, indicated that DDT spray had little, if any, effect on these forms in the Bitterroot drainage.

In general, the weather over the Bitterroot is mild. The prevailing flow of air aloft is from the west. This air passing over the Bitterroot Range loses much of its moisture on the western slopes of these mountains in Idaho. As a result, the Bitterroot Valley receives approximately 12 to 15 inches of precipitation annually. Although these various factors --irrigation, rainfall, logging, ranching, dams, etc.--obviously play a role in the general ecology of aquatic insects, little, if any, information is available on the effects by these or any one of these factors. It is not the aim of this paper to show their effects, but rather to give a picture of the conditions under which these populations were studied.

MATERIALS AND METHODS

Physical Conditions.

Water, ground, and air temperatures were taken at all stations throughout the study period. Inasmuch as stream temperatures tend to be uniform at all depths, follow air temperatures more closely than lakes, and are more uniform in small streams than large ones (Welch, 1952), the water temperature was taken by submerging the thermometer four to five inches below the surface over the area being sampled. Ground temperatures were taken three feet from the waters edge, three inches under the ground surface. Air temperatures were recorded along with ground and water temperatures; and the time of day at which temperatures were taken was noted. The U. S. Weather Bureau maintains a weather station at Sula, approximately 300 feet from collecting station 6: their weather data were used in this study.

The general water level throughout the study was recorded by measuring the distance from the waters edge to the high water marks on the stream banks, placing marks on the cement piers of bridges, and, in the upper East Fork of the Bitterroot, by stream depth.

The average current velocity was calculated at each station throughout the study period by the float method. This method employs the time required for a floating object to travel a known distance. Since stream surface velocity is generally greater than the average velocity, Usinger (1956) found it was necessary to divide surface speeds by 1.05 for channels less than two feet deep, and by 1.33 for channels 10 or more feet in depth to get the average channel speed. Attempts were made at station sites to get the current velocity from the same section of stream from one period to another. Welch (1952) indicated current velocity was reduced at and near the surface because of surface tension, and diminished near the bottom and sides of the channel because of friction.

Several classifications of stream bottom types have been presented in the literature. Davis (1938) classified stream beds into the following types:

> Bedrock--solid, immovable strata.
> Hardpan--hard deposits of clay.
> Clay--soil composed largely of hydrous aluminum silicate.
> Silt--fine earthly sediment carried and deposited by water.
> Muck--consists principally of fine, partially decomposed organic material.
> Detritus--composed of broken organic substances, and usually found on the surface of muck.
> Sand--finely ground rock particles to one-eighth inch in diameter.
> Fine gravel--one-eighth inch to about one-half inch in diameter.
> Coarse gravel--one-half inch, to stones three inches in diameter.
> Rubble--stones from three to 12 inches in diameter.
> Small boulders--stones 12 to 24 inches.
> Large boulders--stones over 24 inches in diameter.

Welch (1948) used Wentworth's classification based upon size of particles: clay less than 0.004 mm. in diameter, silt from 0.004 to 0.062 mm., etc., up to boulders 256 mm. in diameter or more. In this study, bottom types were based on the former classification in a general manner. Fine gravel and coarse gravel were commonly termed gravel; rubble, which consists of stones three to 12 inches in diameter, was classified as to size of stones in the sampling area, rather than being termed rubble. The majority of samples collected were from more than one bottom type, such as sand and gravel, gravel to stones six inches in diameter, sand to gravel to stones six inches in diameter, etc.

All quantitative bottom samples were taken with the Surber square-foot sampler (Plate 1), originally described by Surber (1936). This sampler can be used by one person, but when in swift currents it is advisable to have two people present, one to hold the sampler, and the other to stir the sampling area.

The Surber sampler limited the depths at which quantitative samples could be taken. All samples were taken from a minimal depth of two inches, to a maximal depth of 22 inches. The majority of the samples, however, were taken at depths six to 12 inches. Distances from shore at which bottom samples were collected were usually dependent upon the stream depth and current velocity. Many samples, during the high water period, were taken one to three feet from shore, because of increased depth at greater distances from shore, high current velocity away from shore, or both. During the low flow period, on the other hand, samples were taken at greater distances from shore to reach areas of velocity sufficient to trail the net behind the sampler and to reach depths which would give comparative samples. Cross-sectional samples had to be taken during low water.

Many comments are presented in the literature concerning the effectiveness and reliability of the Surber square-foot bottom sampler. One of the comments on this sampler was presented by Usinger (1956) who states: "Unfortunately, most surveys of stream-bottom organisms have been made with the Surber Square-Foot Sampler. Although this is undoubtedly the most practical sampler thus far devised for shallow riffles, Needham and Usinger (1955) show that it does not give statistically significant data for total weights and numbers of organisms, even in a single relatively uniform riffle. It was found that 194 and 73 samples,

Plate 1

Sampling with the Surber Square-Foot Sampler respectively, would be required to give reliable figures at the 95 per cent level of significance. Hence all existing data on stream-bottom organisms are statistically inadequate, but it is the best we have and may be the best that can be obtained because of the extreme variability of stream habitats."

One of the problems of the Surber sampler is that of organisms being washed around the edges of the sampler, or of larger organisms, such as crayfish, cottids, and some of the large nymphs of *Pteronarcys*, swimming out of the sampling area. This factor was noted throughout the study when nymphs and cottids swam or drifted out of the sampling area. Usinger (1956) reported organisms drifting around the edge of the sampler from the sampling area. Hess (1941) described a circular square-foot sampler, designed to correct this problem. A screen cylinder 18 inches high was placed on the Surber type sampler to prevent the escape of larger organisms from the sampling area and to keep rolling rocks, ice, and other debris from going into the net. Another advantage of the Hess circular sampler is that it can be turned into the bottom, thus no organisms are lost from under the sampler. Slack (1955) used the square-foot Surber sampler and enclosed the front and sides with one-sixteenth inch mesh bronze screen.

Numerous other quantitative samplers have been described in the literature. Allan (1952) developed a hand-operated grab for sampling stream bottom types of small gravel, sand, silt, clay, mud, and plant beds. When this type sampler is used on stony bottoms, the large stones and coarse gravel wedge in the teeth and prevent the jaws from closing.

Wilding (1940) described a sampler developed to take square-foot bottom samples from lake margins, weed beds, and stream bottoms. It consists of two separate brass cylinders. The outer brass cylinder is sunk three to four inches in the stream bottom, the enclosed area stirred up, then the inner cylinder is plunged into the large cylinder. By closing a valve on the inner cylinder, the organisms are collected within. Usinger (1956) developed a drag-type sampler which is not limited to depth, but fails to work on all bottom types.

Regardless of the controversial discussion considering the accuracy of bottom samplers, the Surber sampler was used. Not only is this the standard type used, but it was the only one available. Furthermore the author has, in a period of 12 months, made a critical enough study to recognize that no one square-foot is exactly like the other, therefore great variations should be expected in the samples collected. For this reason special care was taken in selecting similar places in each station area used to check the sampler.

Both the Eckman and the Peterson dredge were used in the study to get bottom samples from the deep areas which could not be sampled with the Surber sampler. Neither of these samplers was effective in the characteristically stony bottom of the Bitterroot River. Weights were placed on the Peterson dredge to give it an approximate weight of 80 pounds. Even this proved to be ineffective for quantitative sampling. Stones were caught between the jaws of the sampler, allowing material to be released from the sample. Some qualitative data were collected, however, from the deep areas of the river at station 1. A highway bridge across the river at this station allowed samples to be taken in the deep areas under the bridge. Had the Peterson dredge functioned effectively on this stony bottom, it would have been possible to take quantitative cross-sectional samples at all depths by this method.

Qualitative data were taken throughout the study on both the immature and adult forms. All organisms collected from April to December were sorted from the debris. Qualitative samples were taken from areas of the stream which could not be sampled quantitatively with the Surber sampler. Fine-mesh screens were used to sample still areas along the edges of the stream. Inasmuch as the square-foot Surber sampler is limited to the size of stones which can be sampled, qualitative collections were taken from under large boulders. This method was used to collect the mature nymphs of Pteronarcys californica just prior to emergence. Adults were collected whenever observed on the station sites. On several occasions throughout the study, adults were collected from under stones and debris along the shore. Square-foot areas of the shore were picked over carefully and all adults were collected. The insect net was used during the summer and sweep-net samples of the adults were taken from the station areas.

Qualitative samples of fish were taken at station 2 by the means of shocking. Arthur Whitney, biologist for the Montana Fish and Game Department contributed time and shocking equipment for collection of these samples. Fish collections were limited, however, to the shallower areas of the stream accessible with chest-high waders. Rhinichthys cataractae and Cottus cognatus were collected occasionally in the square-foot bottom samples. Usually these forms swam out of the sampling area, but if samples were taken in a fast current area, these fish were swept into the net.

Plans for taking some of the fish samples periodically throughout the year could not be carried out because of lack of availability of shocking equipment.

Collecting Periods.

Collecting trips into the study area usually required two full days to get samples from the six stations. On May 5 the river level was so high that only station 1 was sampled. On August 20 all six stations were sampled in one day. Stations 1, 2, and 3 were usually sampled one day and stations 4, 5, and 6 the following day. The dates collected were usually on Saturdays and Sundays. This had its advantages because more fishermen appeared on the stream weekends, and it was noted if any fishermen were collecting bottom organisms (for fish bait) from the station areas. Species of Plecoptera nymphs are used for fish bait in this stream, and this was a factor considered when the sampling stations were selected.

Table I shows the collecting dates throughout the study period from April through December.

TABLE I

COLLECTION DATES AND TOTAL NUMBER
SQUARE-FOOT BOTTOM SAMPLES

Date	Stations	Total Bottom Samples	Date	Stations	Total Bottom Samples
Apr. 1	1-2-3	32	Aug. 20	1-2-3-4-5-6	36
Apr. 2	4-5-6	19	Sept. 8	1-2-3	18
Apr. 28	1-2-3	8	Sept. 9	4-5-6	14
Apr. 29	4-5-6	7	Oct. 4	3-5-6	12
May 5	1	8	Oct. 5	1-2	13
June 11	1-2-3	21	Nov. 2	1-2	8
June 12	4-5-6	18	Nov. 3	3-5-6	10
June 28	1-2	15	Nov. 11	7	5
June 29	3-4-5-6	19	Dec. 4	1	17
July 14	3-4-5-6	19	Dec. 14	1-2-3	12
July 15	1-2	14	Dec. 15	5-6	9

Collections.

All samples collected were placed in pint jars containing 70 per cent alcohol and some glycerine. The bottom samples usually contained a large amount of detritus, algae, and inorganic material along with the bottom organisms. This material present in the samples created a time-consuming problem in separating the bottom fauna. Many workers separate the organisms from the other material in pans immediately after collecting the samples because the live organisms can be detected more easily than the preserved ones. This procedure was impossible in the present study because of the time necessary to sample the six stations. After the samples were placed in alcohol, they were labeled and taken back to the laboratory for sorting. All adults collected were preserved in alcohol, as were the immature forms.

Sorting in the laboratory was done in large, white-enamel pans. Only portions of a sample were placed in a pan at one time. A great amount of time was involved in sorting these samples--the maximum time for any one bottom sample was 16 hours. After the organisms were sorted they were identified. Classification of these immature and mature aquatic organisms was usually to families, in some cases genera and species, and in others to orders, classes or even phyla. Several texts or keys were used to classify these organisms, of which Usinger (1956) and Pennak (1953) were used most frequently. All organisms were not counted for the present study, but were identified and sorted for later counts. All organisms taken in the cross-sectional samples were counted, as were all of the Lepidostomatidae and Pteronarcidae.

Volume, weight, and length measurements were taken for all representatives of the families Lepidostomatidae and Pteronarcidae. Total volume measurements for representatives in the sample were recorded to the nearest one-tenth cubic centimeter. Both individual and total weights were taken for organisms in the sample to the nearest one-tenth milligram. A torsion type balance was used for recording weights. All weights were wet-weight measurements, i.e.: the organisms from alcohol were placed on filter paper for one minute, then removed from the paper and weighed. Length measurements were made under the binocular dissecting scope to the nearest one-tenth millimeter. All lengths recorded were total body lengths, excluding the antennae and cerci.

All fish collected were measured for total length and standard length, and were weighed and identified. Stomachs from 21 fish were collected and preserved for a later determination of fish-food forage ratio. All these fish were collected by shocking.

STUDY AREA

Description of Stations.

Six sampling stations were located along a 65 mile stretch of the main Bitterroot River and the East Fork of the Bitterroot (Fig. 1). These stations were selected on areas large enough to withstand repeated sampling throughout a twelve-month period. An attempt was made to locate the stations away from areas which were used by fishermen for obtaining Plecoptera for fish bait. When these people collect fish bait, they turn over stones and stir great portions of bottom in shallow riffles, which action would be a hazard for studying quantitative bottom samples. Accessability was also a factor for choosing station sites; therefore all stations were located near a road. Because the Surber sampler is limited to depth and type of bottom, stations had to be selected in places which contained riffles and shallow areas. The stations which were finally selected were numbered 1 to 6 in progression, i.e.: 1 was located on the lower Bitterroot, 6 on the East Fork of the Bitterroot.

Station 1 (Plate 2) at Florence Crossing (T38N, R20W, S12) consisted of 300 yards of stream below the Florence highway bridge on the west side of the river. All quantitative samples were taken on the west side of the river. At the north end of the station area, the river flows west. At this bend, within station 1, the cross-sectional samples were taken. The bottom type at this station was composed of sand, fine gravel, and stones up to nine inches in diameter. The areas close to shore consisted primarily of gravel, whereas those areas farther out in the river were composed primarily of sand and stones up to nine inches in diameter.

The land contiguous with the stream is typical of the lower Bitterroot river bottom, ponderosa pine and cottonwoods being the dominant vegetation. Agricultural land is found 200 to 300 yards behind this timbered area on both sides of the river.

Figure 1. Map of the Bitterroot River Drainage. Only the major tributaries are located. The sampling stations are indicated by heavy dots.

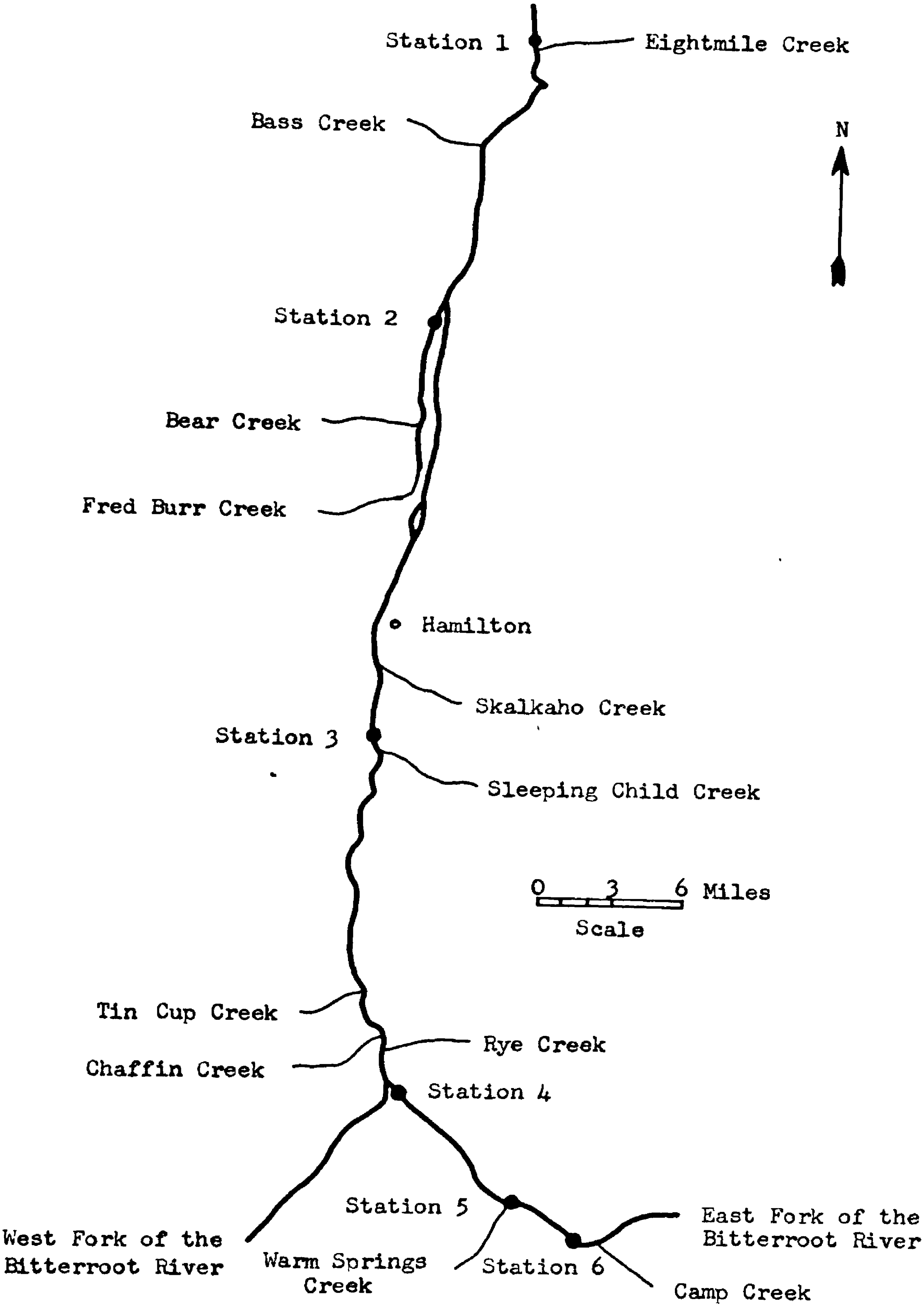

Station 1
Eightmile Creek
Bass Creek
N
Station 2
Bear Creek
Fred Burr Creek
Hamilton
Skalkaho Creek
Station 3
Sleeping Child Creek
0 3 6 Miles
Scale
Tin Cup Creek
Rye Creek
Chaffin Creek
Station 4
Station 5
East Fork of the
Bitterroot River
West Fork of the
Bitterroot River
Warm Springs
Creek
Station 6
Camp Creek

Plate 2

Station 1, During High Water, May 1956

Station 1, December 1956

Station 2 (Plate 3) at Bell Crossing (T36N, R20W, S17) consisted of 400 yards of stream below the Bell Crossing Bridge. All quantitative samples were collected from the west side of the river. The bottom at this station was composed of sand, gravel, and stones up to eight inches in diameter. Three high water channels were present in the main bed of the river at the west side. During low water the three channels were dry except for a bay-like area at the mouth of the largest channel. This bay-like area was similar to a temporary pond in many aspects. Surface currents were detected in this bay, although the water didn't flow through. When sampling in April and December, muck and detrital material was found covering the sand, gravel, and stones in this bay. After high flow period, however, this muck and detrital material was flushed out. Adjoining the stream, scattered ponderosa pine and cottonwoods were the dominant vegetation. Meadow lands and pastures emarginated the timbered area.

Station 3 (Plate 3) was located one-half mile below the mouth of Sleeping Child Creek (T33N, R21W, S24). Samples were collected from the east shore of the river. The bottom type of this area was sand, gravel, and stones up to 10 inches in diameter. There is a diversion dam across the river between this station site and the mouth of Sleeping Child Creek. This dam does not store or back-up any water, it merely diverts a large head of water into an irrigation canal. During high water, samples had to be taken up among the willows (which are shown in Plate 3 on the left side of station 3) because of the depth and high velocity of the stream. Ponderosa pine and cottonwoods are the dominant trees along the river banks. Pasture lands are found on the west side of the river at this station, and rolling hills covered with sage brush and rabbit brush are found on the east side of the river. Numerous warm water springs seep

Plate 3

Station 2

Station 3

into the river above this station, accounting for slightly higher average temperatures than station 2.

Station 4 was located immediately above the Conner bridge (T30N, R20W, S7) 300 yards below the Conner store. This station was located on the East Fork of the Bitterroot River about three-fourths of a mile from the mouth of the East Fork Canyon, and one-half mile above the junction of the East Fork and the West Fork of the Bitterroot River. The mountains close in above this station and form the East Fork Canyon. Ponderosa pine and cottonwoods are the dominant vegetation at this station site with small agricultural fields along both sides of the river. Until the latter part of September, this station was sampled quantitatively as were the other five stations. In late September, the river (including station 4) was straightened out by a bull-dozer. The effects of this work are shown on Plate 4. From April to September, the stream bottom was gravel to rocks eight inches in diameter. High water during May washed out a large portion of the sampling area of this station, and this spring washout was the reason for straightening the river. The stream bottom after the river had been straightened was a mass of very loose shifting gravel and crushed granite stones. Attempts to collect quantitative samples resulted in a net full of this inorganic material with no bottom organisms present. It is interesting to note that samples taken in March 1957, six months after this stream had been straightened, contained very few aquatic organisms, either quantitatively or qualitatively. The bottom type at this time was still a mass of loose shifting gravel and crushed granite rocks.

Station 5 (Plate 4) was located in the East Fork Canyon at the mouth of Warm Springs Creek (T29N, R20W, S1), one-half mile below the

Plate 4

Station 4

Station 5

turn-off to Medicine Hot Springs. Ponderosa pine, cottonwoods and willows are the dominant vegetation at this site. The stream bottom above the mouth of Warm Springs Creek consisted of gravel to stones eight inches in diameter. Sand, gravel, and stones to 10 inches in diameter were found immediately below the mouth of the creek. The current velocity throughout the canyon area was very high, especially during high water. Large boulders used for rip-rap along the highway were found along the stream edge. During the high water period, the water level was up into these large boulders, making it impossible to get quantitative samples from this area. Samples were taken at this time, however, both below the mouth of the creek and in the area above the mouth of the creek away from the highway.

Station 6 (Plate 5) was located about 200 yards above the Sula store (T29N, R19W, S17), which is immediately above the entrance to the East Fork Canyon. The East Fork River in this area is a meandering stream, although the station itself is in a riffle area. Willows and cottonwoods are the dominant vegetation along this section of stream, with ponderosa pine and Douglas fir restricted to the hills away from the river. The land through which the river meanders consists primarily of meadow lands. The stream bottom is composed of sand, gravel, and stones to 10 inches in diameter.

Cross-sectional samples were collected one-half mile above station 6, and the sampling area was termed station 7 (Plate 5). This station was located about 200 yards above the old Sula Post Office bridge. The stream was similar to that of station 6, a meandering type through meadow land, with willows and cottonwoods along the banks. The bottom type was gravel and stones as large as eight inches in diameter.

Plate 5

Station 6

Station 7

TABLE II

DISTANCES AND ELEVATIONS OF SAMPLING STATIONS

Station No.	Approximate Elevation in Feet	Length in Miles		Approximate Elevation Drop in Feet per Mile	
1	3200	From Missoula	20	From Station 2	7.1
2	3300	From Station 1	14	From Station 3	21.1
3	3700	From Station 2	19	From Station 4	18.8
4	4000	From Station 3	16	From Station 5	15.4
5	4200	From Station 4	13	From Station 6	33.3
6	4300	From Station 5	3		
1100 Feet Difference in Elevation Station 1 and Station 6.		Study Area = 65 Miles of Stream.		Average Drop in Feet per Mile in the 65 Miles = 16.9.	

Elevations and distances are approximate measurements taken from a U. S. Forest Service map of the Bitterroot Valley. Elevations for stations were based on bench marks and map contours near the sites, while distances were measured between stations and calculated from the scale used. The differences in elevation between the two extreme stations is approximately 1100 feet. Based on these measurements, the average drop in feet per mile over the 65 miles of stream studied is 16.9. The maximum drop in feet per mile was 33.3 between station 6 and station 5, which was in the East Fork Canyon. The minimum, which was 7.1 feet per mile, was between station 2 and station 1.

Climatological Data--Temperatures.

Water, ground, and air temperatures were recorded at each collecting point. Temperature curves for each station were plotted. Readings for station 4 terminated September 9 along with sampling. Temperatures for the remaining five stations were plotted from April 1 to January 12 (Figs. 2 to 8, Appendix Tables XVII to XXIII).

Temperatures from station 1 at Florence and station 6 at Sula show a comparison of a large meandering river to a small meandering stream at a higher elevation. Water temperature at Station 1 averaged 51.6° F. from April to January as compared to 45.1° F. for station 6. The maximum water temperature recorded for station 1 was 67.0° F. on July 15; the minimum was 36.0° F. on January 12. On the other hand, 64.0° F. on August 20 was the maximum for station 6 and 32.0° F. on December 15 was the minimum.

Small streams with little cover usually show greater temperature fluctuations, both seasonal and daily, than do larger streams (Needham, 1938). Daily fluctuations in water temperature were not recorded in this study; instead, temperatures were taken only at one time during the day at each station. The yearly difference between extreme water temperatures at Sula (station 6), where the stream is small, was 32.0° F., compared to a 31.0° F. difference at Florence (station 1). A difference of 35.0° F. was found at station 3. An explanation for this greater difference at station 3 might be the large number of warm water springs draining into the river above this station. The maximum water temperature for this station during the summer was 69.0° F., which was 5.0° F. higher than the maximum temperatures for stations 2 and 4, and 2.0° F. higher than station 1. The minimum water temperature recorded for station 3 was 34.0° F., whereas all other stations were 32.0° F., except station 1 which was 36.0° F. Temperature variations within a stream are principally the results of depth, current velocity, bottom materials, tributary waters, sunlight or shading, and time of day (Welch, 1952).

Water temperature is important for the growth of aquatic insects. The optimum temperature for development of stream insects is between 65.0° F. and 75.0° F. during the summer (Needham, 1938). The "average" water temperatures (Fig. 2) for the six stations during the summer (July, August, and September), were 63.7° F., 61.5° F., 66.0° F., 60.3° F., 56.0° F., and 56.3° F. for stations 1 through 6 in that order. Station 3 is the only one in which average summer water temperatures reach the range which Needham (1938) sets for optimal development.

Figure 2. Water temperatures for Stations 1 to 6 (Average and Minimum temperature not recorded for station 4) April, 1956 through January, 1957.

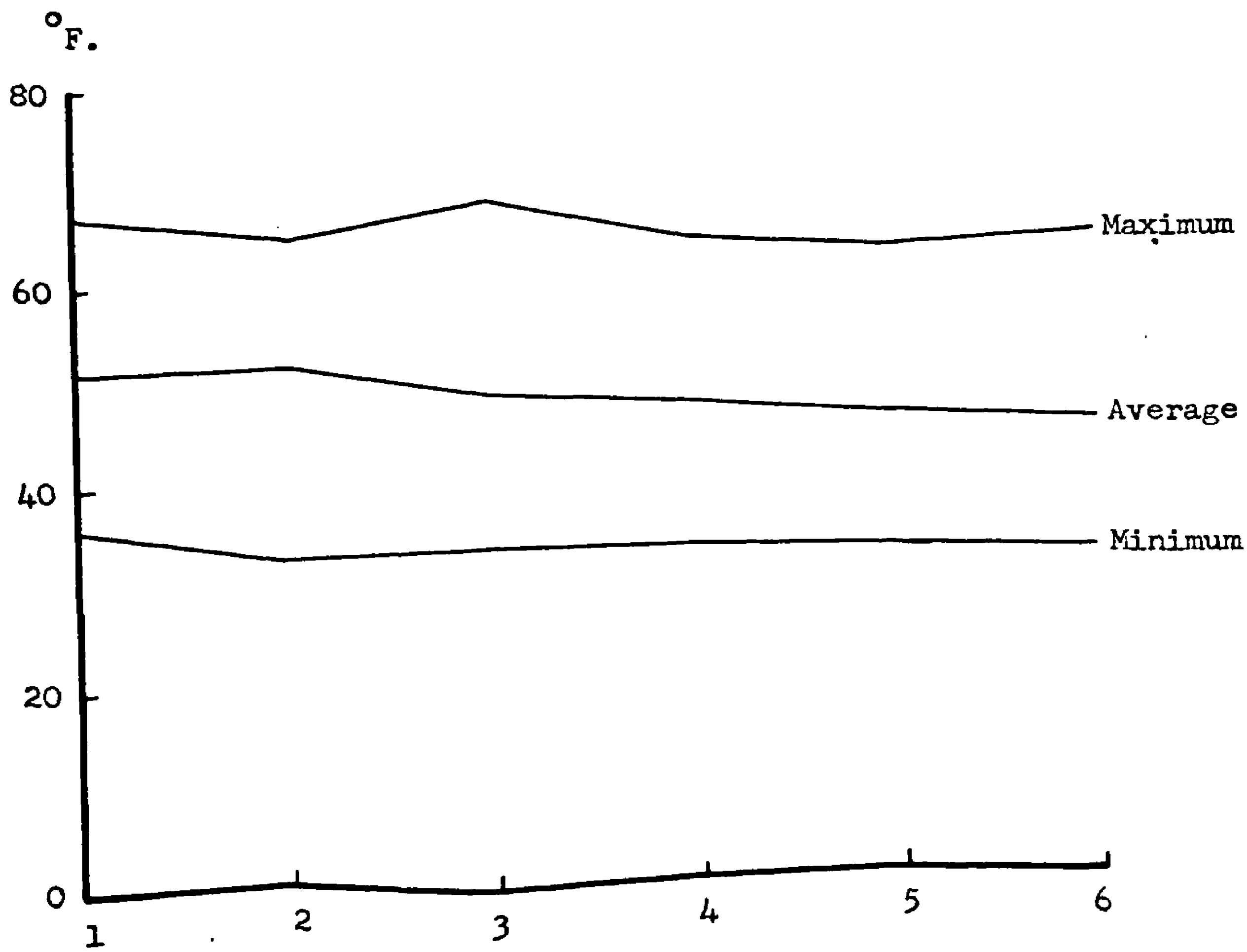

°F.
80
60
40
20
0
Maximum
Average
Minimum
1
2
3
4
5
6

Figure 3. Temperature Curve - Station 1.

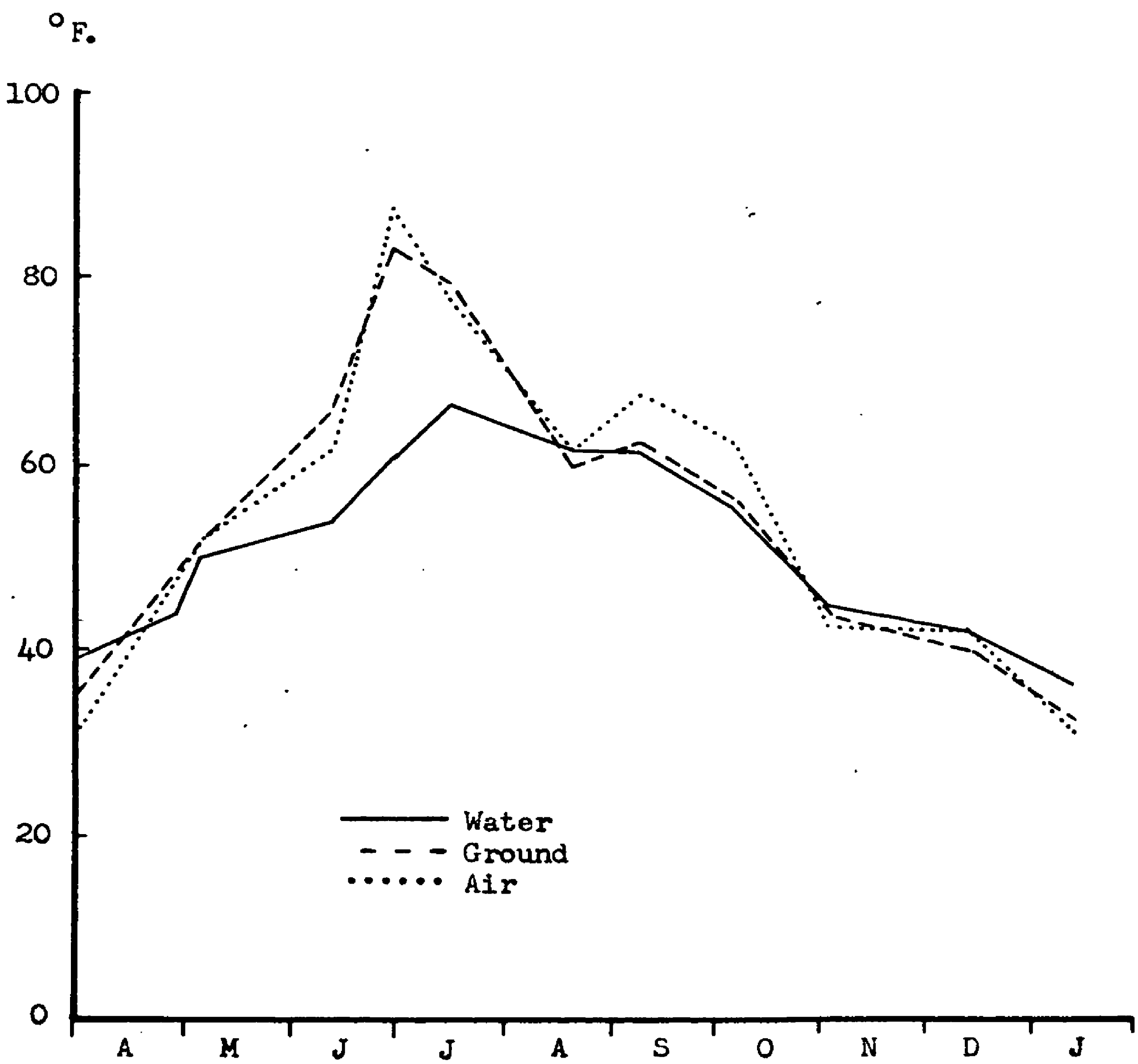

°F.
100
80
60
40
20
0
A
M
J
J
A
S
O
N
D
J
Water
Ground
Air

Figure 4. Temperature Curve - Station 2.

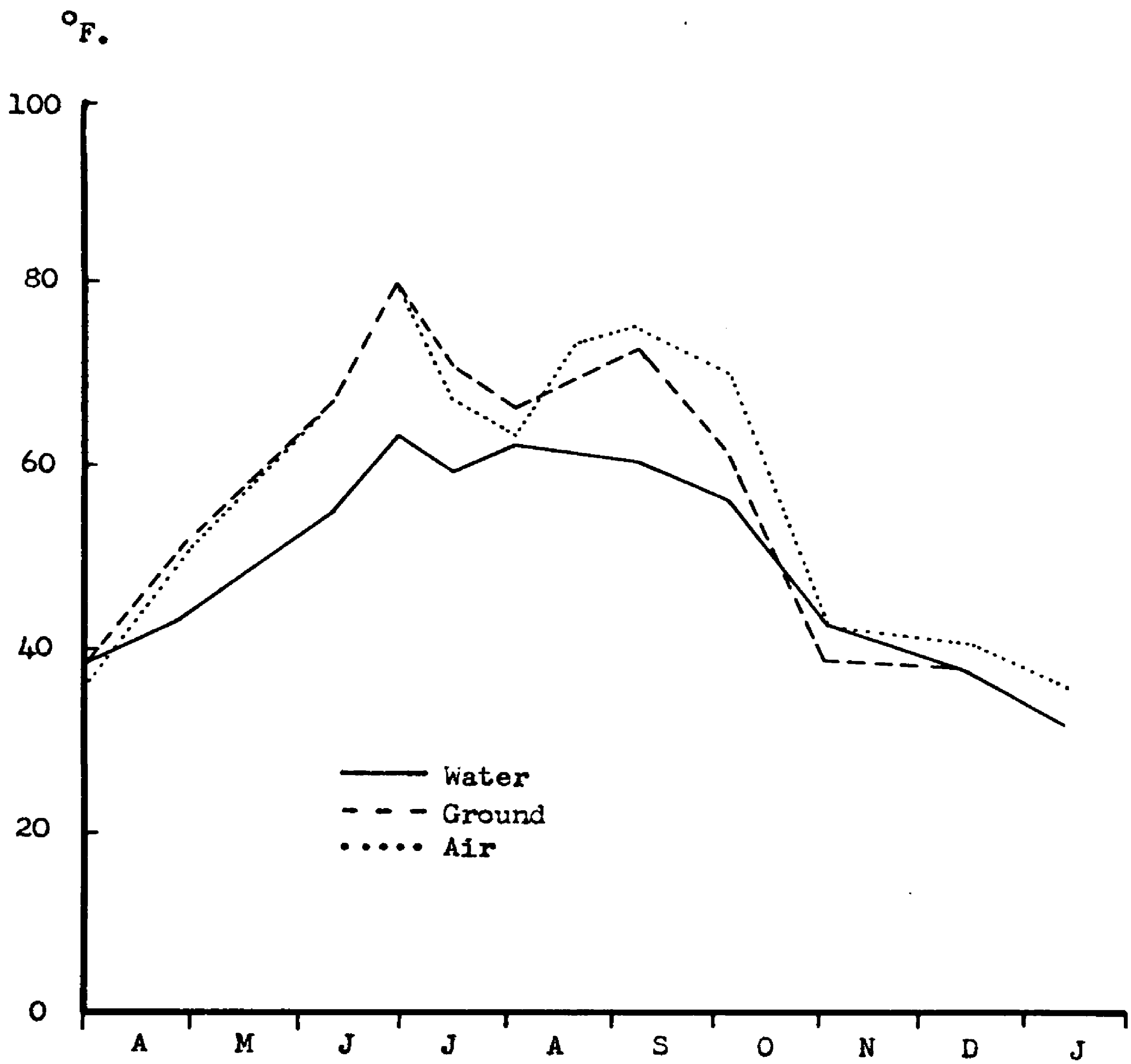
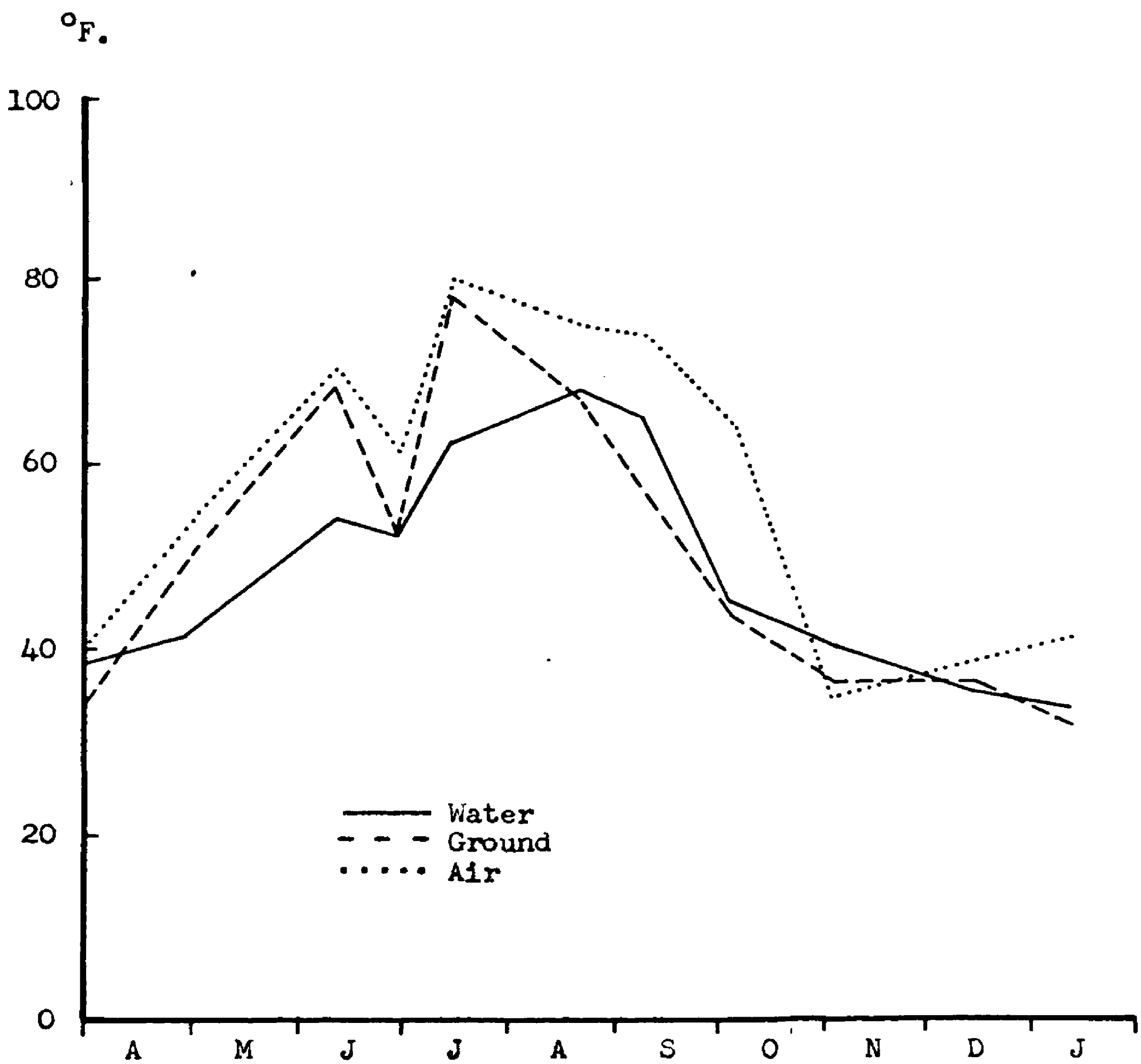

°F.
100
80
60
40
20
0
Water
Ground
Air
A
M
J
J
A
S
O
N
D
J

Figure 5. Temperature Curve - Station 3.



°F.
100
80
60
40
20
0
A
M
J
J
A
S
O
N
D
J
Water
Ground
Air

Figure 6. Temperature Curve - Station 4.

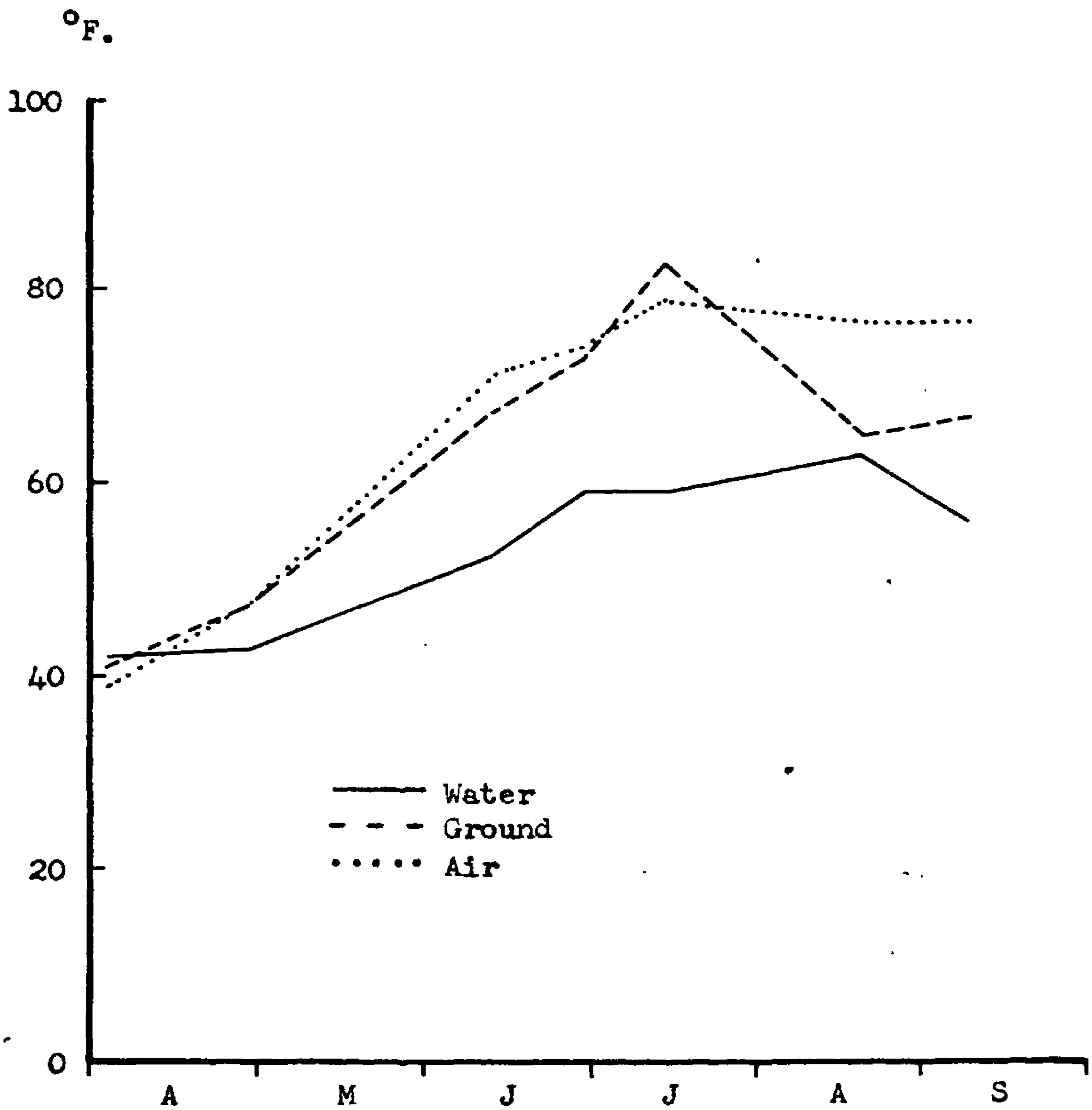

°F.
100
80
60
40
20
0
Water
Ground
Air
A
M
J
J
A
S

Figure 7. Temperature Curve - Station 5.

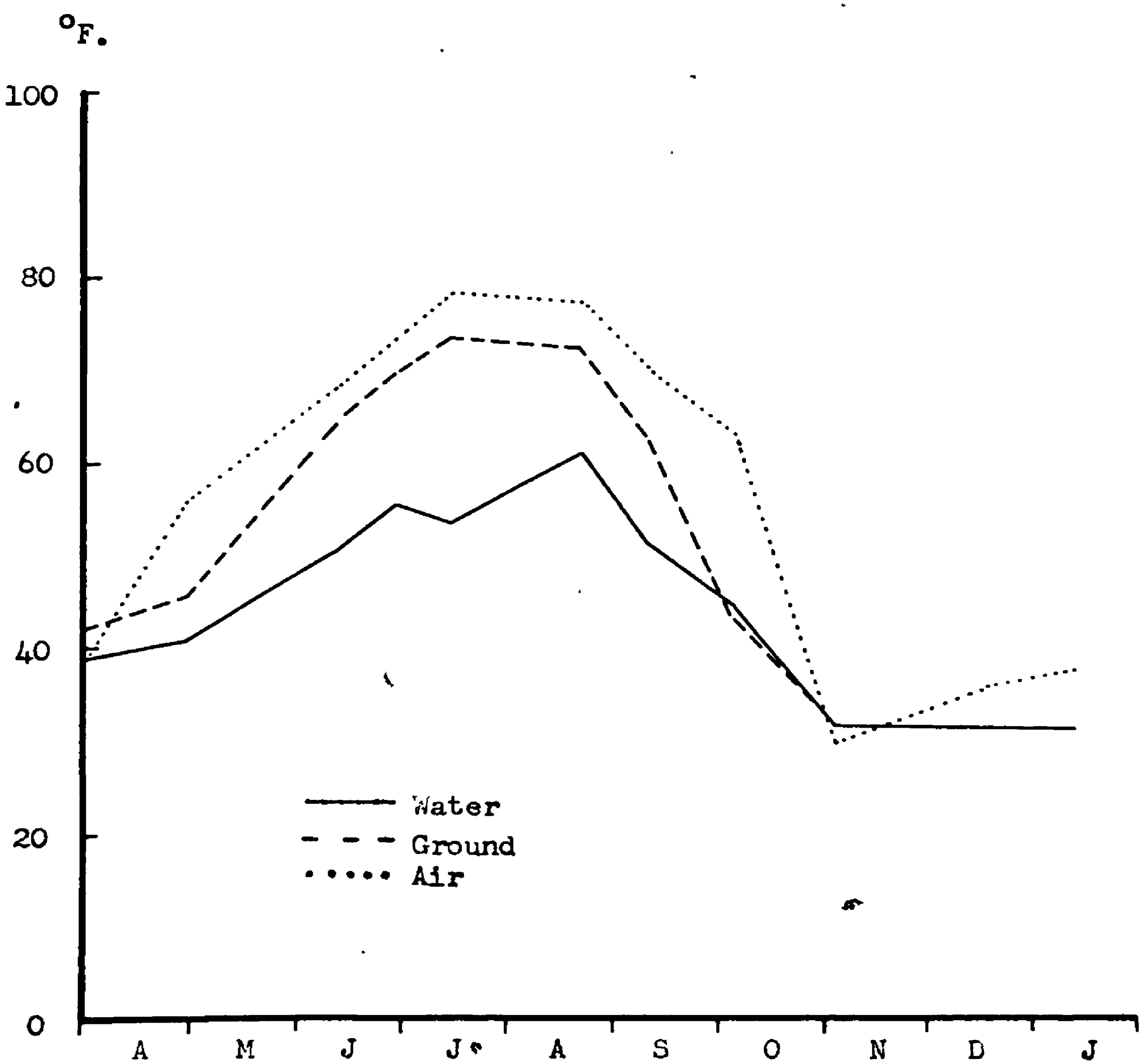
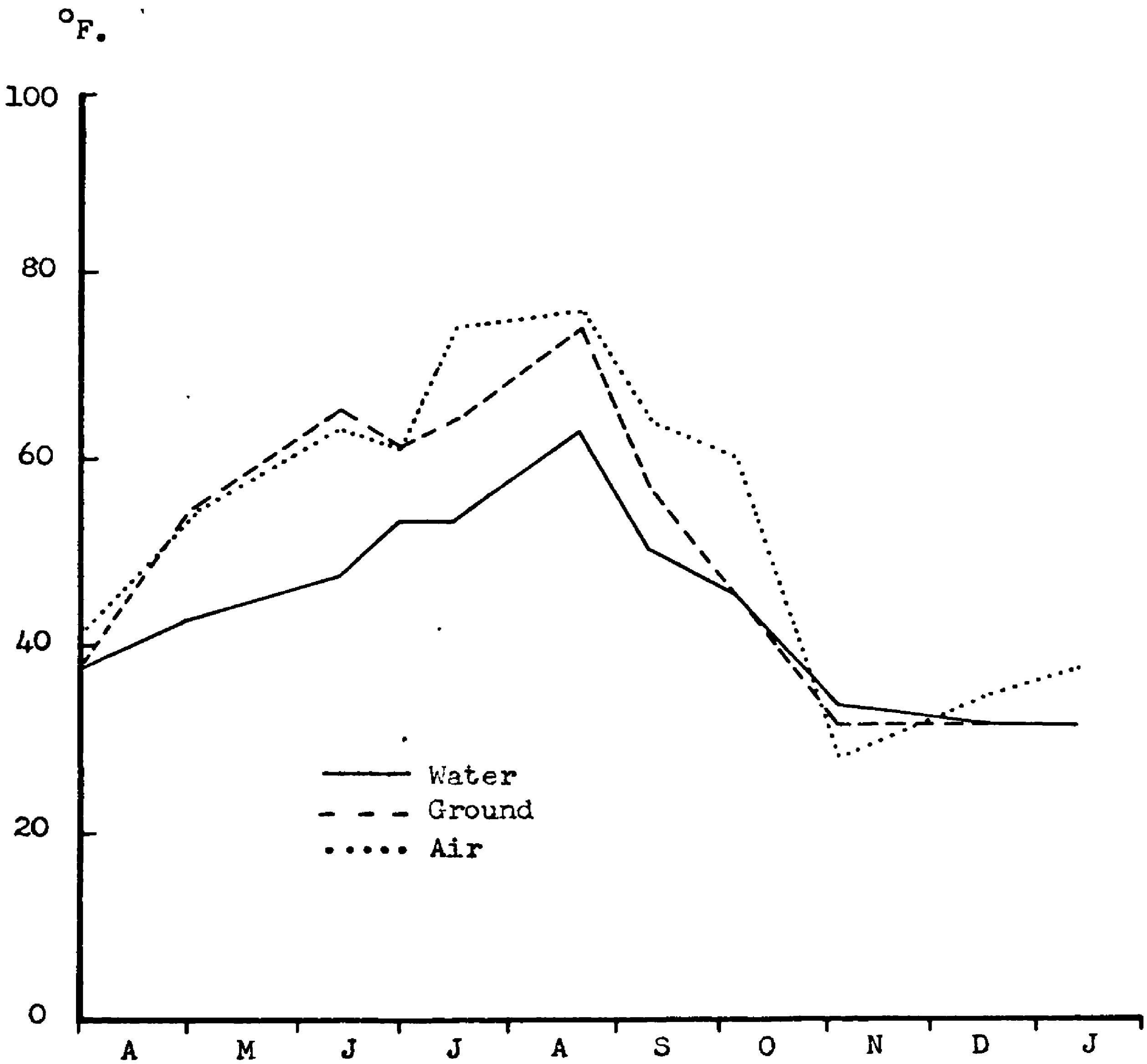

°F.
100
80
60
40
20
0
A
M
J
J
A
S
O
N
D
J
Water
Ground
Air

Figure 8. Temperature Curve - Station 6.



°F.
100
80
60
40
20
0
A
M
J
J
A
S
O
N
D
J
Water
Ground
Air

General Water Level.

The main Bitterroot River at stations 1, 2, and 3 was frozen over throughout most of March, 1956, and was clear of ice when the April 1 samples were taken. The April 1 level represents the flow of the river after the spring ice break-up. Spring runoff began in April and by the 28th (at which time samples were taken) the river was flowing at the high water banks. On May 5, samples were taken at station 1, but the water level was so high that collections were not taken from the other stations. A long gravel bar in the river at station 1 enabled bottom sampling to be carried out throughout the high water period, except during the latter part of May when the river went over its banks. On June 12 the river was again flowing within its banks, but was still as high as when samples were taken on April 28.

The river level continued to drop after June 28 throughout the summer months. The lowest level, as indicated in Fig. 9, appeared between August 20 and September 8. When collections were made on October 5, it was noted that the water level had come up since September. This level, shown in Fig. 9, was the same as during November. This higher level for October and November, as compared to August and September, probably was the result of reduced irrigation on the surrounding valley farms during this fall period. Several small dams located at intervals along the river are used to turn water from the river into canals and ditches used for irrigation. Very little water is taken out of the river above station 5, and the water level at the upper stations continued to drop through November. The water level at the three lower stations, on December 14, had risen considerably because of heavy rains preceding that date.

The East Fork (stations 4, 5, and 6) was free of ice on April 2, when collections were made. By April 29, the water level had risen to the high water banks. During May, the river rose above its high water banks and did considerable damage to station sites. On June 12, the water level had dropped to about the April 29 level. Most of the permanent bottom throughout station 4 was destroyed by high water. High water also damaged station 6 by washing out a riffle used for sampling at the lower end of the area. The water level on June 29 had dropped to about the April 1 level. All recordings after June 29 indicated a steady decrease in water level throughout the summer and fall months. The level on November 3 was the lowest of any recorded. Shore ice extended into the river from both sides, and the ground was covered with snow. The river had risen slightly, on December 15, and shore ice extended out from both shores. The ground around the station was covered with snow as on November 3.

The flood periods of the Bitterroot River occur during May and June (Figs. 9 and 10). Moffett (1936) found, in the South Willow Creek studies in Utah, that the period of recovery of aquatic insects from the standpoint of numbers, volume, and weight per unit area after a flood was three months. He concluded that floods reduce the productivity of streams. Other workers have found the detrimental effects of floods on aquatic populations. Coker (1954) indicated flooding as one of the greatest occasional hazards to stream animals. Briggs (1948) found that the production of bottom fauna was lowest during the periods of highly fluctuating water and during periods of lowest temperature.

Low water periods in the Bitterroot River occurred during the latter part of August and the early part of September for the main river stations, and during November for the East Fork stations. The rate of flow for station 7 (one-half mile above station 6) on November 11 was 108 cu. ft. per sec. as compared to 1061 cu. ft. per sec. for station 1 on December 4. During this low water (flow) period the production of bottom fauna was reduced, but not as outstanding a reduction as was noticed during periods of flood. Low water causes the destruction of some organisms by exposure of "habitual areas" (Briggs, 1948). Dunham (1938) noted migrations of bottom fauna up onto sand bars during a rise in the water level, and down from the sand bars as the water level receded. During the present study, organisms were collected from bottom areas which had been exposed a few days earlier. These forms could have migrated into these areas, or may have been displaced from farther upstream by the rising water level.

Winter conditions.

Winter conditions in the Bitterroot are typical of mountainous regions. Surface or sheet ice, frazil, and anchor ice are the three types of ice that may appear in streams. Frazil ice occurs as clumps at the water surface or as a stationary, slushy mass at all depths. Anchor ice forms over the immovable stream objects on the stream bed during night, under clear skies, in open water, and when water temperatures are slightly below 32.0° F. The amount of anchor ice formed is dependent on the depth of the stream, turbulence, and rate of heat radiation from the water (Maciolek, 1951). Anchor ice is most commonly found in shallow rapid water, from six to 24 inches deep. The mean thickness of this ice is about two inches, ranging up to seven inches in the fastest water (Benson, 1955). Anchor ice and surface or sheet ice were observed during the present study, but no frazil ice was recognized as such.

Various comments on the effects of ice conditions on the stream bottom fauna have been presented in the literature. Maciolek (1951) found subsurface ice to cause fluctuations in the velocity and volume of water: low at night--often leaving small side channels dry; high in the morning--scouring and washing loose debris and bottom fauna. Needham (1930) claimed that ice, being pushed downstream by the current, gouges out and destroys stream bottom organisms. Needham (1938) noted the abrasive action of anchor ice breaking loose from the bottom, which action destroyed bottom organisms. Benson (1955), using the Surber sampler, took quantitative samples of the anchor ice and found an average of 10 organisms per square-foot, along with sand, gravel, and organic debris. Qualitative samples of floating anchor ice revealed a similar condition regarding organisms and materials. Brown (1953), who worked on the West Gallatin River in Montana, observed aquatic organisms in the slush (floating anchor ice), but no stones were observed in this floating anchor ice as have been observed by other workers. Brown concluded that anchor ice had little or no effect on the numbers of bottom organisms. Brown (1956) indicated that anchor ice doesn't occur under surface ice except at its outer edge. When surface ice freezes solidly to the bottom, all organisms are killed. Brown (ibid.) also noted that no free water was associated with the sheet ice as it was with the anchor ice.

Figure 9. General water level - Stations 1, 2, and 3.

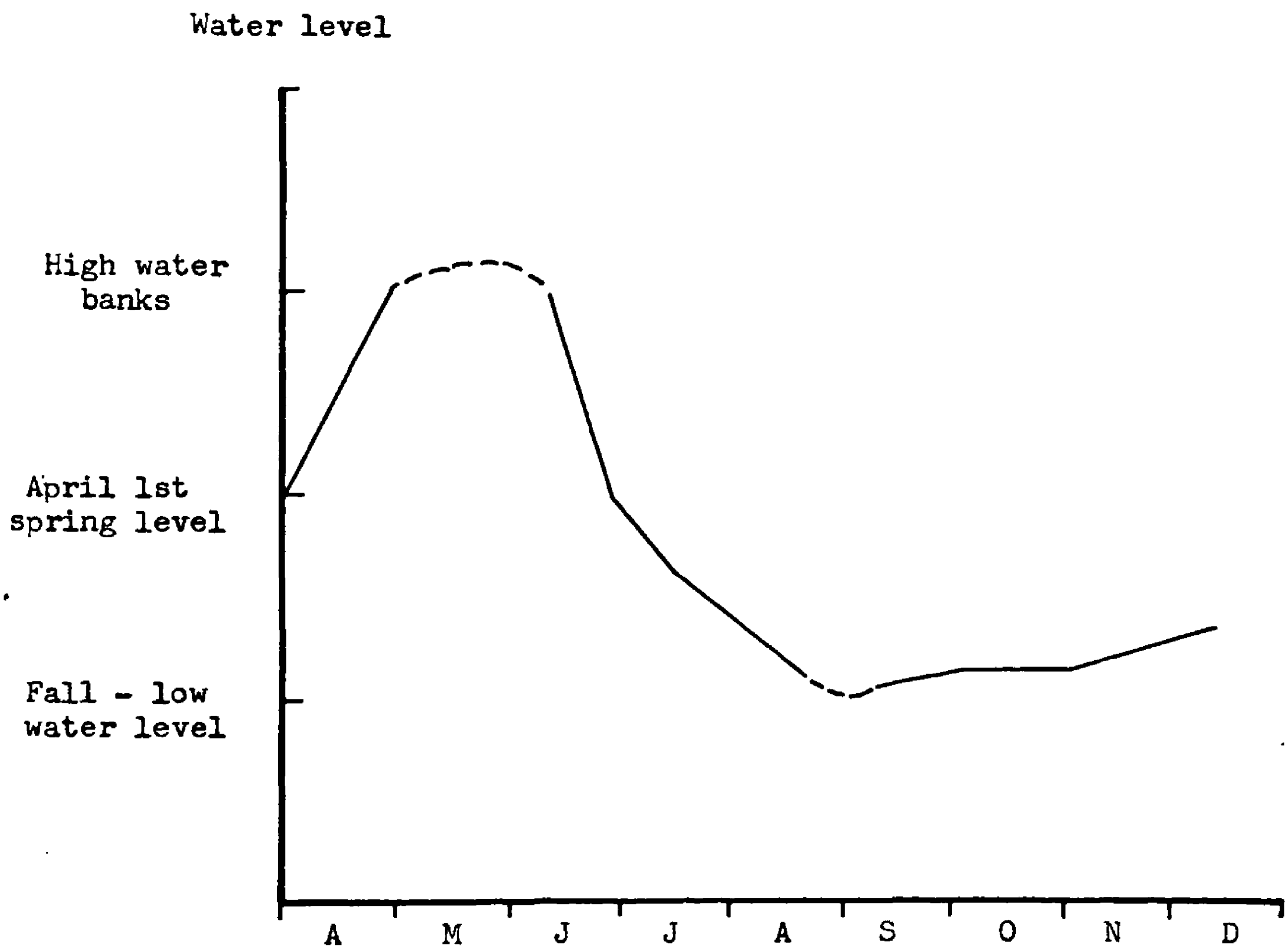
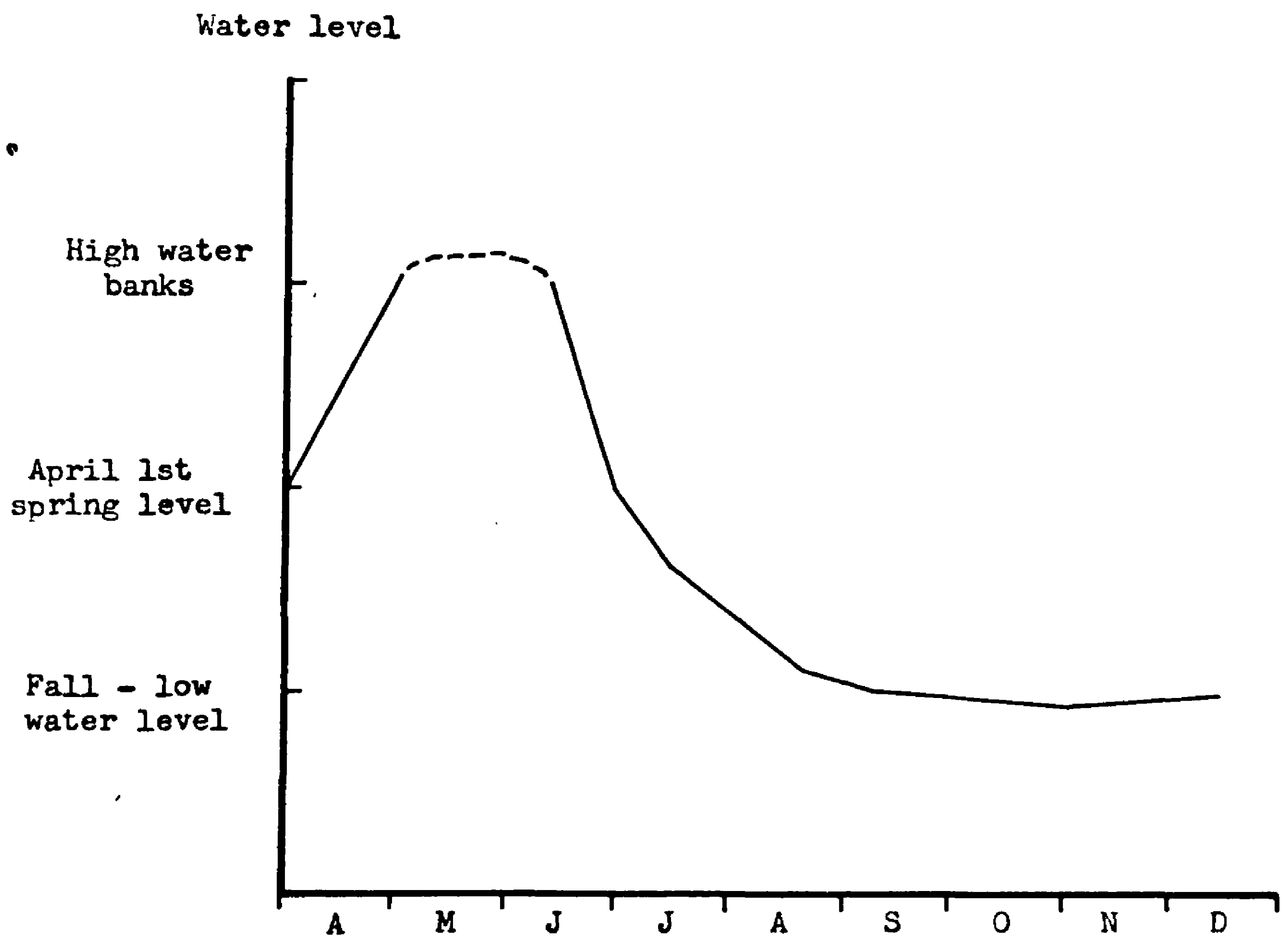

Water level
High water banks
April 1st spring level
Fall - low water level
A
M
J
J
A
S
O
N
D

Figure 10. General water level - Stations 4, 5, and 6.


Water level
High water
banks
April 1st
spring level
Fall - low
water level
A
M
J
J
A
S
O
N
D

Average Current Velocities.

The recordings which were made of the average current velocity for each station throughout the study period are shown in Fig. 11 and in Table XXIV in the Appendix. Notable discrepancies are discussed below.

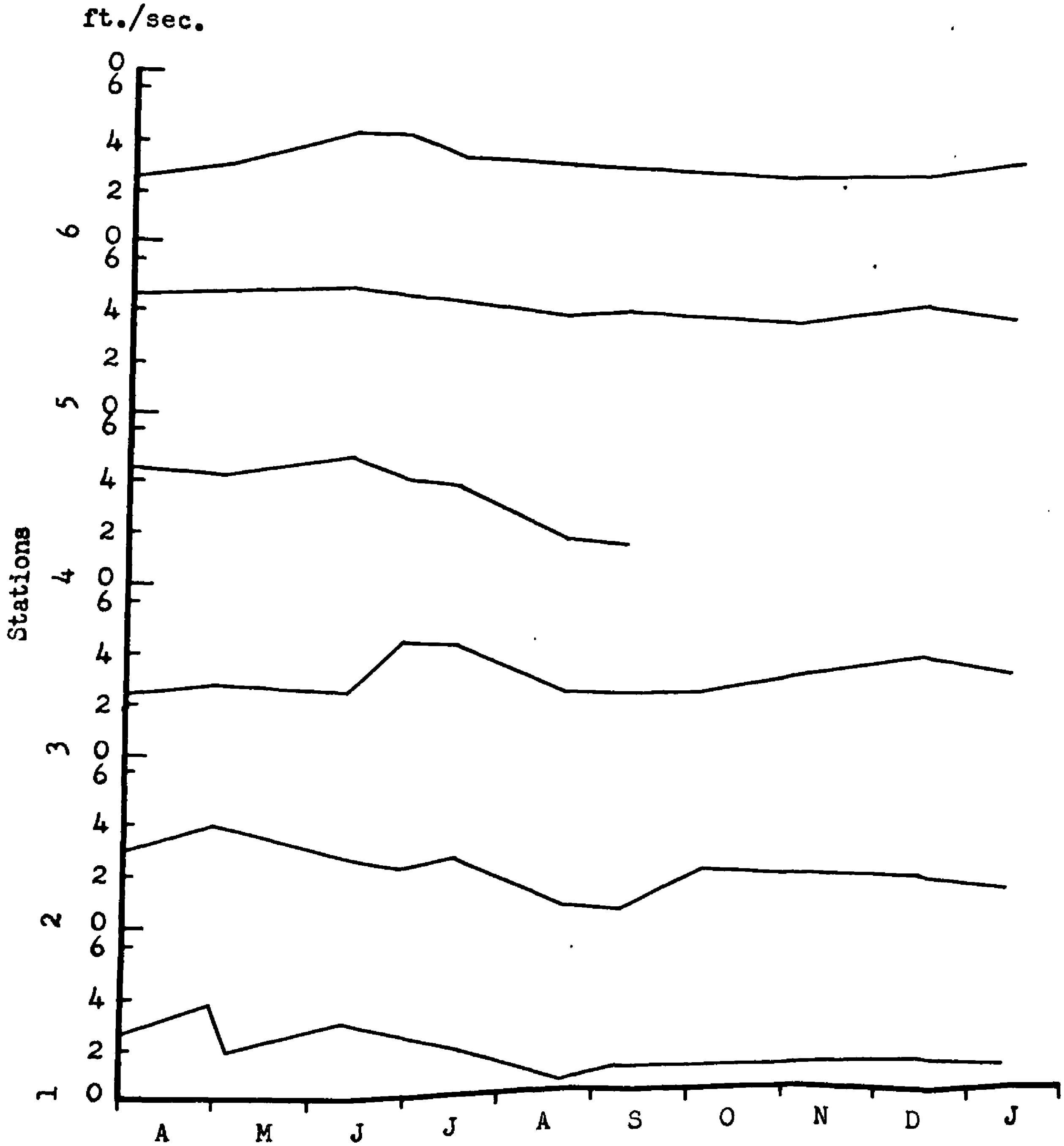
The average current velocity had decreased at station 1 by May 5, at which time the water level raised above the high water banks and flooded the surrounding area. By June 12, the water level was back within the high water banks again, and the average current velocity increased. As the water level continued to drop after June 12, the average current velocity dropped also. In the upper stations, recordings were not made during the peak of high water in May. Because the river channel is confined to a much narrower area through the canyon, it is assumed that the velocity of the current increased, rather than decreased during this period (Bernoulli's theorem). The damage caused by high water at the three upper stations was confined to the river channel and banks rather than the surrounding area.

The increase in current velocity shown on the graph (Fig. 11) for station 3 during the last of June and middle of July was because of the area of river measured. High water from April 28 to June 11 made it impossible to measure the open part of the river. Measurements had to be taken along the river edge, which was not a comparative measure of the average current velocity. When the river level dropped, the last of June, it was again possible to make recordings in the same area as for April 1. All average current velocities after June 29 were from the open river.

Average current velocities were high from April through July at station 4, with the highest on June 12 at 5.2 ft./sec. Current velocities for stations 5 and 6 also were highest on June 12, with high measurements of 5.1 and 4.5 ft./sec. respectively. Coker (1954) indicated the velocity of flow is affected by discharge, slope, form-ratio (proportion of depth to width), load (turbidity retards flow), and temperature (warm water being more fluid than cold water). Increased current velocities at the upper stations are prominent because of the narrow width of the stream through the East Fork Canyon, and the slope--or drop in elevation in feet per mile.

Water currents influence the morphology of stream forms and the quantity of organic production per unit area (Ruttner, 1953). Needham (1927) found 4.6 times as much bottom food in the rapid water bottoms as compared to the pool bottoms. Needham (1934) pointed out that shallow, swift riffles produce more food than deep, swift riffles. Streams of less than seven-feet in width produce much more food per unit area than those wider than seven feet; but taking into consideration the total areas of small and large streams, the larger streams produce far greater amounts of food (Needham, 1934). Lastochkin (1945) concluded that deep areas of rivers have higher biomass productivity than the shallows.

Figure 11. Average current velocity in ft./sec. for each station.


ft./sec.
Stations
6
5
4
3
2
1
0
6
4
2
A
M
J
J
A
S
O
N
D
J

QUALITATIVE STUDY

Qualitative data were taken on all forms collected in the stream bottom samples throughout the study period. Tables III and IV indicate little differences, qualitatively, between bottom fauna of the East Fork of the Bitterroot and the main Bitterroot River. As much information as possible was taken on the adult forms, results of which are shown in Table V. The following discussion concerns these groups of organisms.

Plecoptera.

Nymphs of the family Chloroperlidae were collected throughout the nine-month study period from the upper and lower stations. Adults of this family were collected June 12 and June 29. Nymphs of the family Nemouridae were present during the early spring sampling (April and May), but did not appear in the East Fork collections until August and in the main river samples until November. The adults of this family were collected April 1 and 2 from under rocks as far as 75 feet from shore. At station 1 on April 1, 19 adults were collected from two square-feet of shore examined. At station 2 on the same date, square-foot shore samples, which were taken 15 to 35 feet from shore, averaged three adults per square-foot. Square-foot shore samples at station 5 resulted in only three adults for a total of 30 square-feet of shore examined.

Nymphs of the family Perlodidae occurred in samples throughout the study period. Adults of this family were collected on June 29 and July 14.

Nymphs of the family Perlidae occurred at different times throughout the study period, and when present in samples, were usually in very small numbers. The majority of these nymphs were collected during the early spring (April) sampling, and the early fall (August, September, and October). No adults of this family were collected. In his report, Brunson (1956) stressed the fact that nymphs of the family Perlidae were conspicuous by their absence; whereas previously, both Brunson and the author had collected these nymphs in large numbers. This decrease could have resulted from the DDT spray (used on the spruce budworm) during the early summer of 1956.

Nymphs of the family Pteronarcidae were collected throughout the study period. Adults of Pteronarcella badia were collected along the main river (stations 1 and 3) only on two occasions throughout the study: June 28 and July 14.

Ricker (1943) found Pteronarcys princeps occurring in cold creeks and rivers and P. californica occurring in warm rivers, with no overlap of habitat occurring between the two species. The Bitterroot River and the East Fork of the Bitterroot River are moderately cold streams, averaging 45.1° F. in the upper stations and 51.6° F. in the lower stations from April through December (Fig. 2). No P. princeps occurred in the study area.

P. californica were not collected from stations 1 and 2 but occurred in all the remaining stations. The author concludes this absence was caused by the type of bottom, i.e.: the stones were deeply imbedded in silt. On June 11 at station 3, the hatch had been completed, and no adults could be found. The water temperature at station 3 on this date was 55.0° F. On June 12 at station 4 (16 miles above station 3 on the East Fork), adults of P. californica were observed over the area.

No mature nymphs were observed in the shallow water near shore. The water temperature at this site was 53.0° F. On June 12 at station 5 (13 miles above station 4) these forms were just beginning to emerge. Large numbers of mature nymphs had crawled in close to shore, around the big rip-rap rocks or boulders. Handfuls of these nymphs could be collected from the edges of these rocks. Some of the nymphs were just beginning to emerge. They were observed and collected in various stages of ecdysis. These forms, which were beginning to emerge, had crawled from the water, up onto the edges of the boulders, small shrubs, stems of weeds, etc. Some of the forms had emerged as adults and their wings were not fully expanded. The dorsum of the thorax on other mature nymphs was splitting, preparatory to emergence of the adult stage. The water temperature at this time was 51.0° F. At station 6 (3 miles above station 5) on the same date, no mature nymphs, exuviae, or adults, were observed near shore, thus indicating that emergence had not started at this upper site. The water temperature was 48.0° F. On June 29, adults were observed only at station 6. No mature nymphs were collected or observed along the shore, indicating that emergence had taken place prior to this date. The water temperature at this station was 54.0° F. on June 29.

The distribution of P. californica presents an interesting problem and the emergence of the adults of this species in the Bitterroot rivers is the most noticeable and predictable hatch of any of the stream fauna in the area. This emergence pattern on the Bitterroot begins at the lower parts of the stream, and steadily progresses up the river. Nearly a month's difference exists between the emergence in the lower reaches as compared to the upper sections of the stream.

During June when the water temperature reached 51.0° F., emergence of the adults was observed. No mature nymphs had migrated onto shore when water temperatures were below 50.0° F., and no mature nymphs were observed along shore after the water temperature had reached 53.0° F. or more. Thus it is noted that temperature is a critical factor in the emergence of P. californica.

Ephemeroptera.

All three families (Ephemeridae, Baetidae and Heptageniidae) were collected from the study area. Pennak (1947) found Ephemeroptera nymphs on all four bottom types studied (rubble, bedrock, gravel, and sand), and were most abundant in the rubble type, where they averaged 450 per square meter. Rubble type bottom is characteristic of the Bitterroot River and the East Fork, and large numbers of mayflies were collected in samples throughout the study period. Ide (1935) found an increase in number of species of mayflies from the source of the stream downstream, which fact could be correlated with temperatures. He concluded that water temperature limits the distribution of mayflies, along with other factors such as rate of water flow, bottom type, and vegetation.

In the present study, it was noticed that greater numbers of mayfly nymphs were collected, per unit area, from the East Fork of the Bitterroot than from the main Bitterroot River. Brunson (1956), likewise, found higher numbers of mayfly nymphs per unit area in the East Fork as compared to the main Bitterroot River.

Nymphs of the family Baetidae occurred in large numbers throughout the study period, in both the upper and lower stations. The sub-imagos and adults of this family were collected from June 28 to September 9.

Adults of this family usually occurred in large numbers when observed on the areas. On June 29 at station 6 these forms were emerging in large numbers. The bottom samples contained many shed exuviae and mature nymphs in various stages of emergence to the sub-imago form. The thorax had split lengthwise, and the wings of the sub-imago were hanging from the exuviae on some forms.

Nymphs of the family Heptageniidae also occurred throughout the study period, but did not occur in such high numbers as did the nymphs of the family Baetidae. Sub-imagos and adults of the family Heptageniidae were collected on April 28, May 5, June 28, and October 5.

Nymphs of the family Ephemeridae were collected from August 20 through October 5. These nymphs could not be classified to genus by use of any available keys, and will be sent to an authority for classification. The most outstanding characteristic was the large, flat mandibular tusks, typical of the family Ephemeridae. Only one adult of this family was collected, that was at station 1 on October 20.

Trichoptera.

The family Lepidostomatidae, occurred in large numbers throughout the study period. Only one genus, Lepidostoma, occurs in the western United States (Usinger, 1956). Representatives of the genus Lepidostoma will be sent to an authority for identification to species. Ross (1944) indicated that rarely are many species of this genus found occurring together in the same locality. Data collected on this genus show a significant difference between the sizes of some of the larvae collected. This difference could be different species involved, or as Betten (1936) found--some species may have one brood a year in one locality, and two in another, thus different larval stages may be collected at the same time. Lepidostoma pupae were collected the last of June and the middle of July. Adults of this genus were collected the middle of July.

The other families of Trichoptera which occurred in the samples were Hydropsychidae, Molanidae, Ryacophilidae, Limnephilidae, Brachycentridae, and Hydroptilidae. Larvae of the Hydropsychidae were collected throughout the study period. Larvae of family Molanidae were collected on only two occasions, April 28 from the lower stations, and August 20 from the upper stations. Ryacophilidae larvae were common throughout most of the sampling period in both the upper and lower stations. Limnephilidae larvae, on the other hand, were collected from June 29 through December 14 in the lower stations, but appeared only in samples from the upper stations during August and September. Larvae of the family Brachycentridae were present in the April 1 samples from the lower stations, but were absent through May and June, appearing again from July 14 through December. These larvae were collected from the upper stations only during October and November. Larvae of the family Hydroptilidae were collected from September 8 through December from the lower stations, and none were collected from the upper stations. Adult Trichoptera were collected from station sites on April 1, May 5, June 28, July 14, and August 20.

Diptera.

Five families of this order were collected from sampling areas throughout the study period. Larvae and pupae of the family Tendipedidae were very common in the samples, and appeared at all times of the year. One of the most interesting larvae of this family, is that which occurs in Nostoc parmelioides. This larva was called to the author's attention by William Vinyard who is studying this midge-Nostoc relationship. Apparently, at least one and sometimes two midges occur in each *Nostoc parmelioides* colony. These algal colonies were observed and collected only on the East Fork of the Bitterroot River, and occurred only on granite stones. Adults of the family Tendipedidae were collected or observed throughout the study period, except during the period of high water flow in May and June.

Simulidae larvae were collected irregularly and in small numbers throughout the sampling period. Many forms are characteristic of swift streams, although representatives of this family appeared only during June and September samples from the upper stations and were common in the lower stations throughout the study period. Adults were collected on April 28 and during July, August and September. Larvae of the family Tipulidae were common in samples throughout the study period. Adult Tipulids were collected from May through July on the station areas. Larvae of the family Ephydridae were collected April 2 and during November and December from the upper stations. These larvae were collected in bottom samples from the lower stations during December. Other adult Diptera, not identified, were collected on the station areas during July, August, and September.

Coleoptera.

Larvae and adults of the family Elmidae were the most common coleopterans collected during the studies. These forms appeared during all collecting periods at the lower stations, and from the majority of those of the upper stations. These organisms were more abundant in the former areas than the latter. Other families of Coleoptera collected were

Hydrophilidae, Haliplidae, Dytiscidae and Chrysomelidae. Adult and larval stages of these families were present in only a few of the bottom samples, appearing most commonly during the summer months. One type of Coleoptera larva was collected throughout the study which could not be identified to family.

Hemiptera.

Two families of aquatic Hemiptera were collected from the station areas. Notonectidae were collected only on April 1 from a small back-water at station 1. Large numbers of the family Corixidae were collected in bottom samples and observed from July through October at the lower stations. These forms were observed in school-like groups swimming near shore in the shallow, slow water. They were collected from the upper stations on the East Fork only on November 11, from a small eddy along the stream edge.

Terrestrial Insects.

Many forms of terrestrial insects which fall into the water and drift into the net during sampling were collected. Similarly when sweeping over the stream banks and the river with the sweep net for aquatic adults, many terristrial insects were collected. The majority of these forms collected in the bottom samples were of the order Hymenoptera, of which the family Formicidae occurred most frequently. These terrestrial forms falling into the water are usually termed "drift food". Drift food, however, consists of more than just terrestrial insects. Slack (1955) found that drift food was higher in the forest covered areas, with brush covered, semi-exposed, and exposed areas following in decreasing amounts.

Needham (1938) found that adult terrestrial insects composed 93.02 per cent of the drift food and that 6.98 per cent were aquatic insects. Numerous papers have been published on fish food habits in regard to terrestrial and aquatic insects. Needham (1927) found that 83 per cent of the fish food from trout stomachs studied was aquatic in origin and the remaining 17 per cent was terrestrial in origin. Dimick and Mote (1934) concluded that terrestrial insects were prominent in the diet of Oregon trout during the spring, summer, and fall months, and that aquatic insects formed the bulk of the food throughout all seasons of the year. Morofsky (1940) and Lagler (1952) indicated that aquatic insects are the most important natural fish food for trout, and that terrestrial insects falling into the water also constitute a considerable source.

Hydracarina.

Only a few water mites were collected in the bottom samples during the study. These forms appeared primarily from June to October in the samples, but a few were collected from the upper stations on November 11 and December 15.

Decapoda.

One crayfish (<u>Astacus</u> <u>trowbridgi</u>) of the family Astacidae was collected from station 1 on October 5. Crayfish are quite common in the lower Bitterroot River and side channels below Stevensville. These forms can be collected quantitatively from those areas of the stream where large boulders or other material which constitute cover can be found.

Amphipoda.

One *Gammarus sp.* was collected from station 4 on September 9. The water throughout this section of the river is very rapid; however, a pond is located about one-half mile above this station and is connected to the river. It is probable that this amphipod drifted into the river from this pond.

Nematoda.

Many nematodes were collected in the bottom samples, but because of the mesh size, obviously many were lost from the sample. It is interesting to note that nematodes parasitized almost every group of aquatic insects collected. Some of the specimens of Hydropsychidae were heavily parasitized by nematodes. Mayflies were also parasitized frequently by the nematodes.

Annelida.

Small annelids occurred in large numbers throughout the sampling period. As noted in Tables III and IV, the Lumbriculidae were separated from the small annelids. Lumbriculidae were found in the bottom samples only during September and November from the upper stations and during December for both areas.

Platyhelminthes.

Tricladida were collected frequently from both the upper and lower station areas. Several of these were collected during June and July at the time the water level was dropping, but larger numbers occurred in the bottom samples from the upper stations during November and December.

Gastropoda.

Snails appeared occasionally in the samples from the upper stations with greater numbers being collected during November and December. The genus *Physella* occurred most frequently; however, *Lymnaea* was present also.

Pelecypoda.

Fresh water unionids (*Margaritana margaritifera*) occur throughout the Bitterroot River and East Fork of the Bitterroot River; however, none were collected from the station areas. The fingernail clams (Sphaeriidae) were taken in bottom samples at intervals from the upper stations. A qualitative collection of bottom fauna from a small backwater pool at station 7 resulted in large numbers of these clams.

Pisces.

Small fish were often collected in the bottom samples. Longnose dace (*Rhinichthys cataractae*) and slimy sculpin (*Cottus cognatus*) were the species most frequently collected. The mountain whitefish (*Coregonus williamsoni*) and species of suckers (*Catostomus sp.*) were also present in the bottom samples. The following is a qualitative list of fish occurring in the Bitterroot River and East Fork of the Bitterroot River.

*_Salmo trutta_- - - - - - - - - - - - - -brown trout
*_Salmo gardneri_- - - - - - - - - - - - -rainbow trout
Salmo clarki- - - - - - - - - - - - - -cutthroat trout
*_Coregonus williamsoni_ - - - - - - - -mountain whitefish
Salvelinus fontinalis - - - - - - - -brook trout
Salvelinus alpinus- - - - - - - - - -Dolly Varden
*_Catostomus macrocheilus_ - - - - - - -largescale sucker
*_Catostomus catostomus_ - - - - - - - -longnose sucker
*_Rhinichthys cataractae_- - - - - - - -longnose dace
*_Richardsonius balteatus_ - - - - - - -redside shiner
*_Ptychocheilus oregonense_- - - - - - -northern squawfish
*_Cottus cognatus_ - - - - - - - - - - -slimy sculpin
Mylocheilus caurinum- - - - - - - - -peamouth chub

*Collected from station 2 on August 3 by shocking.

Plankton.

Classification of plankton in the Bitterroot River was not considered in the present study. Impoundments, abandoned meanders, and backwater areas along streams are the breeding grounds for stream plankton (Blum, 1956). It is interesting to note that a Copepod was collected from station 4 on September 9 in the bottom samples, wheras one would expect specimens to go through the mesh. It is quite possible that this organism came from the backwater area one-half mile above this station. Chandler (1937), studying the fate of lake plankton in streams, found that lake plankton undergoes a quantitative decrease as it flows downstream. Stream vegetation, debris, and sedimentation are important factors which decrease the amount of lake plankton in a stream.

Algae.

Swift rocky streams are usually limited in higher plants, but algae may occur in large numbers (Coker, 1954). _Hydrurus foetidus_ (Chrysophyceae) and _Nostoc parmelioides_ (Cyanophyceae) were found only in areas of rather strong currents on the East Fork of the Bitterroot River. These two species are readily recognized in the field. In general, members of Chrysophycae (yellow greens), *Vaucheria sp.* (Chlorophyceae), and *Melosira sp.* (Bacillariophyceae) were predominant in the winter collections. One exception was a bloom of Xanthophyceae (yellow green) and Bacillariophyceae (diatoms) which was limited to a rather small area along the shore at station 1 on February 9, 1957. This bloom consisted primarily of *Tribonema sp.*, and *Melosira sp.* Other algae present in this bloom were *Tabellaria sp.* (Bacillariophyceae), *Ulothrix sp.*, *Tetraedron sp.*, *Scenedesmus sp.*, *Ankistrodesmus sp.*, and *Staurastrum sp.* (Chlorophyceae). Algae are important in stream productivity both from the standpoint of primary production and as a habitat, when forming tangled mats, for many of the smaller aquatic animals (Vinyard, personal communication). It is unfortunate that so little work has been done on such algal-animal relationships. There are indications that algae may be of further importance when occurring as epizootics on animals (Vinyard, 1955).

TABLE III

QUALITATIVE LIST OF ORGANISMS FROM STREAM BOTTOM SAMPLES
STATIONS 1, 2, AND 3, APRIL THROUGH DECEMBER

QUALITIVE LIST	APR.		MAY	JUNE			JULY		AUG.	SEPT.	OCT.			NOV.		DEC.	
	1	28	5	11	28	29	14	15	20	8	4	5	20	2	3	4	14
CHLOROPERLIDAE	*	*		*	*		*	*	*	*	*	*		*	*	*	*
NEMOURIDAE	*	*	*											*	*	*	*
PERLODIDAE	*	*	*	*	*	*	*	*	*	*	*	*		*		*	*
PERLIDAE	*	*		*		*				*	*						
PTERONARCIDAE	*	*	*			*	*	*	*	*		*		*		*	
EPHEMERIDAE									*	*		*					
BAETIDAE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
HEPTAGENIIDAE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
HYDROPSYCHIDAE	*	*	*	*	*		*	*	*	*	*	*	*	*		*	*
MOLANIDAE		*															
RHYACOPHILIDAE					*	*	*	*	*	*			*			*	
LIMNEPHILIDAE						*		*	*	*	*	*		*	*	*	*
BRACHYCENTRIDAE	*						*	*	*	*		*	*	*		*	
HYDROPTILIDAE										*		*	*	*		*	*
LEPIDOSTOMATIDAE	*	*		*	*	*	*		*	*	*	*		*	*	*	*
TENDIPEDIDAE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SIMULIDAE	*	*			*			*	*	*				*		*	*
TIPULIDAE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
EPHYDRIDAE																*	*
ELMIDAE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
HYDROPHILIDAE					*		*					*					
HALIPLIDAE									*		*						
DYTISCIDAE			*					*		*							
COLEOPTERA (MISC.)	*									*	*			*		*	
AESCHNIDAE	*																
COENAGRIONIDAE																*	
NOTONECTIDAE	*																
CORIXIDAE								*	*	*		*					
TERRESTRIAL INSECTS	*											*					
HYDRACARINA							*		*	*	*						
ASTACIDAE (DECAPODA)												*					
NEMATODES	*				*							*		*		*	*
ANNELIDA	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
LUMBRICULIDAE																*	
TRICLADIDA						*				*							
FISH	*	*		*					*	*		*				*	

TABLE IV

QUALITATIVE LIST OF ORGANISMS FROM STREAM BOTTOM SAMPLES
STATIONS 4, 5, AND 6, APRIL THROUGH DECEMBER

Qualitative List	Apr. 2	Apr. 29	June 12	June 29	July 14	Aug. 20	Sept. 9	Oct. 4	Nov. 3	Nov. 11	Dec. 15
Chloroperlidae	*	*	*	*	*	*	*	*	*	*	*
Nemouridae	*	*				*	*	*			
Perlodidae	*	*		*		*	*	*	*	*	*
Perlidae	*	*			*	*	*	*			
Pteronarcidae	*	*	*	*	*	*	*	*	*	*	*
Ephemeridae							*				
Baetidae	*	*	*	*	*	*	*	*	*	*	*
Heptageniidae	*	*	*	*	*	*	*	*	*	*	*
Hydropsychidae	*		*		*	*	*	*			
Molanidae						*					
Rhyacophilidae	*		*	*	*	*	*	*		*	
Limnephilidae						*	*				
Brachycentridae								*		*	
Lepidostomatidae		*	*			*	*	*	*	*	*
Tendipedidae	*	*	*	*	*	*	*	*	*	*	*
Simulidae			*				*				
Tipulidae	*	*	*	*	*	*	*	*	*	*	
Ephydridae	*									*	*
Elmidae		*	*	*	*	*	*	*			*
Haliplidae						*					
Dytiscidae					*	*					
Coleoptera (misc.)	*		*								
Corixidae										*	
Terrestrial Insects			*			*	*				
Hydracarina			*		*					*	*
Amphipoda							*				
Nematodes	*		*				*				
Annelida	*	*	*	*	*	*	*	*	*	*	*
Lumbriculidae							*			*	*
Tricladida			*	*	*				*	*	*
Gastropoda	*		*		*		*		*	*	*
Sphaeriidae			*		*		*			*	
Fish						*					

TABLE V

QUALITATIVE LIST OF AQUATIC INSECT ADULTS COLLECTED OR OBSERVED AT SAMPLING AREAS APRIL THROUGH DECEMBER

Qualitative List	Apr.				May	June				July		Aug.	Sept.		Oct.			Nov.			Dec.		
	1	2	28	29	5	11	12	28	29	14	15	20	8	9	4	5	20	2	3	11	4	14	15
Pteronarcys californica							*		*														
Pteronarcella badia								*		*													
Nemouridae	*	*																					
Chloroperlidae								*		*													
Perlodidae									*	*													
Plecoptera (observed)			*		*																		
Ephemeridae																	*						
Baetidae								*	*	*		*	*	*									
Heptageniidae			*		*			*								*							
Ephemeroptera (observed)					*				*														
Lepidostoma sp.										*													
Other Trichoptera	*				*			*		*	*	*											
Tendipedidae	*	*	*							*	*	*	*	*	*			*		*	*	*	
Simulidae			*							*	*	*		*									
Tipulidae					*			*	*	*	*												
Diptera (misc.)										*	*	*	*										
Coleoptera (misc.)	*					*		*		*	*	*	*		*	*		*	*		*		*
Libellulidae											*												

CROSS-SECTIONAL STUDY

Station 7.

All samples throughout this study were taken from areas near the shore in order to have a similarity of depth, bottom type, and current velocity. However, cross-sectional studies were carried out on both the East Fork and the main Bitterroot River to show the relationship of the organisms represented in the samples to the total population.

Cross-sectional samples were taken at station 7(one-half mile above station 6) on November 11, and a profile (Fig. 12) was made of the river at that point. The width of the stream sampled was 48 feet, and the average current velocity was 3.4 feet per second. Five square-foot bottom samples were collected at distances of 3, 13, 18, 30, and 45 feet from the south shore. Water depths at these sampling spots were 12, 12, 16, 11, and 8 inches deep respectively. The bottom type consisted of gravel and stones of six to eight inches in diameter. In streams 18 to 20 feet in width, Needham (1927) and Pate (1934) found a decrease in productivity at the center, and an increase on both sides of the center. Denham (1938) indicated a correlation between bottom type and bottom organisms both quantitatively and qualitatively in typical cross-sections of a river. The bottom type is usually dependent upon the velocity of the water immediately above it. Results from the cross-sectional samples at station 7 are comparable to those of Needham and Pate discussed above, i.e., a decrease in numbers of organisms near the center of the stream (Table VI, Fig. 14).

These data show a decrease in numbers of organisms per unit area as the depth and distance from shore increases. The square-foot sample taken at depth 16 inches (18 feet from the south shore) produced only 28 organisms per square-foot, compared to 80 per square-foot for the sample (30 feet from the south shore, 18 feet from the north shore) at depth 11 inches.

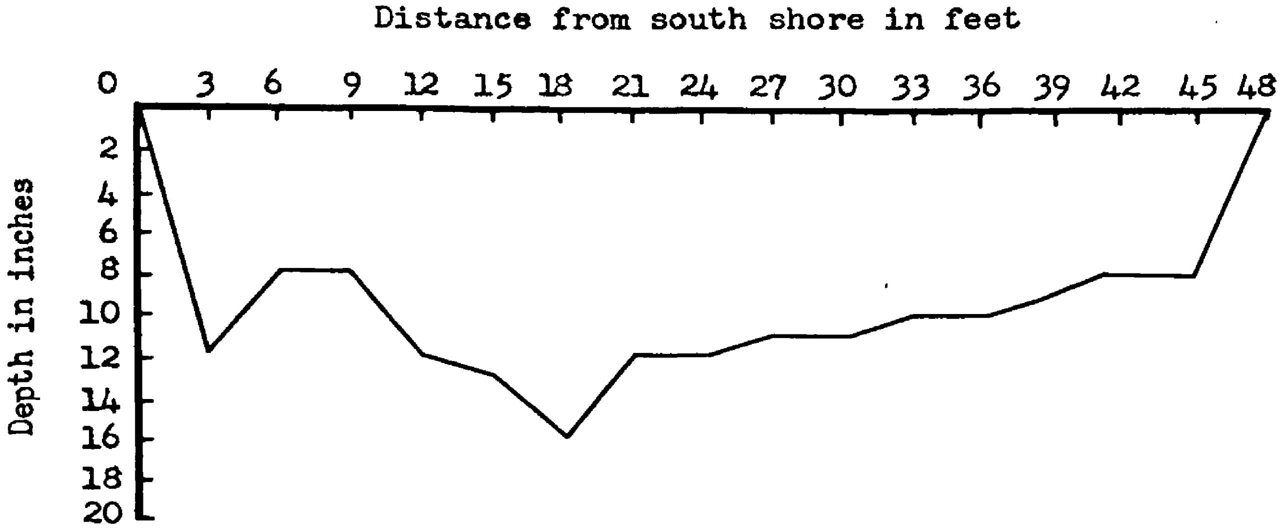
The order Plecoptera was represented in these cross-sectional samples by the families Perlodidae, Chloroperlidae, and the Pteronarcidae, which included *Pteronarcys californica* and *Pteronarcella badia*. *Pteronarcys californica* occurred in all five samples across the stream, while *Pteronarcella badia* was present only in those samples up to 13 feet from shore and depths 12 inches and less. Nymphs of Baetidae and Heptageniidae (Ephemeroptera) were collected from all sampling areas across the stream. The family Baetidae represented the highest numbers in the unit areas sampled. Three families of the order Diptera were present. Ephydridae were the most common and occurred in all the samples, followed by the families Tipulidae and Tendipedidae, which were present only in the first sample taken at depth 12 inches, three feet from the south shore. The order Trichoptera was represented by the families Rhyacophilidae, Brachycentridae, and the Lepidostomatidae. Trichoptera larvae occurred only in those sampling areas of depth 12 inches or less. Large numbers of Annelida occurred in all sampling areas across the stream. Hydracarina, Tricladida, and Gastropoda occurred in the sampling areas close to shore.

Station 1.

Cross-sectional samples were taken at the lower end of station 1 on December 4, and a profile (Fig. 13) was also made of the river at that point. The width of the stream sampled was 400 feet, and the average

Figure 12. Stream profile, Station 7, November 11, 1956.

Figure 13. Stream profile, Station 1, December 4, 1956.


Distance from south shore in feet
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
Depth in inches
2
4
6
8
10
12
14
16
18
20

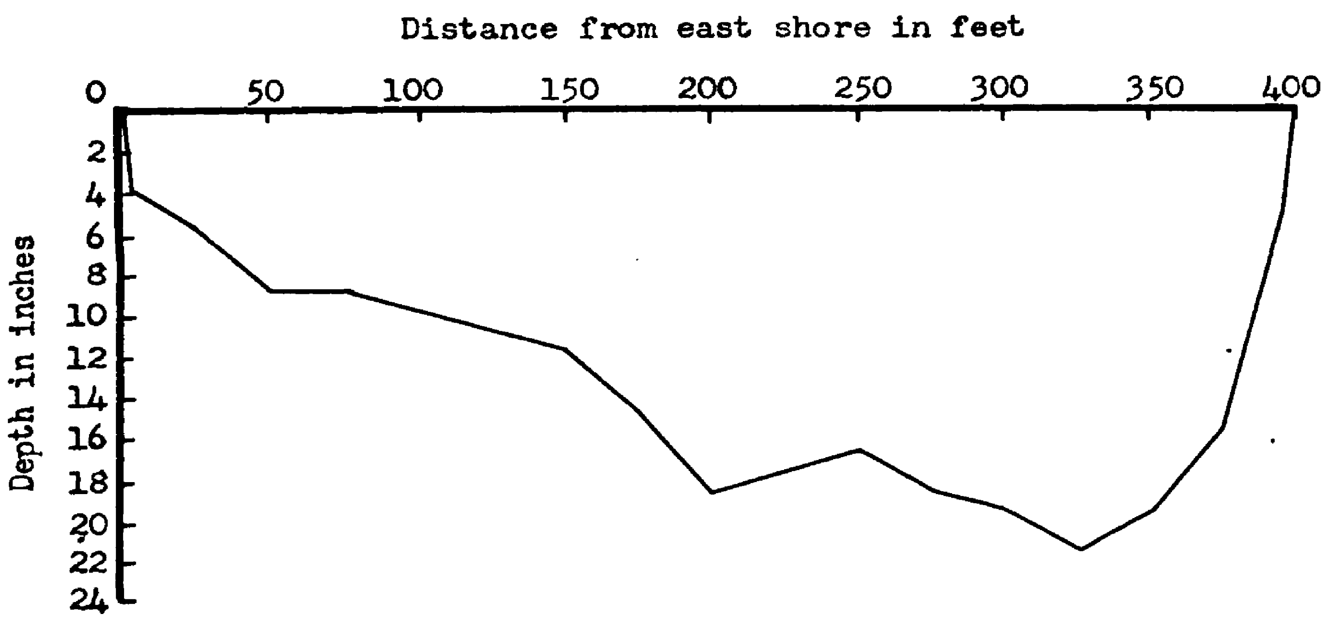

Distance from east shore in feet
0
50
100
150
200
250
300
350
400
Depth in inches
2
4
6
8
10
12
14
16
18
20
22
24

Figure 14. Cross-sectional samples from Station 7, November 11.

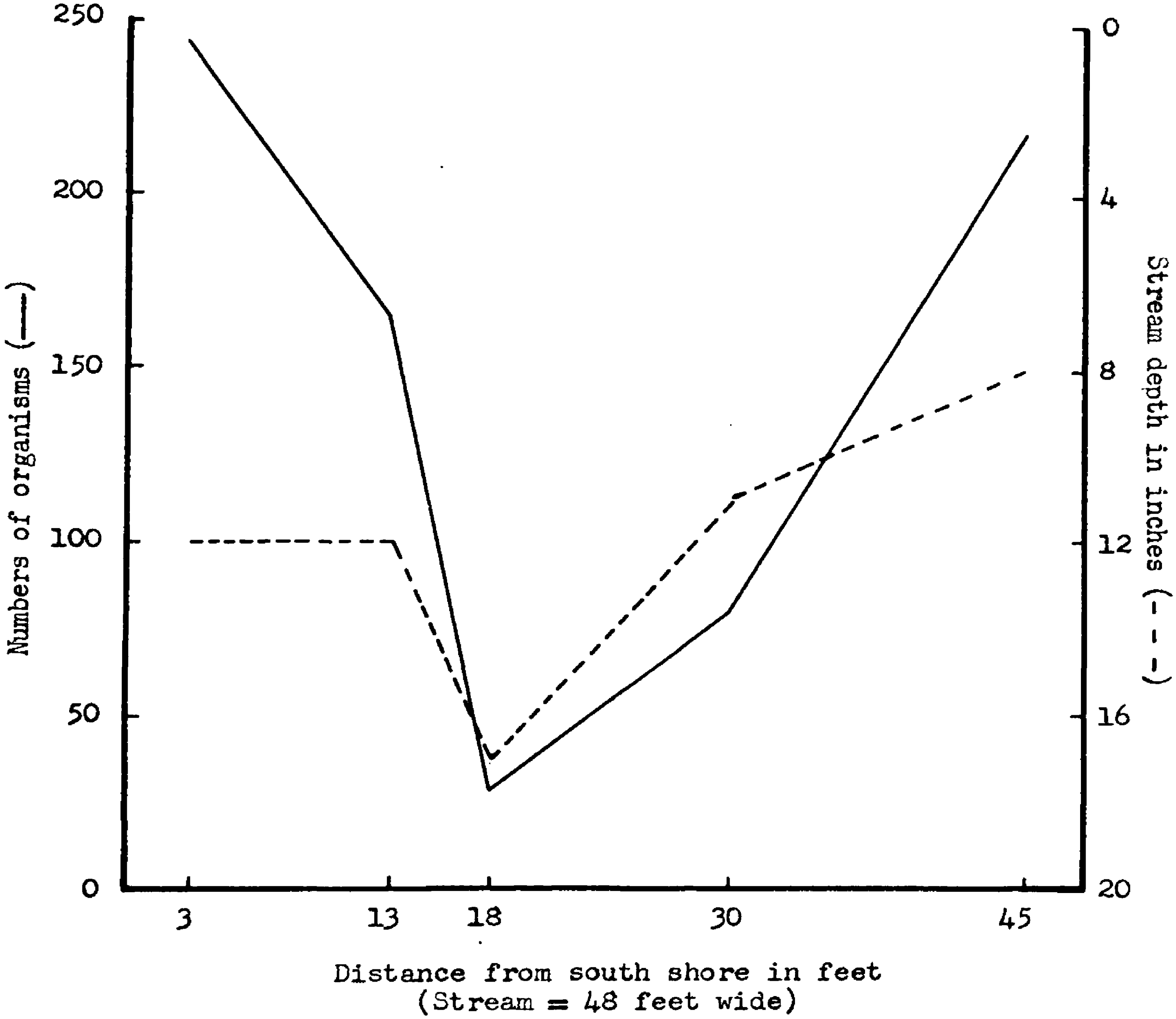

250
200
150
100
50
0
Numbers of organisms (——)
0
4
8
12
16
20
Stream depth in inches (- - -)
3
13
18
30
45
Distance from south shore in feet
(Stream = 48 feet wide)

TABLE VI

BOTTOM ORGANISMS PER SQUARE-FOOT, CROSS SECTION AT STATION 7, SULA BASIN, NOVEMBER 11, 1956
WIDTH OF STREAM = 48 FEET AT THIS STATION

Distance From South Shore in Feet	3	13	18	30	45
Depth in Inches	12	12	17	11	8
Bottom Type(Gravel to Stones)(Inches in Diameter)	6	8	8	6	6
Perlodidae	3	2	1	1	5
Chloroperlidae			1		
Pteronarcidae	(10)	(9)	(2)	(3)	(5)
Pteronarcella badia	5	1			2
Pteronarcys californica	5	8	2	3	3
Total Plecoptera	13	11	4	4	10
Baetidae	193	126	12	31	88
Heptageniidae	11	13	1	13	11
Total Ephemeroptera	204	139	13	44	99
Tendipedidae	1				
Tipulidae	3				
Ephydridae	4	4	5	1	17
Total Diptera	8	4	5	1	17
Rhyacophilidae					1
Brachycentridae	1				
Lepidostomatidae	3			1	1
Total Trichoptera	4			1	2
Annelida	12	11	6	30	89
Hydracarina	2	1			
Tricladida	1				
Gastropoda					1
Totals	244	166	28	80	218

current velocity was 3.1 feet per second. The bottom type across the stream consisted of gravel to stones three to eight inches in diameter. A total of 17 square-foot bottom samples was collected; one sample was taken three feet from either shore, and the other 15 samples were spaced every 25 feet across the stream. In general, quantitative results were similar to those at station 7 in regard to distance from shore and depths. Numbers of organisms per unit area were smaller in the center of the stream, and in the deeper sections of the stream.

The families of the order Plecoptera which were collected from these cross-sectional samples included Perlodidae, Chloroperlidae, Nemouridae, and Pteronarcidae (Pteronarcella badia) (Fig. 15, Table VII). The families Baetidae and Heptageniidae (Ephemeroptera) occurred in all samples across the stream. Four families of the order Diptera were present. The Tendipedidae occurred in large numbers, especially near the shores. Other families of Diptera occurring in the samples were Simulidae, Tipulidae, and Ephydridae. Six families of the order Trichoptera occurred in the samples with at least one family represented in each of the sampling areas. The families of Trichoptera present were Hydroptilidae, Rhyacophilidae, Hydropsychidae, Brachycentridae, Limnephilidae, and Lepidostomatidae. Elmidaen (Coleoptera) larvae and adults occurred in the samples across the stream. Two Coleopteran larvae were collected from one sample which could not be identified, and were listed as unknown Coleopteran larvae. The first sample, collected three feet from the east shore at depth four inches, contained very large numbers of Annelida which were so small they washed through the fine mesh net, and many were lost. There were so many in this sample, that no attempt was made to count them. It was the only square-foot sample during the entire study in which such high numbers of these organisms were encountered per unit area. One nymph of the family Coenagrionidae (Odonata) was collected from the sample taken 175 feet from the east shore at depth 15 inches. Three nematodes were taken from this same unit area, and one from the sample 225 feet from shore at depth 18 inches.

Figure 15. Cross-sectional samples from Station 1, December 4.

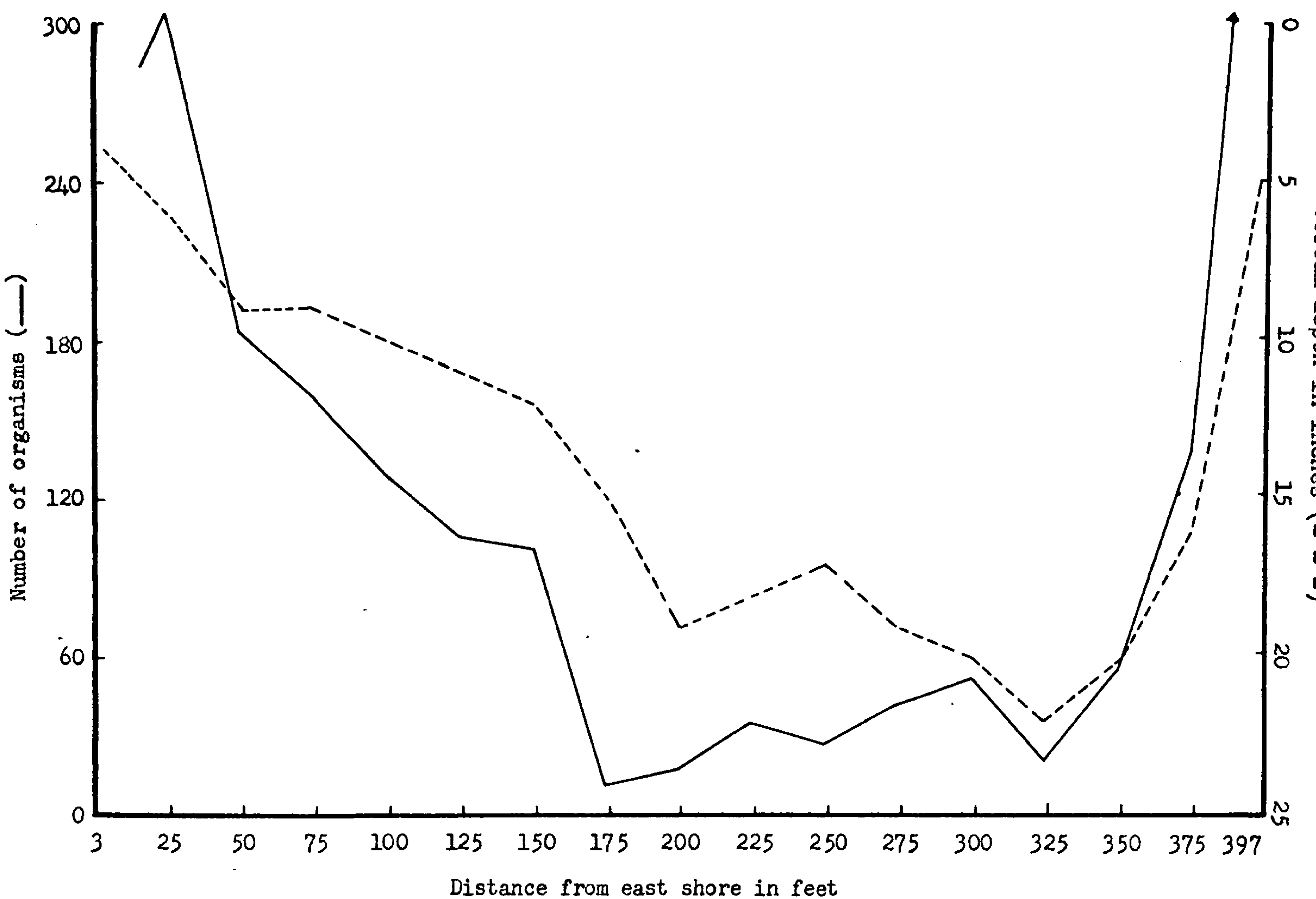

Number of organisms (——)
300
240
180
120
60
0
Stream depth in inches (- - -)
0
5
10
15
20
25
3
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
397
Distance from east shore in feet

TABLE VII

BOTTOM ORGANISMS PER SQUARE-FOOT, CROSS SECTION
STATION 1 AT FLORENCE, DECEMBER 4, 1956
STREAM WIDTH = 400 FEET

Distance From East Shore in Feet	3	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	397
Depth in Inches	4	6	9	9	10	11	12	15	19	18	17	19	20	22	20	16	5
Bottom Type: (Gravel to Stones) (Inches in Diameter)	4	5	5	5	6	6	6	6	8	4	4	4	3	3	4	5	6
Perlodidae	2		1	14	2	6	4			1		2			1	1	26
Chloroperlidae	6	2	3	2													11
Nemouridae	4	3		1	5	1	1		1	1	3		9	1	5	19	64
Pteronarcidae				2													4
Total Plecoptera	12	5	4	19	7	7	5		1	2	3	2	9	1	6	20	105
Baetidae	30	108	13	26	34	45	33		1	3	4	12	14	5	8	44	567
Heptageniidae	1	1		33	10	4	1	1		2	3	10	8	1	19	36	35
Total Ephemeroptera	31	109	13	59	44	49	34	1	1	5	7	22	22	6	27	80	602
Tendipedidae	207	91	102	41	14	14	6	3	2	12	2	4	2	2	1	6	175
Simulidae	1	1		1	1		1		1						1	2	3
Tipulidae	1	5	2	2		1	2		1	2	3	1	1	2	4	2	5
Ephydridae						1	1	1					3		1	2	
Total Diptera	209	97	104	44	15	16	10	4	4	14	5	5	6	4	7	12	183
Hydroptilidae		11	19	4	17	9			4								3
Rhyacophilidae		1	1	4	2	4	2		1	2	9		6		2	3	
Hydropsychidae				8	25	20	22	1	1	5	3	13	6	9	7	2	22
Brachycentridae					1												
Limnephilidae																1	3
Lepidostomatidae	1	44	4	13	11	1	6			1					3	9	31
Total Trichoptera	1	56	24	29	56	34	30	1	6	8	12	13	12	9	12	15	59
Elmidae larvae		11	4	3	5		2		1	1			1			3	10
Elmidae adults																	1
Coleoptera (misc.)		2															
Total Coleoptera		13	4	3	5		2		1	1			1			3	11
Annelida	*	24	34	5	2		20	1	5	4			2	1	3	10	14
Odonata								1									
Nematodes								3		1							
Total	253	304	183	159	129	106	101	11	18	35	27	42	52	21	55	140	974

*Not counted.

Station 3.

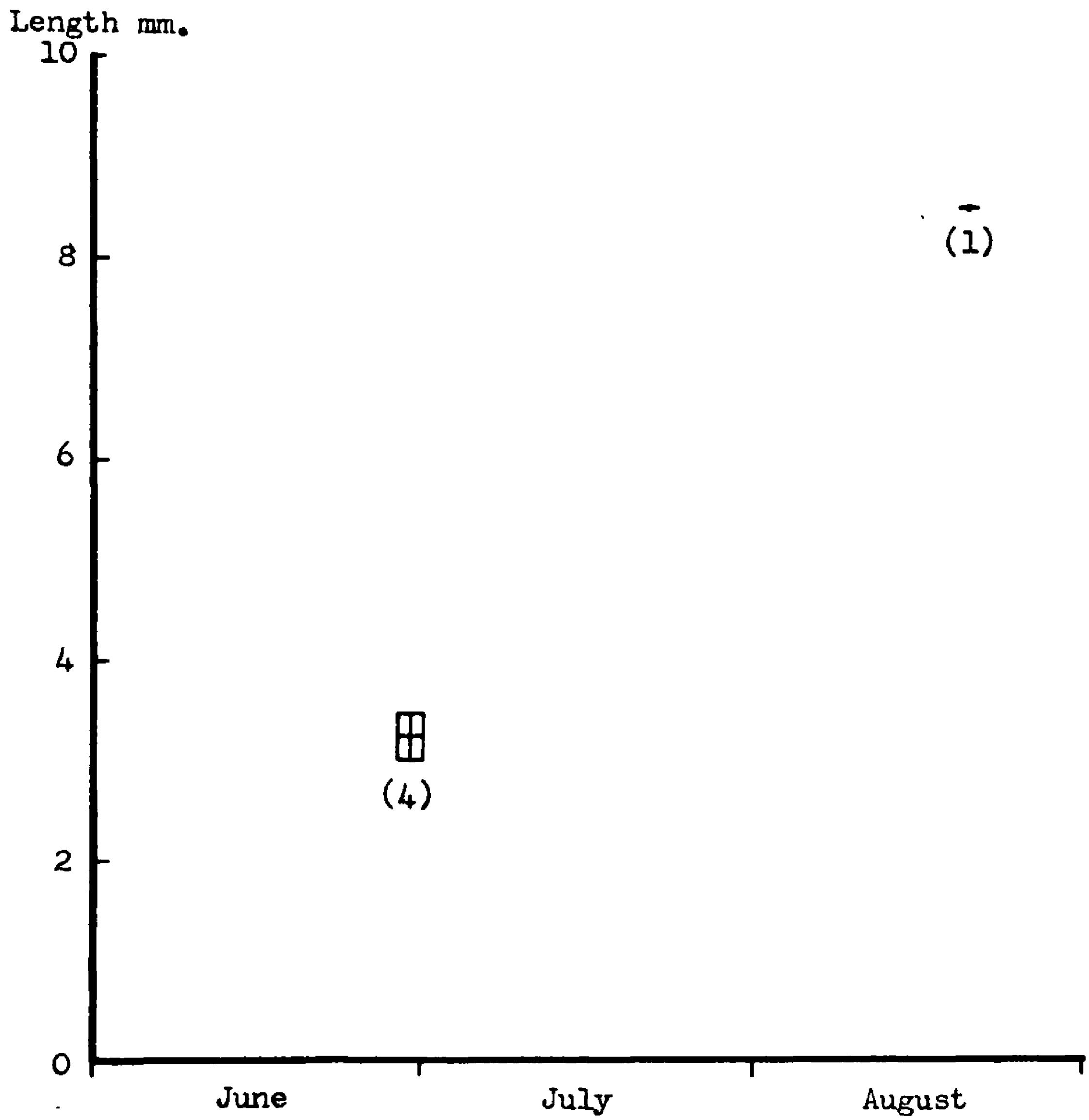
Station 3 is the farthest downriver in which P. californica has been collected throughout this study. Nymphs were present in only two samples, indicating either a small population or, more likely, a limitation of sampling because of the large size of the stream. The first indication (exuviae) of P. californica at this site was on June 11. At this time the water level was at the high water banks, similar to the last of April. The water temperature was 55.0° F., ground temperature 69.0° F., and air temperature 71.0° F. at 5:00 p.m. Shed exuviae of nymphs were found throughout the area on rocks, branches, etc., and along the waters edge, thus indicating the recent emergence of this species. No adults or nymphs were observed in this area, and no nymphs were collected in the bottom samples at this date.

On June 29, the water level was dropping but was still slightly higher than the April 1st level. Bottom samples were taken one to three feet from shore as were previous samples, but this new area previously was dry ground. A total of five square-feet was sampled from depth six to twelve inches resulting in .8 nymphs per square-foot. The mean length of these nymphs was 3.3 mm. with a maximum of 3.5 mm., and a minimum of 3.0 mm.

On July 14, the water level had dropped below the April 1st level, thus enabling sampling at greater distances from shore. Six square-foot bottom samples were taken at depths six to twelve inches, and two to eight feet from shore. No nymphs were present in these samples.

Figure 16. Station 3 - Length-growth curve - <u>Pteronarcys</u> <u>californica</u>.

(Numbers of specimens measured in parenthesis)


Length mm.
10
8
6
4
2
0
(1)
(4)
June
July
August

On August 20, the water level was very low, the six inch depth being 75 feet from the high water line. Six bottom samples were taken at depths six to twelve inches, and 75 to 100 feet from the high water banks. One nymph was represented in the three (of the six total) square-foot samples from the six inch depth, 75 feet from the high water bank. The length of this nymph was 8.6 mm. and it weighed 3.8 mg. If this one organism represents a mean length, the length-growth increased from 3.5 mm. to 8.6 mm. from June 29 to August 20. No nymphs were collected in the outer three samples at depth twelve inches, 100 feet from the high water banks.

After August 20, no nymphs were found in the bottom samples. Collections were made under optimum sampling conditions at depths six to twelve inches, and from 40 to 115 feet from shore. Bottom types sampled were gravel to rocks eight to ten inches in diameter.

Station 4.

Station 4 was one of the most productive areas for P. californica. All bottom samples from April through September contained nymphs which ranged in number from .5 to 10.5 nymphs per square-foot, and in weight from 3.1 mg. per square-foot to 1324.8 mg. per square-foot. Two samples contained very small nymphs that were not weighed.

Four square-foot bottom samples were taken on April 2, at depths six to twelve inches. In the total of 23 nymphs, the average was 5.75 per square-foot. The mean length of these nymphs was 20.7 mm., with a maximum of 40.8 mm. and a minimum of 7.5 mm. If the following periods could have been represented by as large a number as these April 2 samples, it would have been possible to plot age groups. It was difficult to take samples on April 29 because of the rise in water level and velocity of the current; and only one specimen occurred in the sample. It measured 22.0 mm. in length and weighed 152.0 mg.

On June 12, the water level was very high but clear. Flood waters during the preceding two weeks had washed out most of the station area. However, about 40 yards of undisturbed bottom remained at this station site on this date. Adult Pteronarcys were observed on the area, but no mature nymphs were observed in the shallow water along the river edge. The water temperature was 53.0° F., ground temperature 68.0° F., and air temperature 72.0° F. at 3:00 p.m. Four square-foot bottom samples were taken at depths six to twelve inches, two to six feet from shore. One nymph 21.8 mm. long, and three very small nymphs averaging 2.9 mm. were taken. These three small nymphs are of a different age class than those collected during April. Hence these can be plotted as such on the graph (Fig. 17). It is interesting to note that these very young nymphs were first observed at the time of the emergence of the adults. These three small nymphs could not be weighed on the torsion balance. Maximum length was 3.0 mm., and the minimum length 2.8 mm.

Three square-foot samples were taken on June 29. Two nymphs were collected: one large nymph, 39.1 mm. in length; and one small nymph, 3.7 mm. An increase in size is indicated in the length of the latter nymph over the mean length of 2.9 mm. of those collected June 12.

Nymphs in the three square-foot bottom samples, taken July 14, showed a steady trend in the growth-series of these young nymphs. Collected in these samples were 11 nymphs, with a mean length of 4.2 mm., maximum length of 5.2 mm., and minimum length of 3.0 mm. These 11 organisms weighed 11.6 mg. and averaged .86 mg. One nymph, measuring 3.3 mm., was in the process of ecdysis when collected. An exuvia also which measured 3.8 mm. was found in the samples.

On August 20, six samples were collected, three at depth six inches (four to six feet from shore) and three at depths twelve inches (six to eight feet from shore). Seven small nymphs were collected in these samples: four in the six inch depth samples and three in the twelve inch depth samples. The mean length was 5.5 mm., maximum length 6.1 mm., and minimum length 5.0 mm. The average weight was 2.7 mg., which was a marked increase (as were the length measurements) over those taken in July.

Four square-foot bottom samples were taken September 9 at depth six to twelve inches and four to twelve feet from shore. The water level was the lowest to date of this series of collections. The stream bottom was very heavily covered with algae. The problem of backwashing or drifting of organisms out of the samples was first noted during the time these samples were taken. Two large _Pteronarcys_ nymphs were observed drifting out of the square-foot area. This backwashing occurred only at the twelve inch depth.

A total of 34 _Pteronarcys_ nymphs were collected in these four samples. Six large nymphs averaged 30.7 mm. in length, and 28 small nymphs averaged 7.6 mm. One of the large nymphs (measuring 23.7 mm. and weighing 189.2 mg.) and seven of the small ones (with a mean length of 7.2 mm. and averaging 4.3 mg.) came from the two square-foot bottom samples which were taken at the six inch depth and four to eight feet from shore. The remaining five large nymphs and 21 small ones came from the two square-foot samples at the twelve inch depth and 10 to 12 feet from shore. These latter nymphs were of larger size both in length and weight as compared to those nymphs at the six inch depth. The large nymphs at the 12 inch depth averaged 32.1 mm., with a maximum length of 44.1 mm. and a minimum length of 27.8 mm. The average weight was 435.2 mg. It is interesting to note that the 44.1 mm. nymph weighed 931.3 mg. The small nymphs from this depth had a mean length of 7.7 mm., maximum of 10.6 mm., minimum of 4.2 mm., and averaged 6.0 mg. in weight.

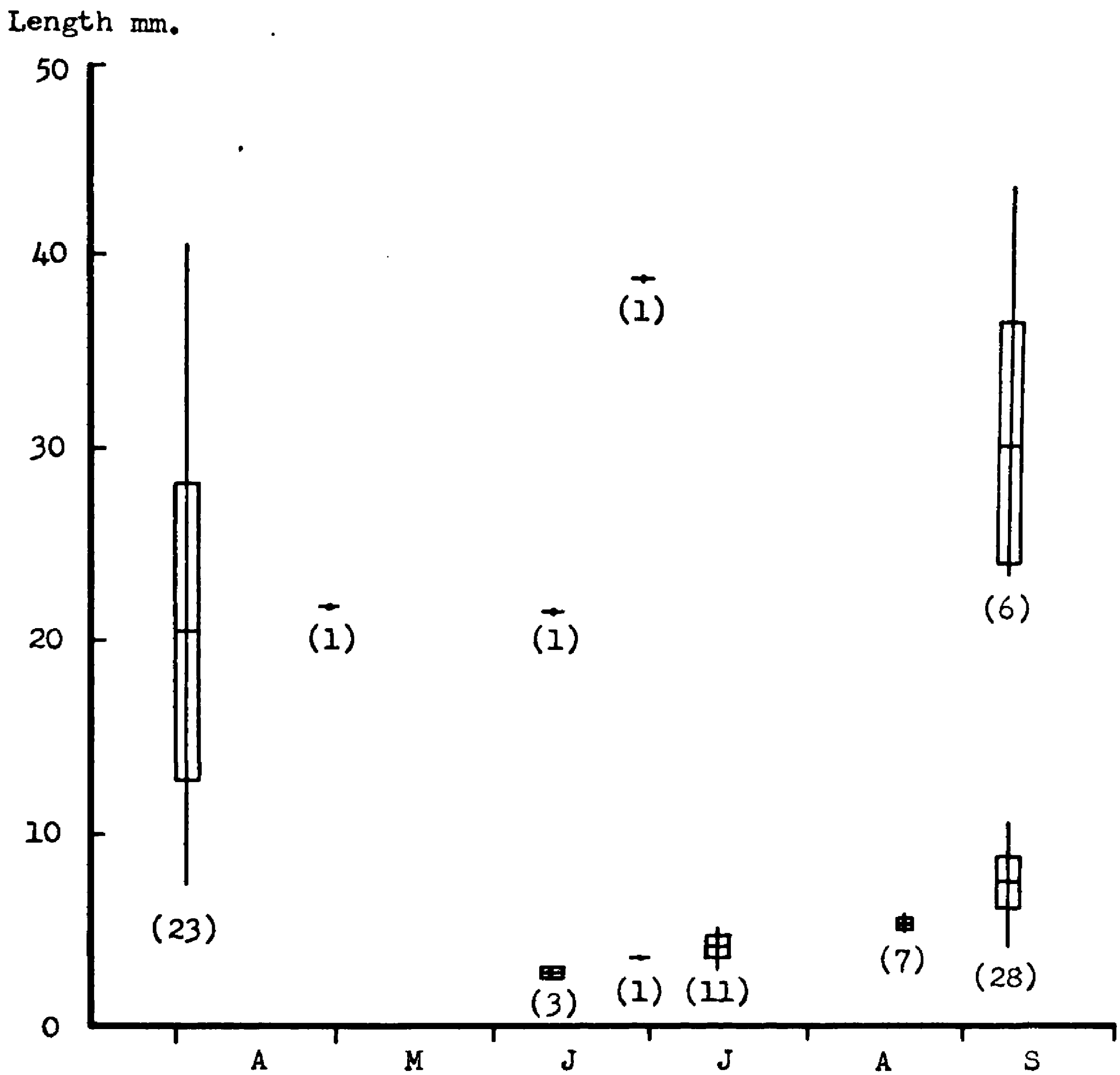
Sometime between September 9 and October 6, a bull-dozer moved into the station area and dozed out the river channel to eliminate shore or bank washing. This action destroyed the permanent bottom type and made it useless to continue sampling in this area. Attempts were made to sample the area later, but the mass of loose-shifting crushed rock on the stream bottom made the results negligible.

Station 5.

On April 2, eight samples were taken at depths six to twelve inches, four to ten feet from shore. No nymphs were found in any of the samples. The water level was low, although the average velocity of the current was 4.6 feet per second. On April 29, samples had to be taken two feet from shore because of high water. No nymphs were found in these samples.

The water level, on June 12, was still very high, thus prohibiting sampling from any areas except along the shore. Pteronarcys were just beginning to emerge at this station. The water temperature was 51.0° F., ground temperature 65.0° F., and air temperature 69.0° F. The average velocity of the current was 5.1 feet per second. The mature nymphs were observed crawling in close to shore around the large rocks. A qualitative collection was made at this time of the mature nymphs and newly emerged

Figure 17. Station 4 - Length-growth curve - *Pteronarcys californica*.
(Numbers of specimens measured in parenthesis)


Length mm.
50
40
30
20
10
0
(23)
(1)
(1)
(1)
(6)
(3)
(1)
(11)
(7)
(28)
A
M
J
J
A
S

adults. Only a few adults were observed as compared to many mature nymphs along shore. This difference in number obviously indicates the beginning of emergence at this station area.

Ten samples were taken in the station area. Because of the high water level and the fact that the mature nymphs were crawling from water 24 to 36 inches deep directly onto the large shore rocks, it was impossible to get quantitative samples of this hatch. The shallower areas, two to 10 inches deep, along the waters edge produced no mature nymphs, but 11 smaller (younger) nymphs were collected. These 11 were collected in the 10 samples; six of the nymphs were larger than the other five. The larger nymphs averaged 21.6 mm. (with a maximum length of 25.8 mm. and minimum of 15.0 mm.) and had an average weight of 140.6 mg. The five small nymphs had a mean length of 3.0 mm. with a maximum of 3.6 mm. and a minimum of 2.6 mm.

The water level on June 29 was low enough to get samples away from shore. Six samples were taken: three above the mouth of Warm Springs Creek, at depth six to 12 inches and 40 feet from shore, and three below the mouth of the creek at the same depth two to three feet from shore. No <u>Pteronarcys</u> nymphs were present in the samples taken below the mouth of Warm Springs Creek; however, two small nymphs were present in the three samples taken above the mouth and 40 feet from shore. These nymphs measured 3.0 and 3.6 mm. No mature nymphs or adults were observed on the station area.

Samples collected July 14 below the mouth of Warm Springs Creek, close to shore, contained no nymphs. The three samples taken above the mouth of the creek, 10 to 30 feet from shore, at depths of six to 12 inches, contained seven <u>Pteronarcys</u> nymphs. Two of these were of the larger size (measuring 33.0 mm. and 26.9 mm.) and averaged 300.0 mg. in weight. The five smaller nymphs averaged 4.2 mm. in length (with a maximum of 4.9 mm., minimum of 3.9 mm.) and averaged .7 mg. in weight. The water level was lower than on June 29, but was not as low as on August 20. The average current velocity was 4.0 feet per second thus permitting better conditions for sampling than previously.

The samples, which were taken on August 20 close to shore and below the mouth of Warm Springs, contained no nymphs. Three samples were taken above the mouth of the creek and 20 to 30 feet from shore. These contained one large nymph, measuring 32.4 mm. in length and weighing 380.2 mg., and seven small nymphs. The small nymphs had a mean length of 7.5 mm. with a maximum of 9.0 mm., minimum of 6.0 mm., and average of 4.6 mg. in weight. The surfaces of the rocks throughout the station area were covered with algae. The water temperature was 62.0° F., ground temperature 73.0° F., air temperature 78.0° F.; and the average current velocity was 3.1 feet per second.

Four samples were collected September 9: two below the mouth of the creek close to shore, and two above the mouth, 10 to 30 feet from shore. No Pteronarcys were present in any of the bottom samples. The rocks on the river bottom, as noted during August samples, were covered with algae. A two and one-half pound rainbow trout, caught from the station area by a fisherman during the sampling period, was opened and the stomach contents examined. The stomach was a solid mat of algae, and no aquatic insects or other organisms were observed in the contents.

Four bottom samples were taken on October 4, at depths six to 12 inches, 10 to 30 feet from shore. Eight small Pteronarcys were collected in these four samples. Six of the nymphs came from the samples two to six inches deep and 10 to 15 feet from shore, and two from 12 inches deep and 30 feet from shore. The mean length of these forms was 9.9 mm., with a maximum length of 12.9 mm., minimum length of 7.4 mm., and an average weight of 12.0 mg. The stream bottom was covered with algae similar to the two previous collections.

On November 3, the ground around this station area was snow covered, and shore ice extended out from both sides of the river. The water temperature was 32.0° F., ground temperature 32.0° F., and air temperature 30.0° F. The average velocity of the current was 2.8 feet per second. The freezing water temperature made sampling difficult, because the action of the net in the water caused ice to form in the net. Several attempts were made to get bottom samples (because so much ice formed in the net). Two samples were collected above the mouth of Warm Springs Creek: one from eight feet from shore at a depth of six inches and the other 30 feet from shore from a depth of 12 inches. From these two samples, four nymphs were collected: two from the six inch depth and two from the 12 inch depth. The mean length of these nymphs was 11.3 mm., with a maximum of 13.8 mm., minimum of 9.9 mm., and in weight averaged 20.2 mg.

On December 15, shore ice extended out into the river, except for a small channel of open water six feet from shore. Two samples were collected from this channel at the six inch depth, and two from the 12 inch depth off the edge of the ice 30 feet from shore. Six small Pteronarcys nymphs were taken from these samples: five from six feet from shore (six inches deep), and one from 30 feet from shore (12 inches deep). The average length of these nymphs was 9.6 mm., with a maximum of 15.1 mm., minimum of 6.8 mm., and had an average weight of 30.1 mg.

It will be noted that the small nymphs steadily increased in length and weight from one sampling period to the next, except for the mean length of the December forms. The decrease in mean length of the December nymphs was not accompanied by a decrease in their weight. The average weight of each nymph collected during November was 20.2 mg., while the average weight of December nymphs increased to 30.1 mg. The gain in average weight from October to November was 8.2 mg., and the gain in average weight from November to December was 9.9 mg. Thus weight gains were comparable even though the December mean length decreased.

Station 6.

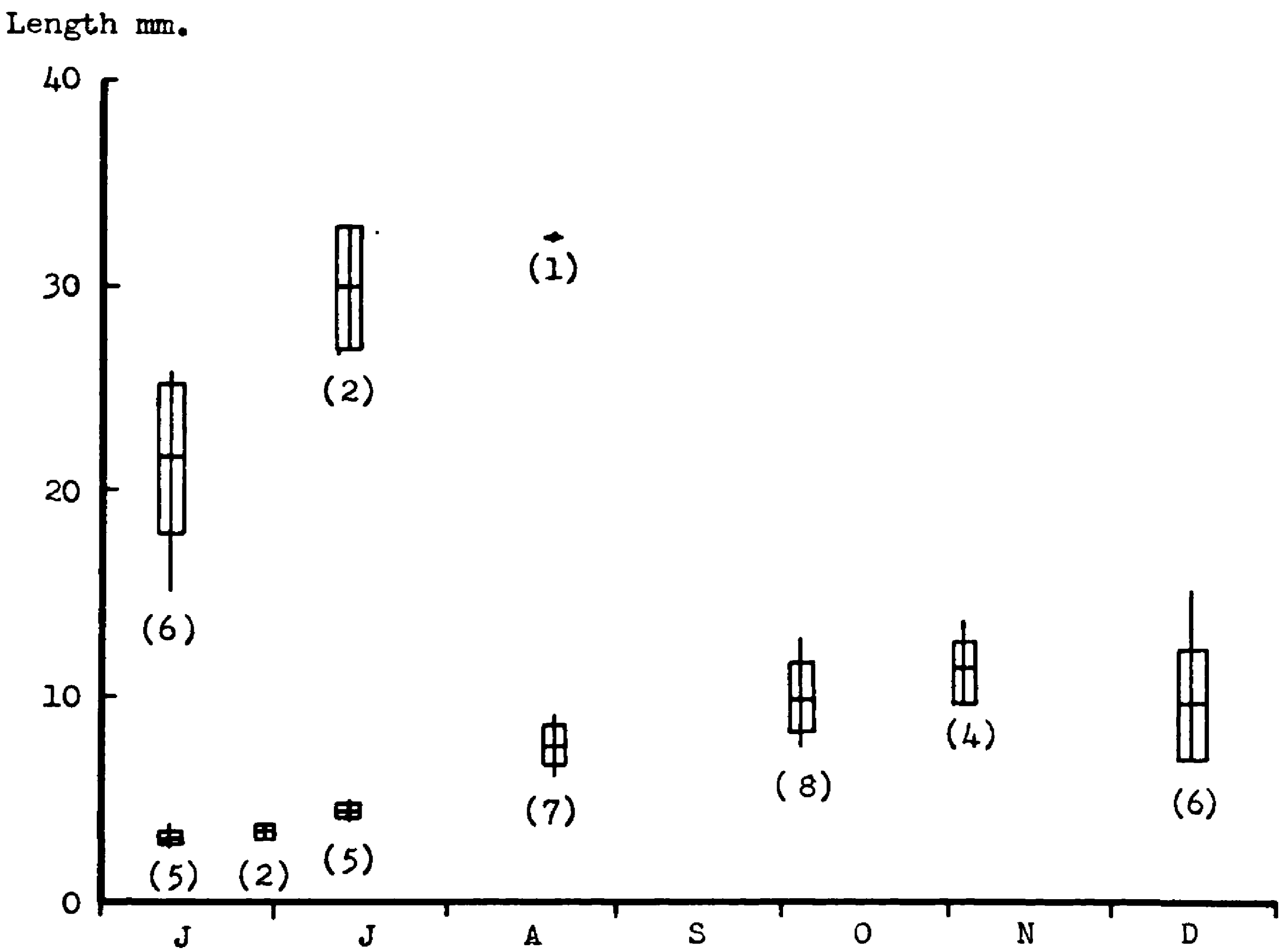
Seven samples were collected at this station on April 2, at depths six to 12 inches, 10 to 30 feet from shore. The stream bottom was covered with algae throughout the station site. The water temperature was 38.0° F. Seventeen nymphs were collected, averaging 2.4 nymphs per square-foot. The total weight was 3942.6 mg., or an average of 563.2 mg. per square-foot. The mean length of the nymphs was 23.4 mm., with a maximum of 30.9 mm., minimum of 17.0 mm., and the weight averaged 231.9 mg.

The water level on April 29 was high with increased velocity, thereby limiting the sampling area. Three samples were taken at the nine inch depth. Five nymphs were collected, averaging 29.2 mm. in length, with a maximum of 38.9 mm., minimum of 23.0 mm., and had an average weight of 289.5 mg.

On June 12, part of the station was washed out where some of the preceding samples were taken. The water temperature was 48.0° F. The four samples collected were from the 20 inch depth, four to 12 feet from

Figure 18. Station 5 - Length-growth curve, _Pteronarcys_ _californica_.

(Numbers of specimens measured in parenthesis)


Length mm.
40
30
20
10
0
(1)
(2)
(6)
(5)
(2)
(5)
(7)
(8)
(4)
(6)
J
J
A
S
O
N
D

shore. No nymphs were present in the samples. No mature nymphs or adults could be seen along the stream.

The water level on June 29 was down to a level similar to that of April 2, thus enabling sampling at greater distances from shore. Five samples were collected at the 12 inch depth, four to 10 feet from shore. No Pteronarcys nymphs were collected in the bottom samples. Adults were found on the small shrubs, trees, and ground, and were observed flying throughout the station area. A collection of these adults was made throughout the station area for a qualitative study. The mean length of the adult males was 33.13 mm., but insufficient numbers of adult females were collected to determine the mean length. Observations were made along the stream edge to see if any mature nymphs were still present. No mature nymphs were observed along the stream edge. The water temperature was 54.0° F.

Six samples were taken on July 14 at depths six to 12 inches, six to 20 feet from shore. Eleven nymphs were collected: four of the larger size, and seven of the small nymphs. The four larger nymphs had a mean length of 27.4 mm., maximum length of 32.1 mm., minimum length of 23.1 mm., and an average weight of 193.7 mg. The seven young nymphs averaged 3.7 mm. in length, with a maximum of 5.1 mm., minimum of 3.0 mm., and 0.7 mg. in weight. The stream bottom throughout the area was covered with algae. The water temperature was 54.0° F.

On August 20, the water temperature was 64.0° F., and the stream bottom throughout the station area was covered with algae. Six samples were taken at depths six to 12 inches, 10 to 40 feet from shore. Three large nymphs and one small nymph were collected in these six samples. The larger nymphs averaged 29.8 mm. in length, with a maximum of 39.1 mm., minimum of 22.3 mm., and averaged 327.6 mg. in weight. The small nymph measured 6.4 mm. and weighed 2.8 mg.

On September 9, six samples were taken at depths six to 12 inches, eight to 35 feet from shore. One large nymph was washed around the net and consequently lost. Two other large nymphs were collected in the six samples: one measured 43.1 mm., and weighed 843.8 mg.; and the other was 25.4 mm. in length and weighed 220.6 mg.

On October 4, four samples were taken and two small nymphs were collected. The mean length of these nymphs was 6.1 mm., with a maximum of 6.6 mm., minimum of 5.5 mm., and averaged 0.7 mg. in weight. The water temperature was 46.0° F.

On November 3, the water temperature was 34.0° F. and the water level at this station was the lowest of any recorded during the study. Shore ice extended out into the river from both sides. Four samples were collected at depths six to 12 inches, 10 to 20 feet from shore. No _Pteronarcys_ nymphs were collected.

On December 15, the water temperature was 32.0° F. and shore ice extended out into the river from both sides. The river level at this station was up slightly because of heavy rains previously. Five samples were collected at depths six to 12 inches, 15 to 30 feet from shore. One nymph was collected, measured 34.2 mm., and weighed 521.7 mg.

Greatest total numbers (Table IX) of _P. californica_ nymphs were collected at station 4 than any of the other stations. Station 7 (Fig. 20), however, resulted in the highest numbers of nymphs per unit area--i.e.: the five square-foot cross-sectional bottom samples on November 11 resulted in 4.20 nymphs per square-foot. This is the highest noted for any collection throughout the year (Fig. 21). The average number of these nymphs collected from stations 3 to 7 (none in 1 and 2), based on 179 square-foot samples from April to December, was 1.09 per square-foot (Table IX). Classen (1931) indicated that in Pteronarcys three years are required to complete a generation. Ricker (1943) indicated a three-year cycle for Pteronarcys princeps, based on three distinct sizes of nymphs: (1) the mature nymphs with well developed wing pads, (2) slightly smaller nymphs with much smaller wing pads, and (3) those less than half of the length of the mature ones.

These data on Pteronarcys californica, in the Bitterroot River, show a three-year cycle, and indicate a possible four-year cycle. The very small nymphs present in the samples can be separated from those older nymphs as shown on the length-growth curve (Fig. 17) for station 4. The adults were present at station 4 on June 12. Bottom samples at this time from the same station resulted in the collection of three very small nymphs, averaging 2.9 mm. in length, and also a nymph 21.8 mm. Since these very small (2.9 mm.) nymphs were collected at the time of emergence of the adults, it is assumed that these forms are one year old. Thus a three-year cycle is shown.

Data supporting a four-year cycle are inconclusive because of the small numbers of nymphs collected. But, as the length-growth graphs for stations 4, 5, and 6 show (Figs. 17, 18, and 19), there is the possibility of two age groups of nymphs involved in the larger size group. During August at station 6, for example, a small nymph 6.4 mm. was represented—along with nymphs 22.3 mm., 27.9 mm., and 39.1 mm. This 39.1 mm. nymph shows considerable more development than the smaller nymphs (22.3 and 27.9 mm.): the wing pads are more developed than are those of the smaller nymphs, although not as defined as are those of mature nymphs in the spring just prior to emergence. September nymphs from stations 4 and 6 also indicate the possibilities of a four-year cycle in this species. Greater numbers will have to be collected, however, to determine the life cycle for this species from this area.

Figure 19. Station 6 - Length-growth curve - *Pteronarcys californica*.

(Numbers of specimens measured in parenthesis)

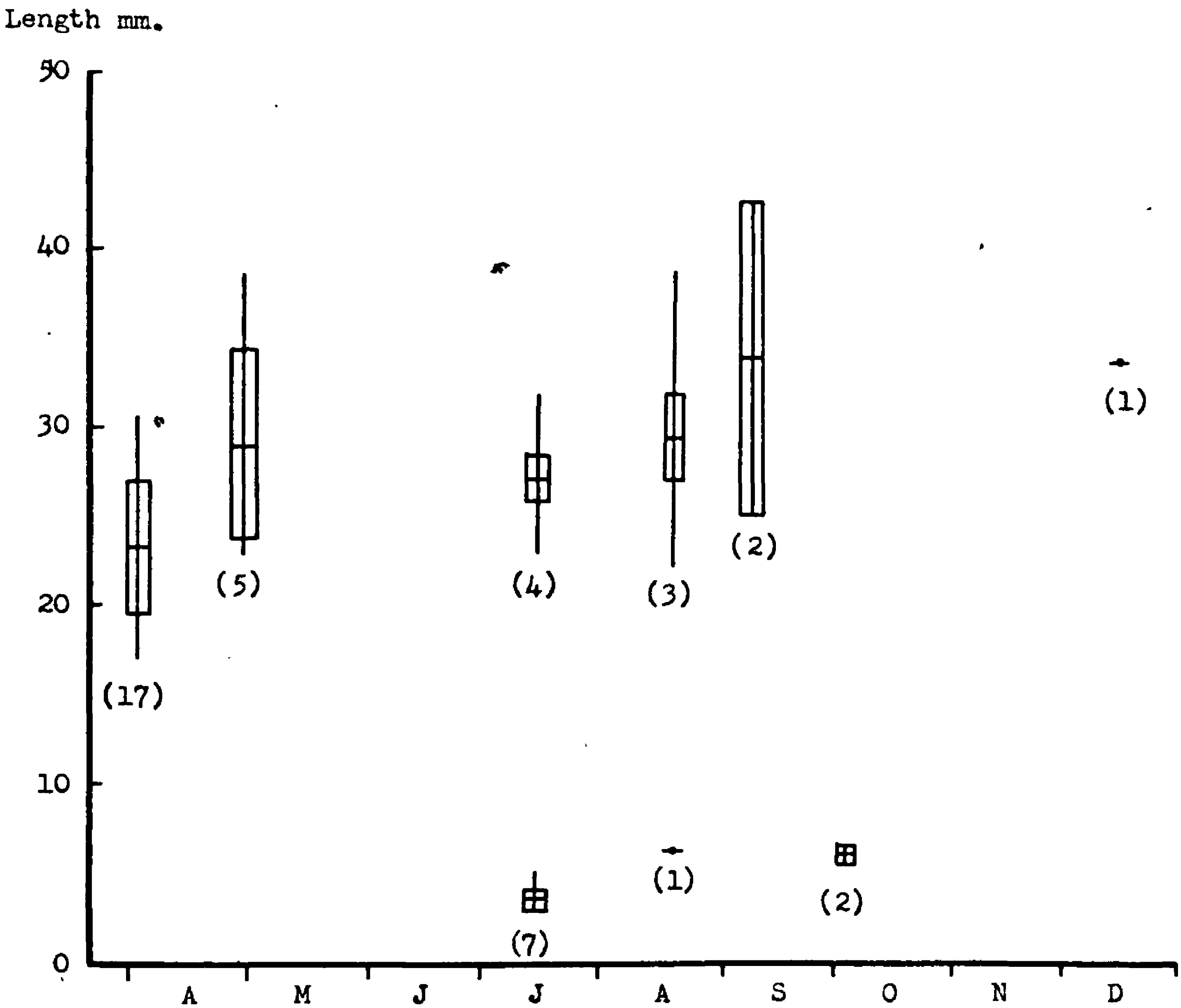

Length mm.
50
40
30
20
10
0
(17)
(5)
(4)
(3)
(2)
(1)
(7)
(1)
(2)
A
M
J
J
A
S
O
N
D

Figure 20. *Pteronarcys californica* per square-foot at collecting stations.

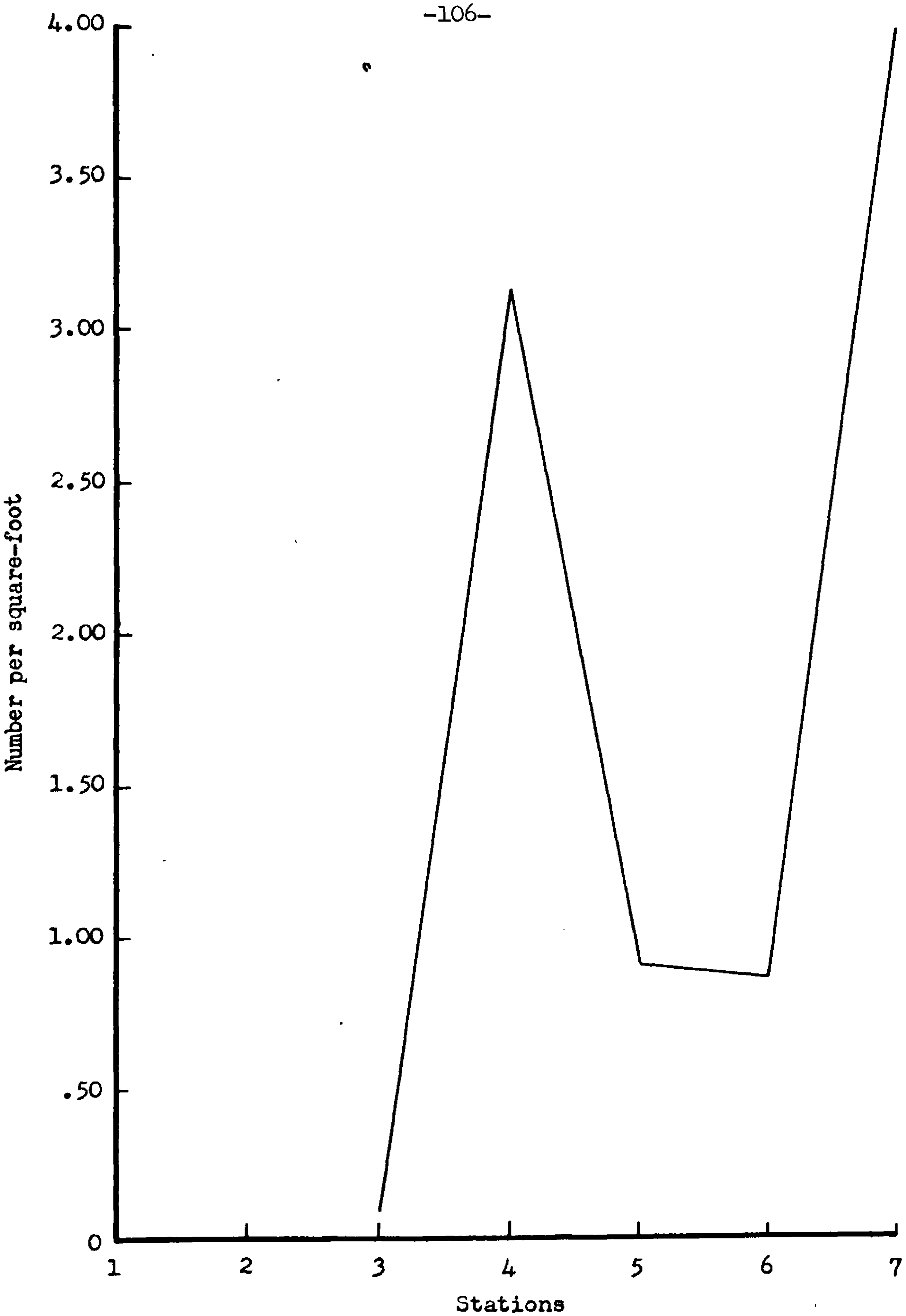

Number per square-foot
4.00
3.50
3.00
2.50
2.00
1.50
1.00
.50
0
1
2
3
4
5
6
7
Stations

Figure 21. Pteronarcys californica per square-foot at monthly collections.

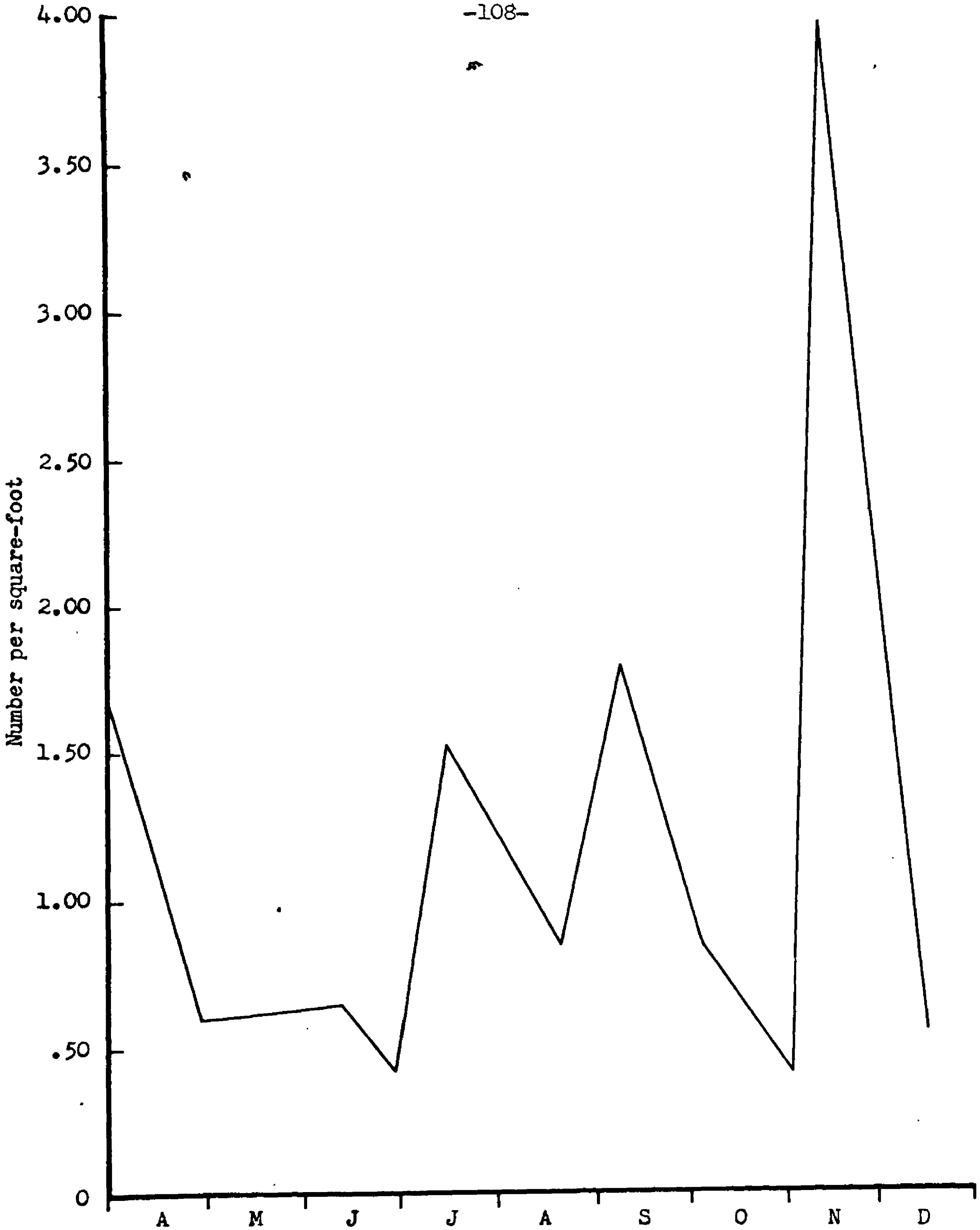

Number per square-foot
4.00
3.50
3.00
2.50
2.00
1.50
1.00
.50
0
A
M
J
J
A
S
O
N
D

TABLE VIII

PTERONARCYS CALIFORNICA FROM COLLECTIONS
APRIL THROUGH DECEMBER

Collection Dates	Number of *P. californica*	Number of Samples	*Avg. Number *P. californica* per Square-Foot	Stations Sampled
Apr. 1, 2	40	24	1.67	3,4,5,6
Apr. 28,29	6	10	.60	3,4,5,6
June 11,12	15	23	.65	3,4,5,6
June 28,29	8	19	.42	3,4,5,6
July 14,15	29	19	1.53	3,4,5,6
Aug. 20	20	24	.83	3,4,5,6
Sept. 8, 9	36	20	1.80	3,4,5,6
Oct. 4, 5	10	12	.83	3,5,6
Nov. 2, 3	4	10	.40	3,5,6
Nov. 11	21	5	4.20	7
Dec. 14,15	7	13	.54	3,5,6
Total	196	179		

*Mean for all stations = 1.09 per square-foot

TABLE IX

PTERONARCYS CALIFORNICA FROM COLLECTING STATIONS
APRIL THROUGH DECEMBER

Station Number	Number of *P. californica*	Number of Samples	*Avg. Number *P. californica* per Square-foot
3	5	48	.10
4	82	26	3.15
5	46	51	.90
6	42	49	.86
7	21	5	4.20
Total	196	179	

*Mean for all stations = 1.09 per square-foot

QUANTITATIVE STUDIES ON PTERONARCELLA BADIA

Pteronarcella badia occurred in samples throughout the study area. Larger numbers of these nymphs were found in the lower stations--with a maximum of 13.67 nymphs per square-foot, taken August 20 at station 2. The maximum number of nymphs for any sample from the upper stations was 5.0 per square-foot, taken November 11 at station 7. Graphs (Figs. 22 and 23) illustrate length-growth and mean weights of these nymphs respectively. There was a significant difference in size (Figs. 22 and 24) between nymphs of this species occurring in the main Bitterroot River and those collected from the East Fork of the Bitterroot. No significant difference could be found, however, between nymphs occurring within the main Bitterroot, or between those occurring in the East Fork.

It is noted that nymphs, from April to December, from the lower stations were considerably smaller in both length and weight during the summer and early fall (Fig. 25). But with the onset of winter, the lower station nymphs increased rapidly in size, and, by December, closely approached the size of the nymphs from the upper stations. The water temperature probably is a factor, because temperatures in the upper stations dropped off rapidly from September on, whereas in the lower stations a more gradual drop was noted. Nymphs collected from the lower stations during December, were almost as large as those nymphs collected in the same stations in April. But nymphs collected from the upper stations during December, were larger in both weight and length than those collected the previous April from the lower areas. These data indicate that during January, February, and March, when the water temperature is near 32.0° F., the rate of growth in this species is very slow, and possibly that there is a loss of weight during the winter months.

On April 1, 10 nymphs were collected from stations 1 and 2. These nymphs averaged 13.0 mm. in length, with a maximum of 17.5 mm., and a minimum of 9.3 mm. The mean weight of these nymphs was 53.2 mg. Variations in weight to length correlation were noticed from some of these nymphs: one specimen measured 16.9 mm. and weighed 101.4 mg. compared to another which measured 17.5 mm. and weighed 81.0 mg. Only one nymph of this species was collected on April 28 and 29. This nymph was taken at station 3 and measured 18.5 mm. and weighed 100.8 mg. No nymphs were collected during May or June.

On June 28, four female imagos of this species were collected at station 1. These females averaged 18.0 mm. in length, with a maximum of 19.5 mm., and minimum of 16.2 mm. The water temperature on June 28 was 61.0° F.

On July 14, another adult female measuring 17.1 mm. and an adult male measuring 15.0 mm. were collected at station 3. No other P. badia adults were collected during the study period. At this time, when these two adults were taken, four very small nymphs were collected at station 3. These nymphs averaged 3.0 mm. in length, with a maximum of 3.4 mm., minimum of 2.6 mm., and had a mean weight of 0.4 mg. On August 20, 44 nymphs were collected from stations 2 and 3. These nymphs averaged 4.8 mm. in length which was an increase of 1.8 mm. over the mean length of the July 15 nymphs. The maximum length of these August nymphs was 7.2 mm., minimum length 3.5 mm., and averaged 1.9 mg. in weight.

On September 8, 19 nymphs were collected from stations 1 and 2, and two nymphs from station 5. Statistically, there was a significant difference in size, found between these lower station nymphs, and the station 5 nymphs. The nymphs from stations 1 and 2 averaged 5.8 mm. in length (with a maximum of 7.2 mm. and minimum of 4.0 mm.), in contrast to those nymphs from station 5 which averaged 10.1 mm. (maximum of 11.2 mm., and minimum of 9.0 mm.). The mean weight of the lower station nymphs was 3.1 mg. in contrast to 10.9 mg. from station 5.

Samples collected during October revealed 12 nymphs from station 2. The size of these nymphs continued to show a steady increase in length and weight; the mean length was 7.8 mm. (maximum of 10.3 mm., minimum of 6.1 mm.) and averaged 7.8 mg. in weight. On November 2, 30 nymphs were collected from four samples at station 2. The mean weight of these nymphs more than doubled from October to November--i.e.: the average weight was 16.8 mg. in November as compared to 7.8 mg. in October. The mean length of these November nymphs was 9.8 mm., an increase of 2.0 mm. over the October nymphs, with a maximum of 12.5 mm., and a minimum of 7.0 mm.

On November 11, cross-sectional samples were taken at station 7. Eight P. badia nymphs were collected from samples and averaged 11.3 mm. in length (with a maximum of 14.6 mm., minimum of 8.2 mm.), and 32.2 mg. in weight. It is noted that these nymphs were found only in samples taken from three to 13 feet from shore, at depths eight to 12 inches.

On December 4, cross-sectional samples were taken at station 1. Six P. badia nymphs were collected from these samples; two at depth nine inches 75 feet from shore, and four at depth five inches two feet from shore. The mean weight of these nymphs more than doubled the mean weight of November nymphs from these lower stations. The mean weight of December nymphs was 44.7 mg. as compared to 16.8 mg. in November. The average length increased from 9.8 mm. in November to 13.6 mm. in December.

On December 15, four nymphs were collected from stations 5 and 6. The mean length of these nymphs was 14.7 mm. (with a maximum of 16.3 mm., minimum of 12.9 mm.), and averaged 62.1 mg. in weight. An increase in weight of 29.9 mg. was noted from the November 11 to December 15 nymphs in the upper stations, with a 3.4 mm. increase in length.

Greater numbers of nymphs of Pteronarcella badia were collected from station 2 than any of the other stations (Fig. 26, Table X). The average number occurring in the quantitative samples throughout the nine month study period from all stations was 0.42 nymphs per square-foot. Station 2 averaged 1.64 nymphs per square-foot, with station 7 following with 1.60 nymphs per square-foot. Station 4 produced no nymphs of this species in the 26 square-foot bottom samples collected. Stations 5 and 6 averaged only 0.06 nymphs per square-foot for 51 and 49 square-foot samples respectively from each station.

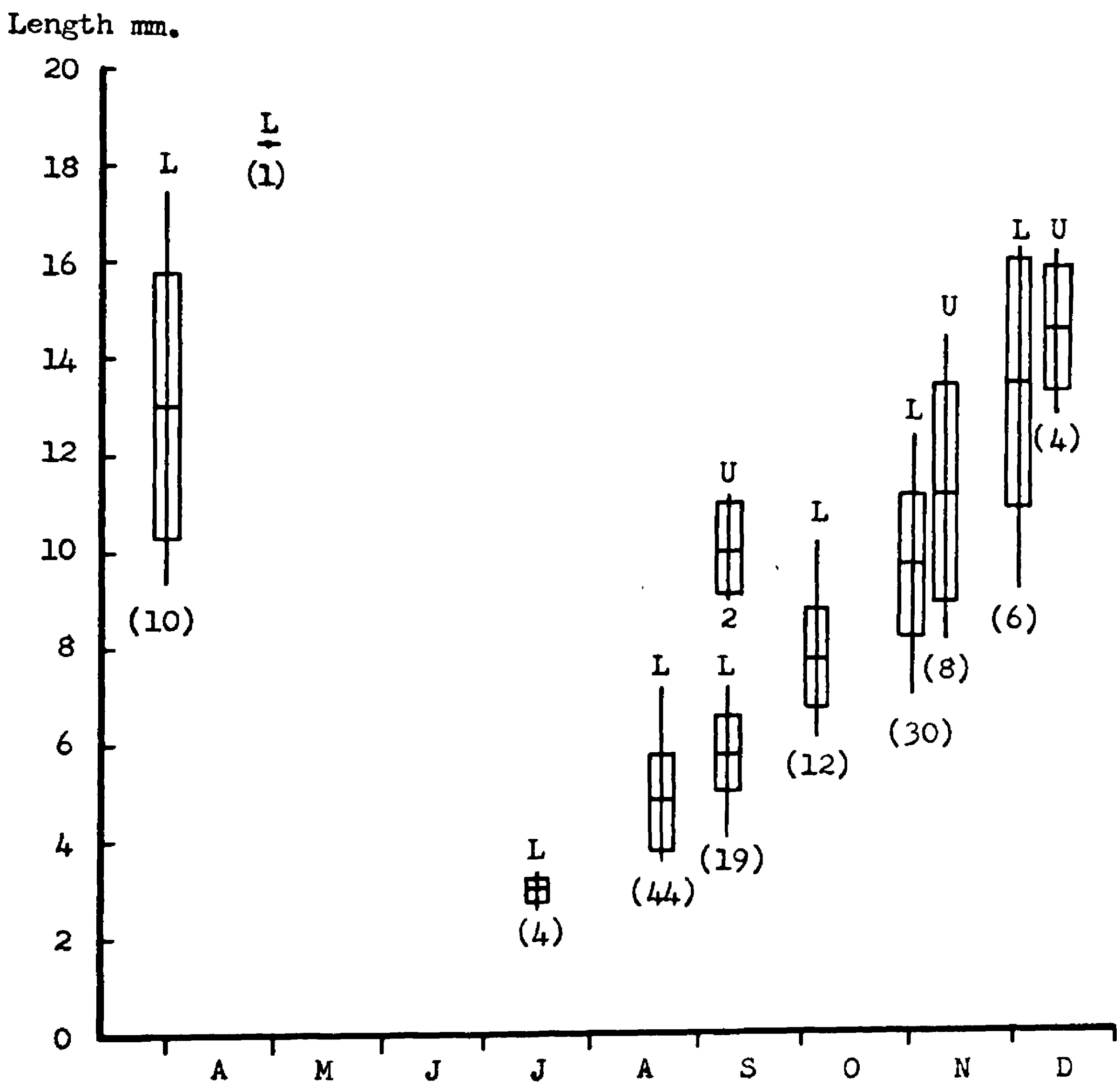
Greater numbers of these nymphs per unit area were collected during November than any of the other periods (Fig. 27, Table XI). Weights per unit area (Table XII) were also highest during November. It is noted that high numbers of nymphs per unit area occurred at station 2 and station 7, with small numbers represented from the other stations (Table X).

These data on Pteronarcella badia, in the Bitterroot River, indicate a one-year cycle. Summaries for this species can be found in Tables X, XI, and XII.

Figure 22. Length-growth *Pteronarcella badia*. Comparing nymphs from stations 1, 2, and 3 to stations 5, 6, and 7.

L = Lower stations (1, 2, and 3)
U = Upper stations (5, 6, and 7)

(Numbers of specimens measured in parenthèsis)



Length mm.
20
18
16
14
12
10
8
6
4
2
0
L
L
(1)
(10)
L
(4)
L
(44)
U
2
L
(19)
L
(12)
L
(30)
U
(8)
L
(6)
U
(4)
A
M
J
J
A
S
O
N
D

Figure 23. Average weights of *Pteronarcella badia*. Comparing nymphs from stations 1, 2, and 3 to stations 5, 6, and 7.

L = Lower stations (1, 2, and 3)
U = Upper stations (5, 6, and 7)

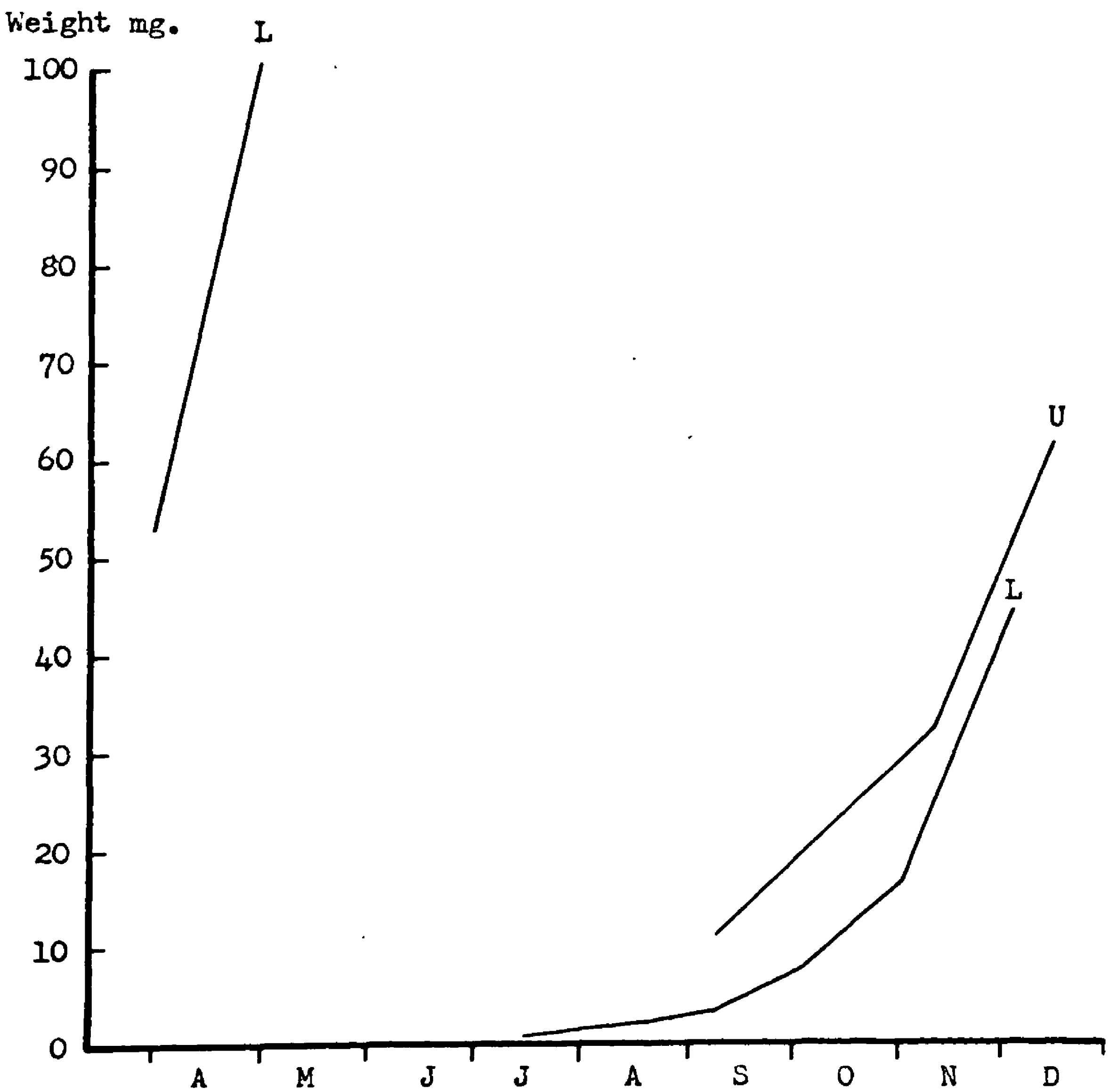

Weight mg.
L
100
90
80
70
60
50
40
30
20
10
0
U
L
A
M
J
J
A
S
O
N
D

Figure 24. _Pteronarcella_ _badia_ - Mean weights and lengths plotted on logarithmic scale.

L = Lower stations (1, 2, and 3)
U = Upper stations (5, 6, and 7)

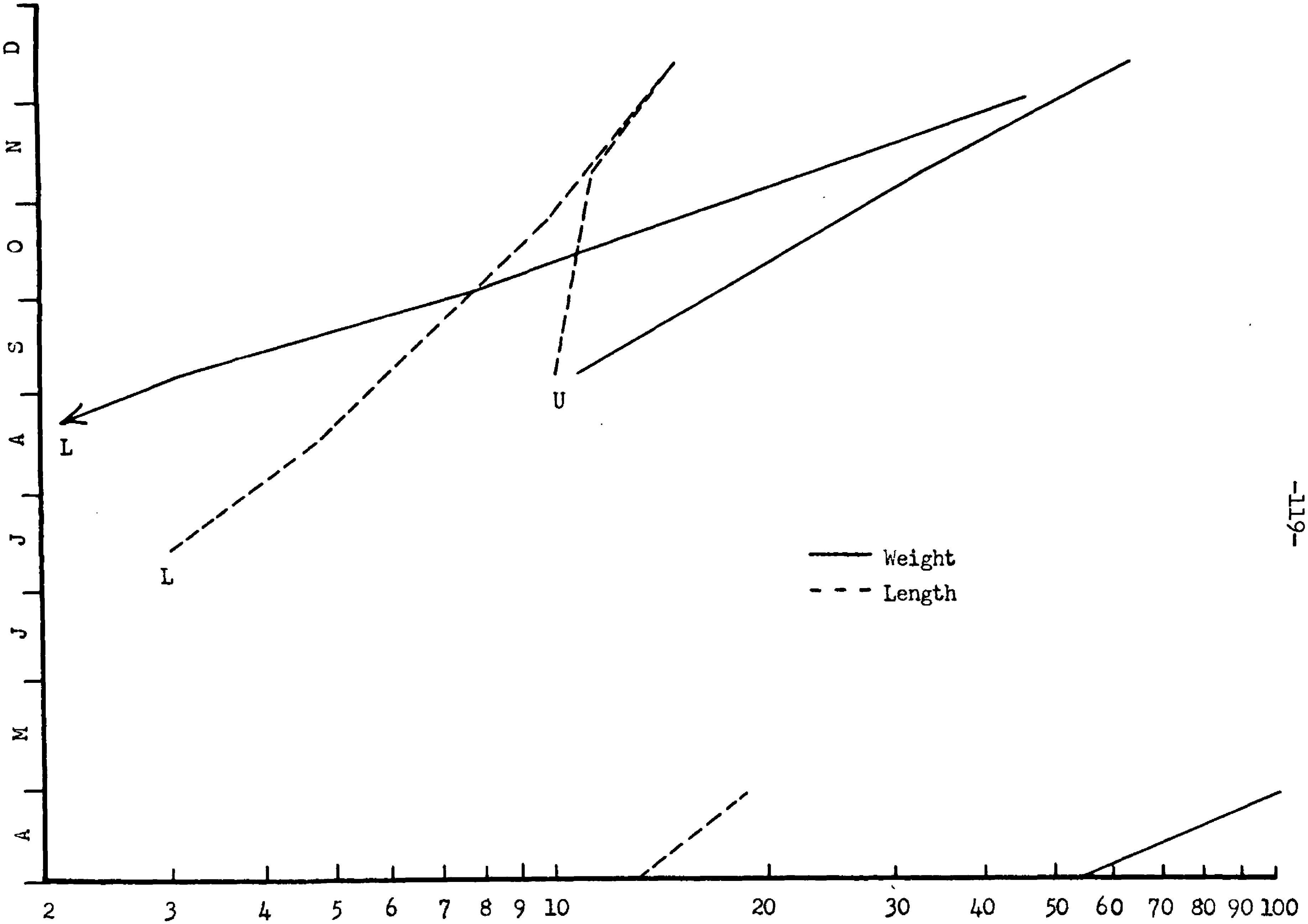

D
N
O
S
A
J
J
M
A
L
L
U
Weight
Length
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100

Figure 25. Pteronarcella badia - Weight-length relationships.

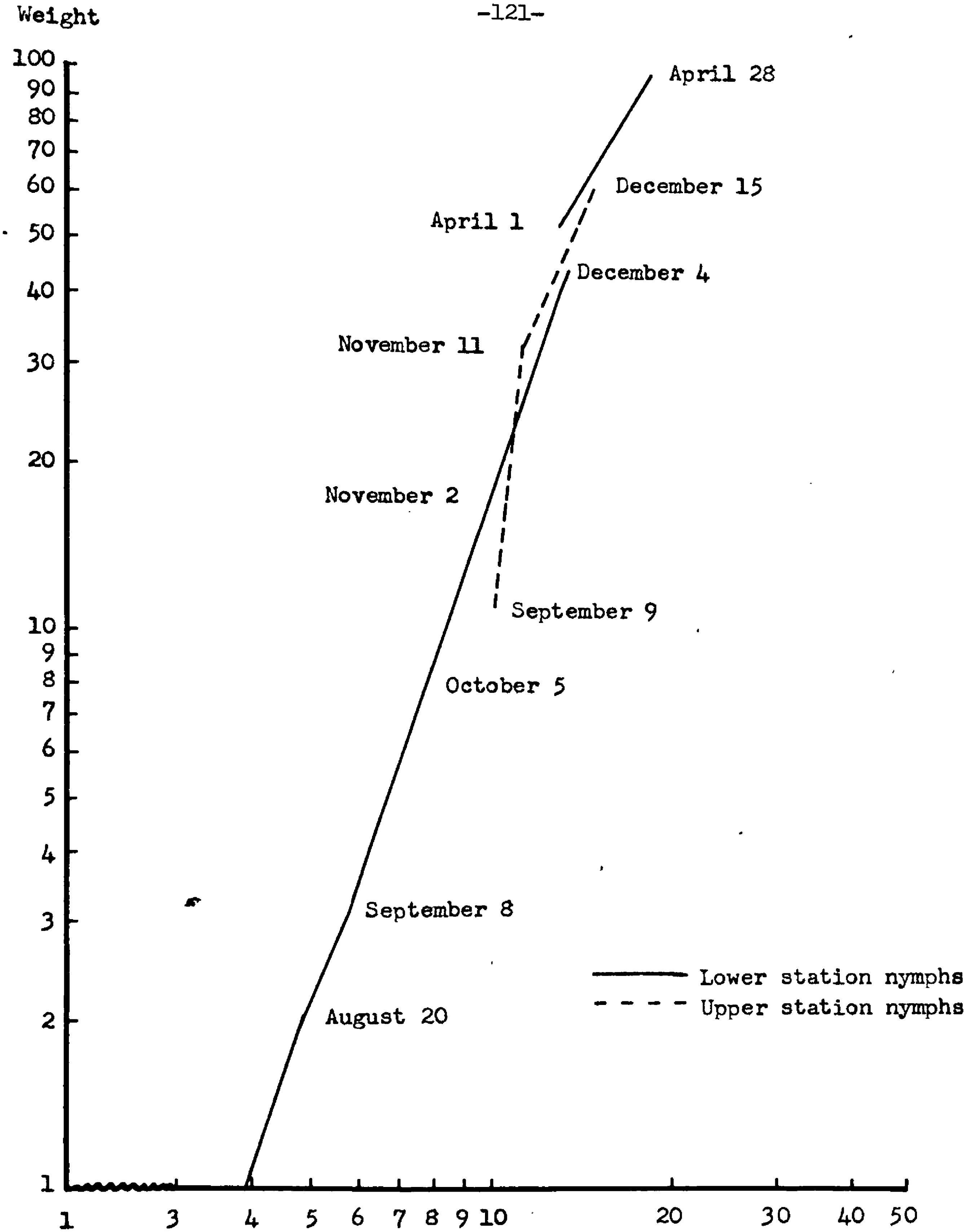
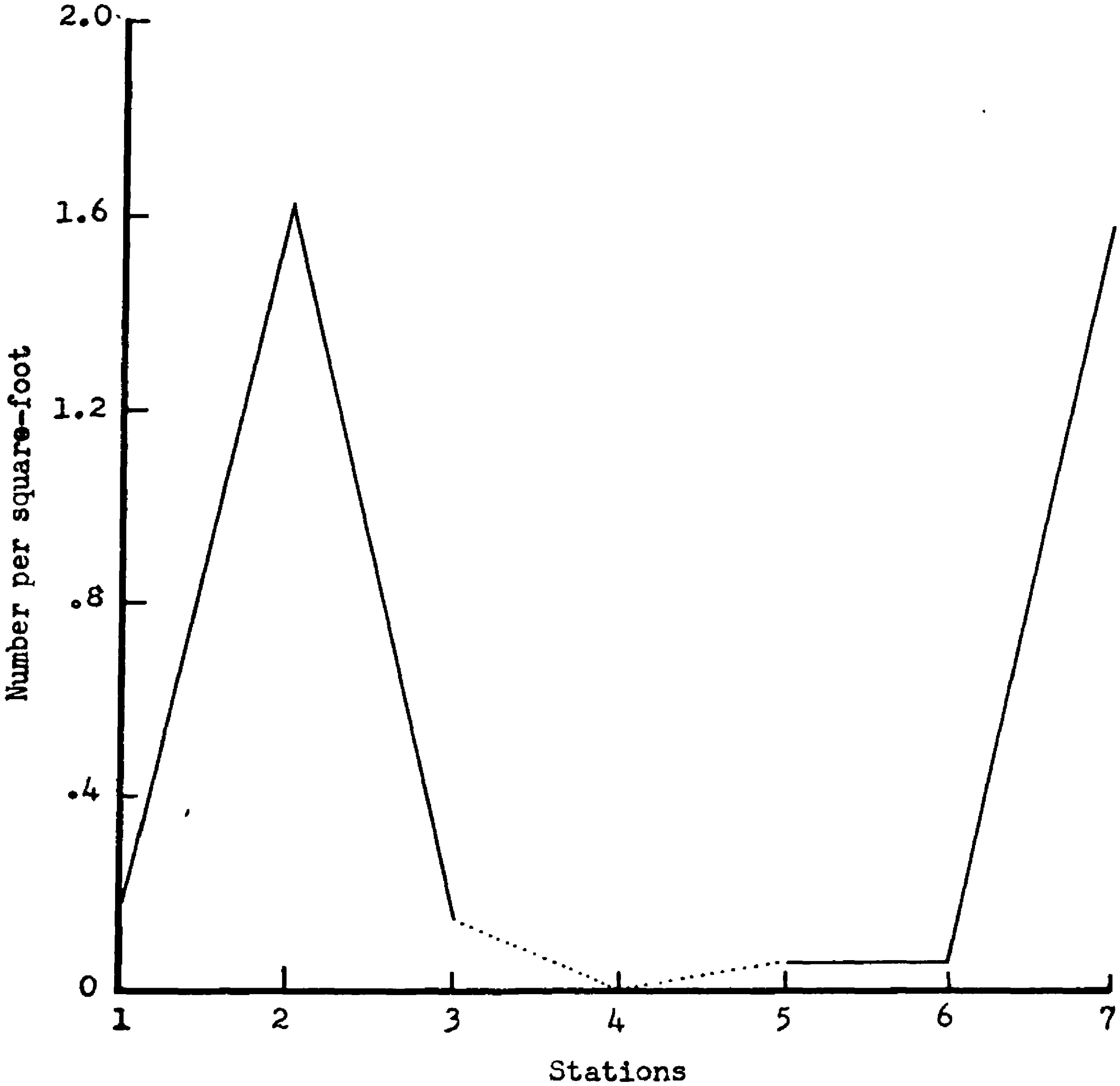

Weight
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
1
3
4
5
6
7
8
9
10
20
30
40
50
April 28
December 15
April 1
December 4
November 11
November 2
September 9
October 5
September 8
August 20
Lower station nymphs
Upper station nymphs

Figure 26. <u>Pteronarcella</u> <u>badia</u> per square-foot at collecting stations.



2.0
1.6
1.2
.8
.4
0
Number per square-foot
1
2
3
4
5
6
7
Stations

Figure 27. <u>Pteronarcella</u> <u>badia</u> per square-foot at monthly collections.

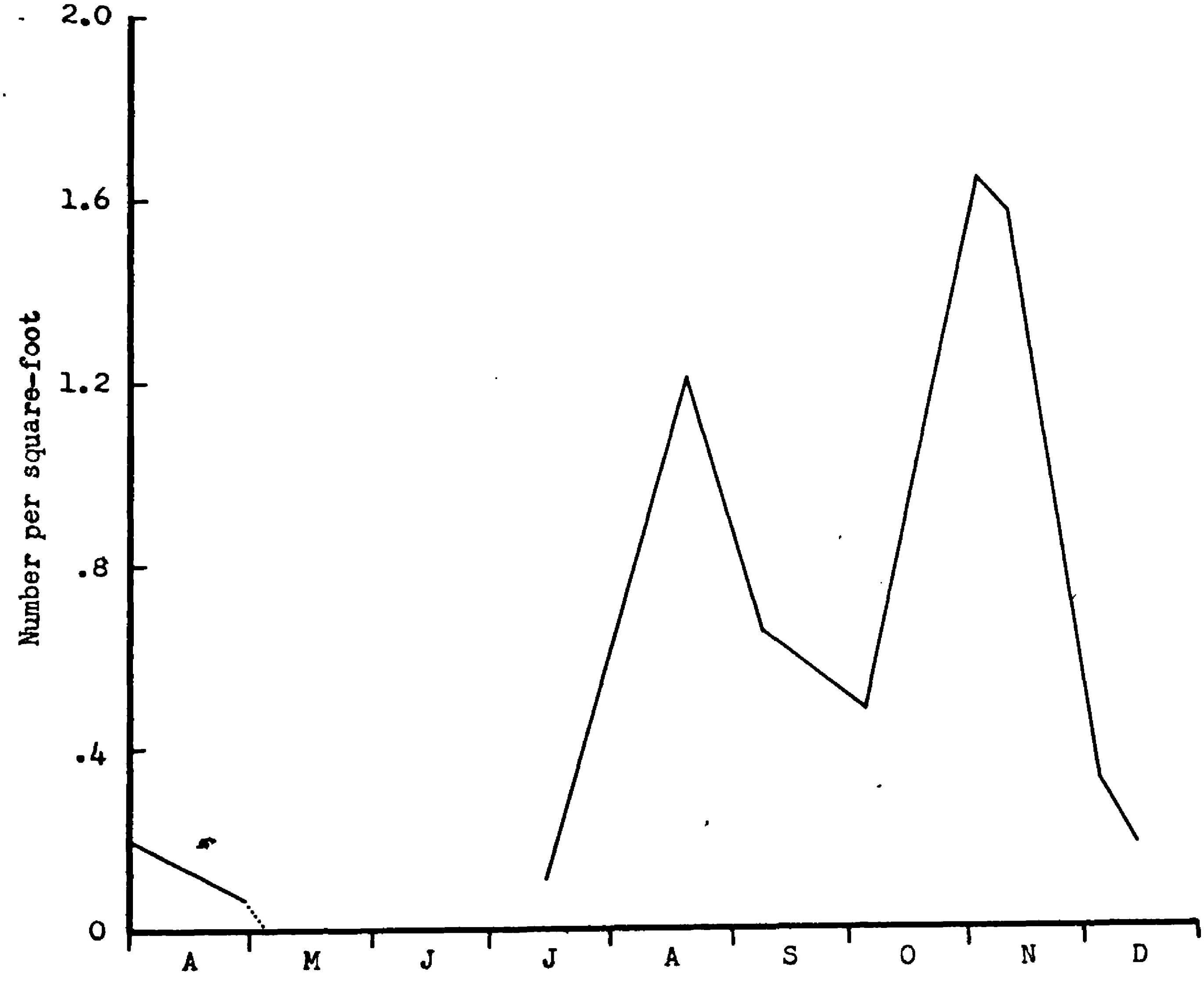

Number per square-foot
2.0
1.6
1.2
.8
.4
0
A
M
J
J
A
S
O
N
D

TABLE X

PTERONARCELLA BADIA FROM COLLECTING STATIONS
APRIL THROUGH DECEMBER

Station Number	Number of *P. badia*	Number of Samples	*Avg. Number *P. badia* Per Square-Foot
1	14	91	.15
2	105	64	1.64
3	7	48	.15
4	0	26	0.
5	3	51	.06
6	3	49	.06
7	8	5	1.60
Total	140	334	

*Mean for all stations = .42 per square-foot.

TABLE XI

PTERONARCELLA BADIA FROM COLLECTIONS
APRIL THROUGH DECEMBER

Collection Dates	Number of *P. badia*	Number of Samples	*Avg. Number *P. badia* Per Square-Foot	Stations Sampled
Apr. 1, 2	10	51	.20	1,2,3,4,5,6
Apr. 28,29	1	15	.07	1,2,3,4,5,6
May 5	0	8	0.	1
June 11,12	0	39	0.	1,2,3,4,5,6
June 28,29	0	34	0.	1,2,3,4,5,6
July 14,15	4	33	.12	1,2,3,4,5,6
Aug. 20	44	36	1.22	1,2,3,4,5,6
Sept. 8, 9	21	32	.66	1,2,3,4,5,6
Oct. 4, 5	12	25	.48	1,2,3,5,6
Nov. 2, 3	30	18	1.67	1,2,3,5,6
Nov. 11	8	5	1.60	7
Dec. 4	6	17	.35	1
Dec. 14,15	4	21	.19	1,2,3,5,6
Total	140	334		

*Mean for all collections = .42 per square-foot.

TABLE XII

PTERONARCELLA BADIA FROM 334 SQUARE-FOOT BOTTOM SAMPLES
APRIL THROUGH DECEMBER

Collection Dates	Total Collected	Weight Mg./Sq.Ft.	Avg. Wt. of Nymphs	Number Measured	Max. Length (mm.)	Min. Length (mm.)	Avg. Length (mm.)	Standard Deviation	Standard Error
Apr. 1, 2	10	10.4	53.2	10	17.5	9.3	13.0	2.69	.85
Apr. 28,29	1	6.7	100.8	1			18.5		
May 5	0	0	0	0					
June 11,12	0	0	0	0					
June 28,29	0	0	0	0					
July 14,15	4	.1	.4	4	3.4	2.6	3.0	.28	.14
Aug. 20	44	2.3	1.9	18	7.2	3.5	4.8	.99	.24
Sept. 8, 9	21	2.6	3.9	21	11.2	4.0	6.2	1.54	.34
Oct. 4, 5	12	3.8	7.8	12	10.3	6.1	7.8	1.11	.32
Nov. 2, 3	30	28.0	16.8	30	12.5	7.0	9.8	1.48	.27
Nov. 11	8	51.5	32.2	8	14.6	8.2	11.3	1.26	.63
Dec. 4	6	15.8	44.7	6	16.4	9.2	13.6	2.25	.79
Dec. 14,15	4	11.8	62.1	4	16.3	12.9	14.7	2.55	1.04

QUANTITATIVE STUDIES ON LEPIDOSTOMA

The following quantitative study of the genus Lepidostoma is based on a total of 18,198 larvae, collected from 334 square-foot bottom samples over a period of nine months--April through December. The length-growth history of this organism is summarized in Fig. 28, but will be presented chronologically.

On April 1 and 2, 51 samples were taken from the six station sites, and 571 larvae were collected averaging 11.20 per square-foot. From the six stations sampled at this time, Lepidostoma appeared only in stations 1, 2, and 3. The mean length of these organisms was 3.93 mm. (with a maximum of 6.0 mm., and minimum of 2.0 mm.), and the mean weight was 2.3 mg.

On April 28 and 29, 15 bottom samples were taken. From these samples, 788 larvae were collected, averaging 52.53 per square-foot. Station 3 produced the highest numbers of Lepidostoma throughout the sampling period, for example: of the 788 collected at this time (April 28 and 29), 760 were from station 3. The mean length of these forms increased to 4.46 mm. from 3.93 mm. on April 1 and 2 and had a maximum of 6.0 mm., minimum of 2.3 mm., and mean weight of 2.8 mg.

On May 5, eight samples were taken at station 1. The water level was so high at this time that no other stations were sampled. The samples from station 1 were at depths 3 to 18 inches, all of which were on bottom which was exposed or above the water line at the time the April samples were taken. No Lepidostoma were found in these samples.

On June 11 and 12, 39 samples revealed 0.97 Lepidostoma per square-foot. These figures show a considerable drop in numbers compared to those before the high water period. The mean length of these forms was 6.44 mm., with a maximum length of 8.0 mm., minimum of 4.0 mm., and an average weight of 8.5 mg.

On June 28 and 29, 34 samples resulted in 1.03 Lepidostoma larvae per square-foot, and 5.71 Lepidostoma pupae per square-foot. The larvae averaged 6.11 mm. in length with a maximum of 7.2 mm., and minimum of 5.0 mm. These length-measurements were smaller than those of June 11 and 12 indicating a possible wash of organisms downstream. The mean weight of these larvae also was smaller, 7.8 mg. as compared to 8.5 mg. for those of the previous collection. The pupae from these samples averaged 6.00 mm. in length, with a maximum of 6.9 mm., minimum of 4.7 mm., and had a mean weight of 10.2 mg. These pupal length-measurements were smaller than were larval measurements of the same collection, but the mean weight of the pupae was greater than for the larvae.

Thirty-three samples, taken July 14 and 15, revealed 0.58 pupae per square-foot. These pupae averaged 5.88 mm. in length, with a maximum of 6.2 mm., minimum of 5.0 mm., and had a mean weight of 9.68 mg. Three very small larvae were collected from these samples along with the pupae. These larvae had a mean length of 1.93 mm., with a maximum of 2.0 mm., and a minimum of 1.8 mm. Adult Lepidostoma were collected in the sweep net samples at this time, thus determining the period of emergence for this group.

On August 20, 36 bottom samples resulted in 43.61 Lepidostoma larvae per square-foot. These larvae averaged 1.45 mm. in length, with a maximum of 2.1 mm., minimum of 1.0 mm., and had a mean weight of 0.26 mg. These larvae averaged smaller in length as compared to those small larvae collected July 14 and 15. It was noted throughout the fall and winter sampling, that a few larvae in each collection were considerably larger than the main group. But so few of these larger larvae were collected that it was impossible to note a significant difference. The three larvae collected in July samples were present at the same time of the pupae and adults, whereas the larger number of small larvae appeared in the August 20 samples, at which time no pupae or adults were observed.

Samples collected September 8 and 9 revealed 6,368 Lepidostoma larvae in 32 square-foot samples, averaging 199.00 larvae per square-foot. The mean length of these larvae was 1.98 mm., with a maximum of 2.9 mm., minimum of 1.3 mm., and averaged 0.46 mg. in weight. These measurements were an increase over the August 20 measurements, but, compared to those larvae taken July 14 and 15, an increase of only 0.05 mm. in mean length was noted. These September samples were the final ones taken from station 4. Lepidostoma at station 4, on September 9, averaged 295.25 per square-foot, compared to a maximum of 550.83 per square-foot at station 3, and a minimum of 0.25 per square-foot at station 5.

Twenty-five samples were taken October 4 and 5 from the remaining five stations (station 4 had been bull-dozed) resulting in 248.92 Lepidostoma larvae per square-foot. Four samples collected from station 3 at this time revealed 1284.5 Lepidostoma per square-foot, which was the maximum number recorded per square-foot for this genus from any of the collections. These October larvae averaged 2.75 mm. in length, with a maximum of 4.4 mm., minimum of 1.8 mm., and averaged 0.69 mg. in weight.

Bottom samples were collected November 2 and 3 from stations 1, 2, 3, 5, and 6, and November 11, samples were taken at station 7. Eighteen samples (November 2 and 3) revealed 103.67 Lepidostoma per square-foot, and five cross-sectional samples at station 7 on November

11 resulted in 1.00 Lepidostoma larvae per square-foot. The mean length of all these November larvae was 3.13 mm., with a maximum length of 5.6 mm., minimum of 1.8 mm., and averaged 1.05 mg. in weight. The increase in mean length of the larvae was less between October and November than between the September and October forms. The average weight, however, increased at a greater rate.

Thirty-eight samples were taken during December. Seventeen cross-sectional samples were collected at station 1 on December 4, resulting in 7.29 Lepidostoma per square-foot; and 21 samples were collected from stations 1, 2, 3, 5, and 6 on December 14 and 15, averaging 28.43 larvae per square-foot. The mean length of all these December larvae was 3.19 mm., with a maximum of 5.7 mm., minimum of 1.7 mm., and averaged 1.50 mg. in weight. This mean length-measurement was only 0.06 mm. more than for November larvae—indicating a smaller increase in length-measurements as compared to previous recordings. The mean weights, however, continued to increase at a steady rate as shown on the logarithmic weight and length graph (Fig. 29). The length-weight relationship is shown in Fig. 30.

More Lepidostoma larvae occurred throughout the study period in station 3 than the total of all other stations (Table XIII). The mean number of these larvae at this station throughout the nine month study period was 254.35 per square-foot. Stations 2 and 4, below and above station 3, were 62.19 and 58.69 per square-foot respectively. Stations 1, 5, and 6 continued to decrease in number as the distance from station 3 increased. It is interesting to note that this form occurred throughout the section of the stream studied and that one area (station 3) resulted in such high numbers per unit area (Fig. 31, Table XIV). The highest number per unit area of these larvae occurred during the late summer and fall (August through November), with the peak being in October (Fig. 32). Needham (1939) found that high numbers of organisms per unit area are not necessarily correlated with high weights per unit area. During October, when maximum numbers of larvae per unit area occurred (248.92 per square-foot for all stations), the weight was 171.5 mg. per square-foot. Samples collected the last of April resulted in only 52.53 larvae per square-foot, but the weight of larvae per square-foot was 148.7 mg. (Table XV). The difference was in the average weight of the larvae: October larvae had a mean weight of 0.69 mg., compared to 2.8 mg. for the larvae collected during the last of April.

These data on <u>Lepidostoma</u>, in the Bitterroot River, indicate a one-year life cycle. A summary of <u>Lepidostoma</u> occurs in Tables XIII, XIV, and XV.

Figure 28. Lepidostoma - Mean length-growth.

(Numbers of specimens measured in parenthesis)

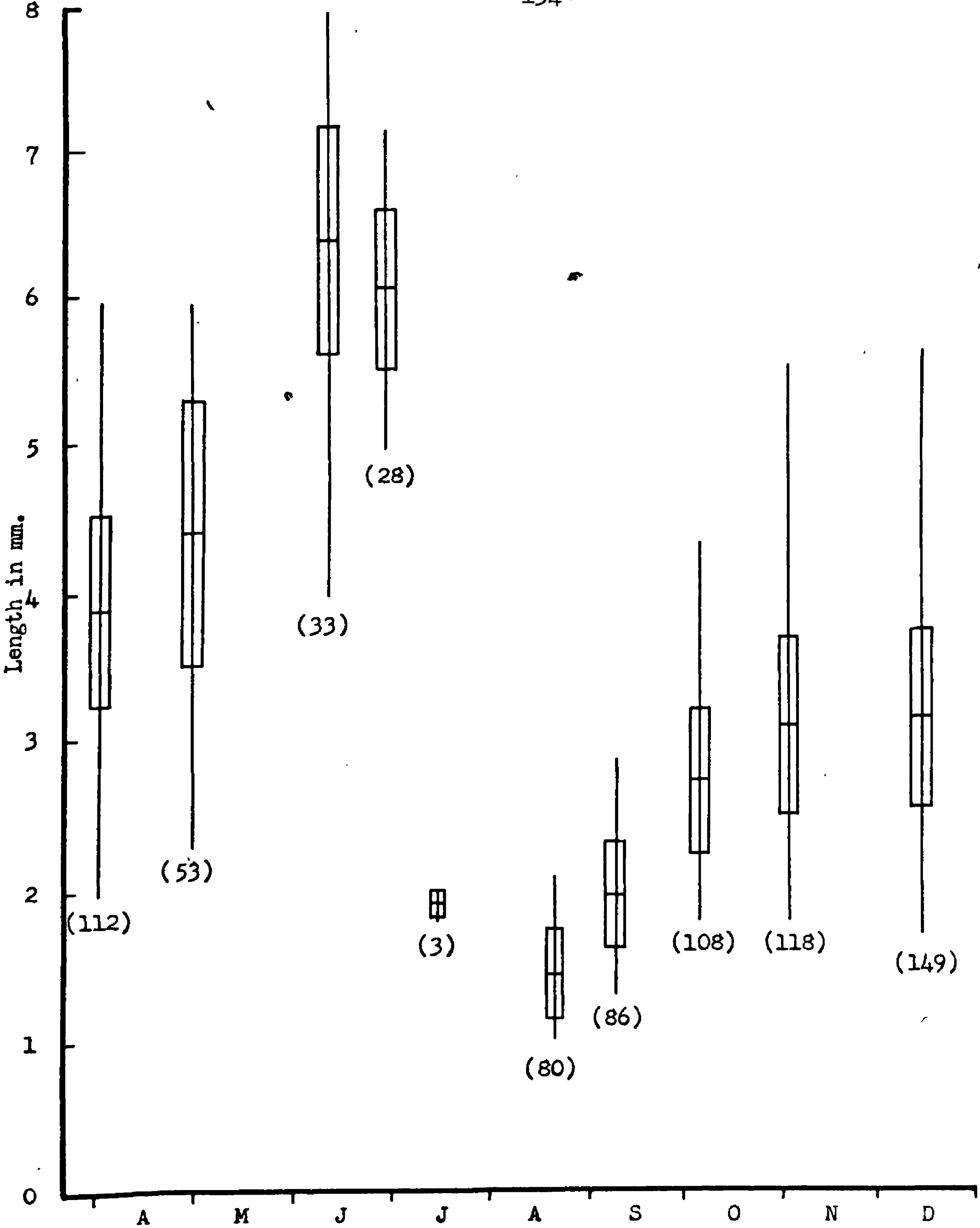

Length in mm.
0
1
2
3
4
5
6
7
8
(112)
(53)
(33)
(28)
(3)
(80)
(86)
(108)
(118)
(149)
A
M
J
J
A
S
O
N
D

Figure 29. Lepidostoma - Logarithmic weights and lengths.

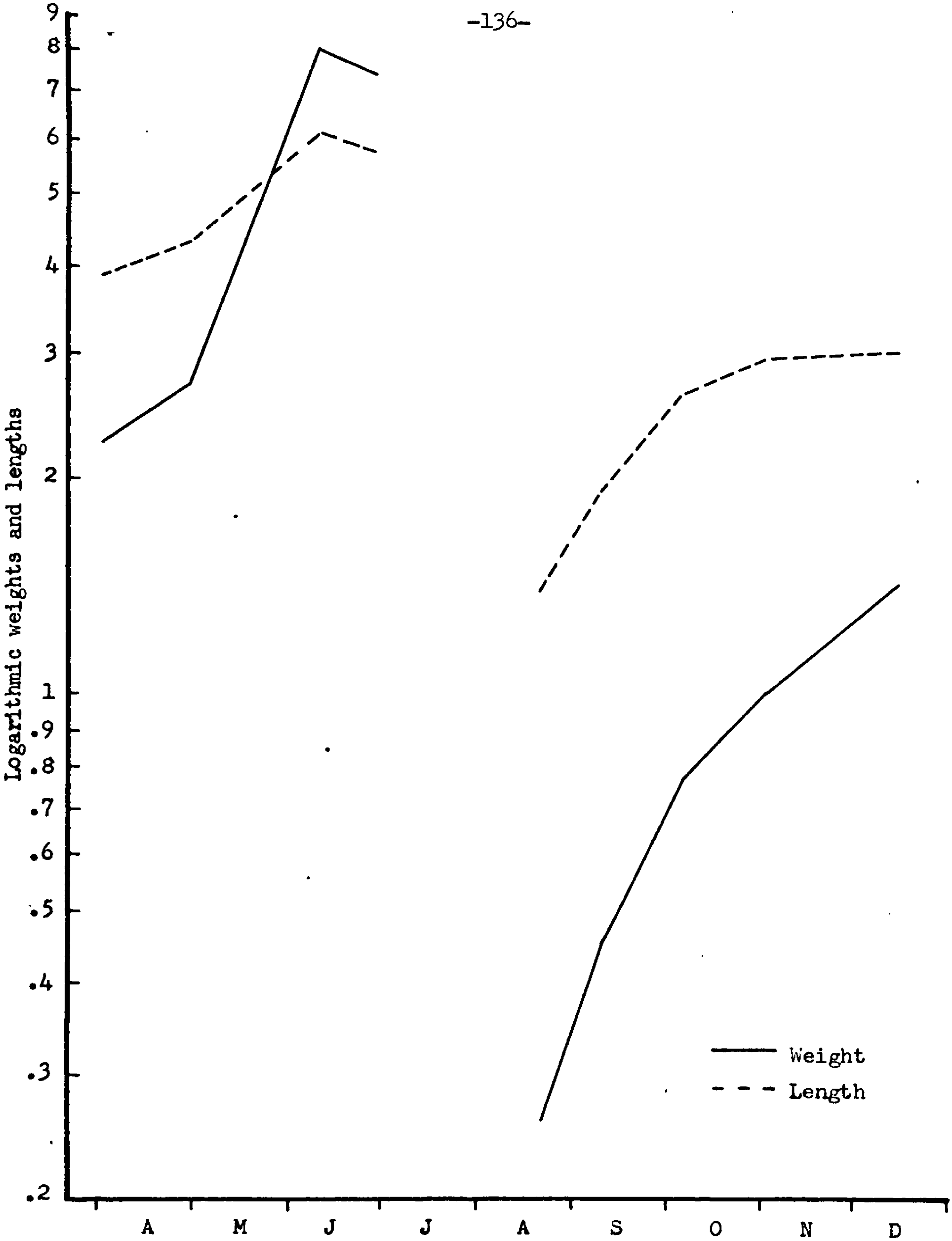
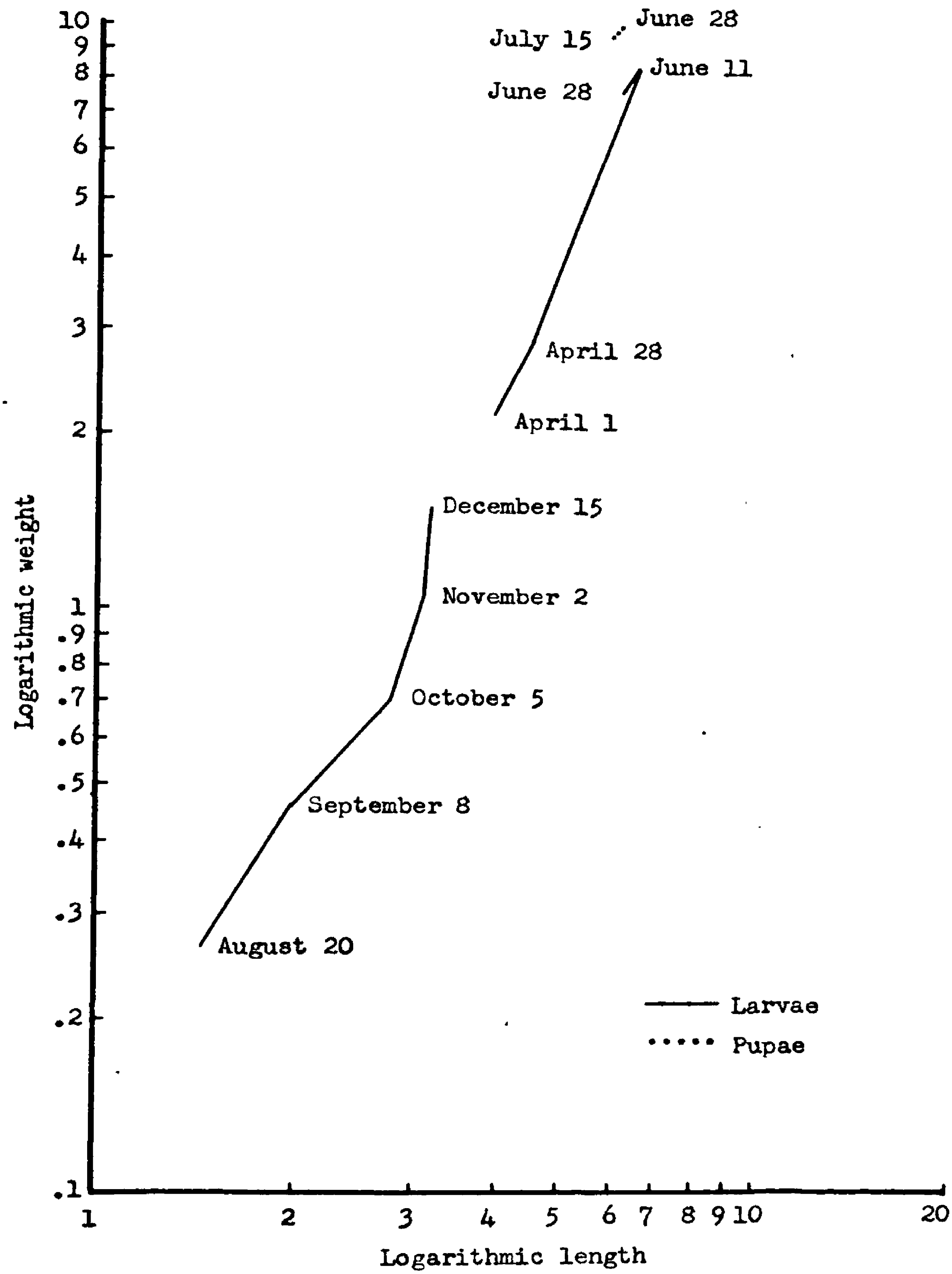

Logarithmic weights and lengths
9
8
7
6
5
4
3
2
1
.9
.8
.7
.6
.5
.4
.3
.2
A
M
J
J
A
S
O
N
D
Weight
Length

Figure 30. Lepidostoma - Length-weight relationships, April to December.



June 28
July 15
June 11
June 28
April 28
April 1
December 15
November 2
October 5
September 8
August 20
Larvae
Pupae
10
9
8
7
6
5
4
3
2
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
1
2
3
4
5
6
7
8
9
10
20
Logarithmic weight
Logarithmic length

TABLE XIII

LEPIDOSTOMA FROM COLLECTING STATIONS APRIL THROUGH DECEMBER

Station Number	Number of Lepidostoma	Number of Samples	*Avg. Number Lepidostoma Per Square-Foot
1	407	91	4.47
2	3,980	64	62.19
3	12,209	48	254.35
4	1,526	26	58.69
5	36	51	.71
6	35	49	.71
7	5	5	1.00
Total	18,198	334	

*Mean for all stations = 54.48 per square-foot.

TABLE XIV

LEPIDOSTOMA FROM COLLECTIONS APRIL THROUGH DECEMBER

Collection Dates	Number of Lepidostoma	Number of Samples	*Avg. Number Lepidostoma Per Square-Foot	Stations Sampled
Apr. 1, 2	571	51	11.20	1,2,3,4,5,6
Apr. 28,29	788	15	52.53	1,2,3,4,5,6
May 5	0	8	0.	1
June 11,12	38	39	.97	1,2,3,4,5,6
June 28,29	35	34	1.03	1,2,3,4,5,6
July 14,15	3	33	.09	1,2,3,4,5,6
Aug. 20	1,570	36	43.61	1,2,3,4,5,6
Sept. 8, 9	6,368	32	199.00	1,2,3,4,5,6
Oct. 4, 5	6,223	25	248.92	1,2,3,5,6
Nov. 2, 3	1,866	18	103.67	1,2,3,5,6
Nov. 11	5	5	1.00	7
Dec. 4	124	17	7.29	1
Dec. 14,15	607	21	28.43	1,2,3,5,6
Total	18,198	334		

*Mean for all collections = 54.48 per square-foot.

Figure 31. *Lepidostoma* per square-foot at collecting stations.

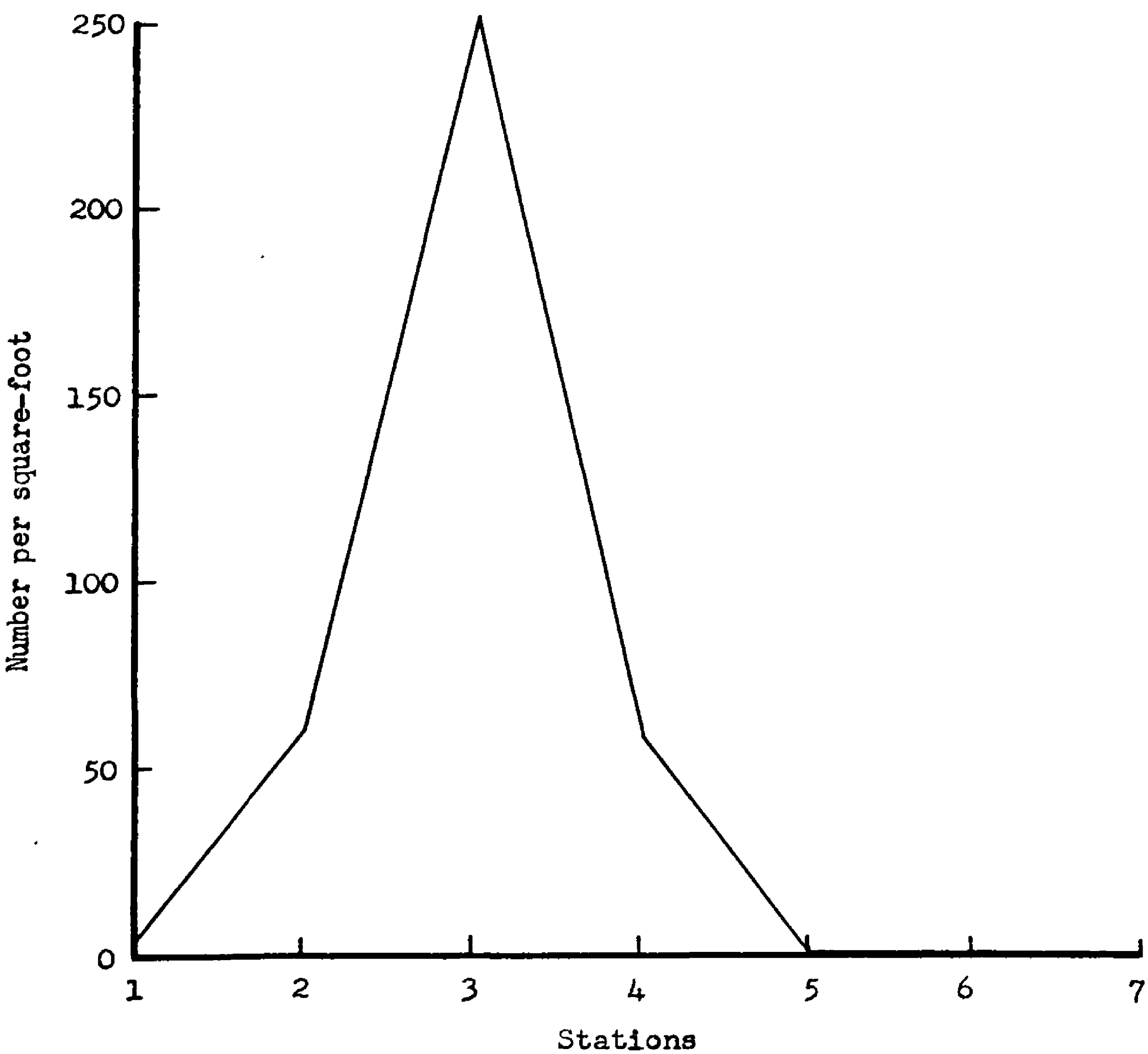

Number per square-foot
250
200
150
100
50
0
1
2
3
4
5
6
7
Stations

Figure 32. Lepidostoma per square-foot at monthly collections.

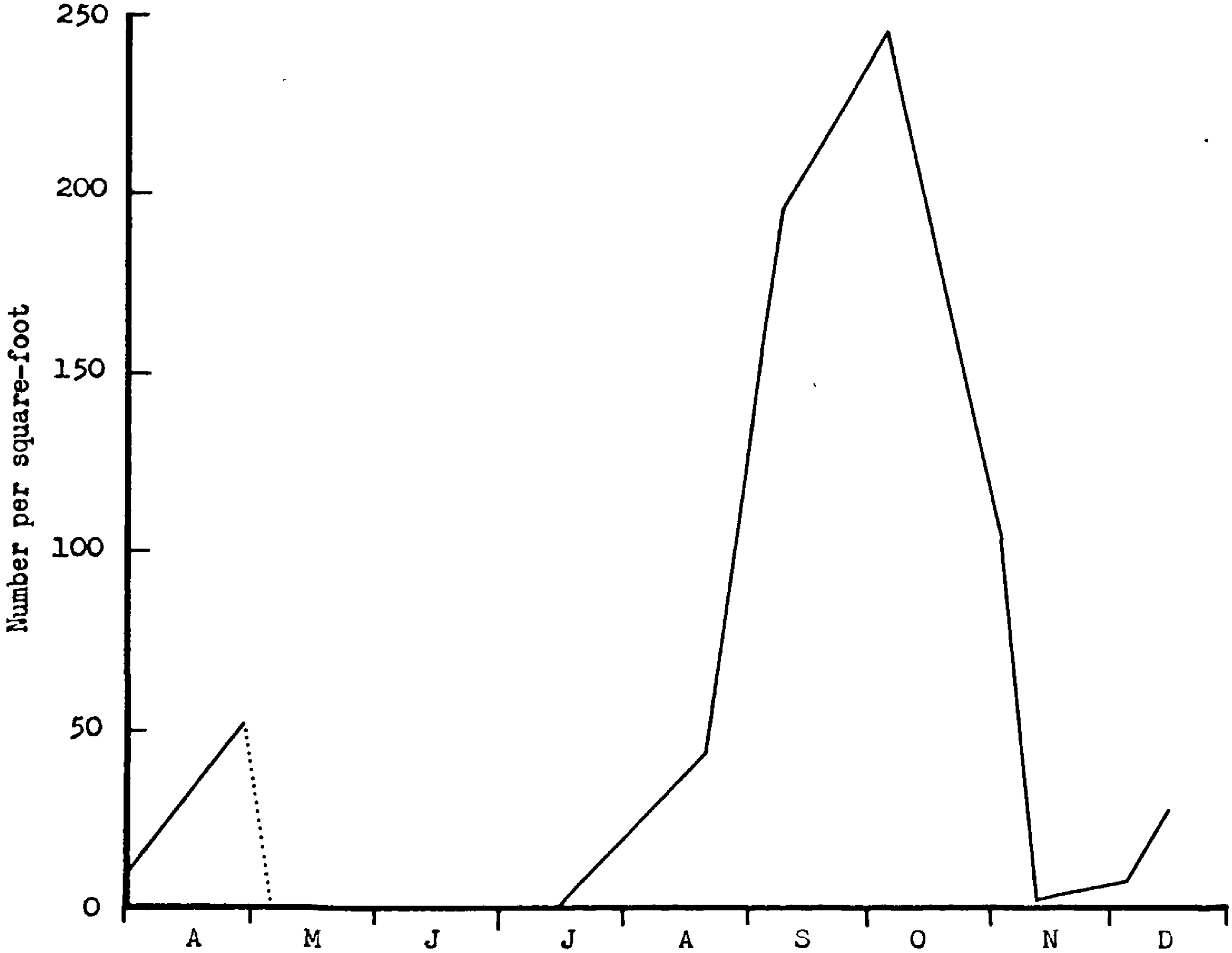

Number per square-foot
250
200
150
100
50
0
A
M
J
J
A
S
O
N
D

TABLE XV

LEPIDOSTOMA FROM 334 SQUARE-FOOT BOTTOM SAMPLES APRIL THROUGH DECEMBER

Collection Dates	Total Collected	Weight Mg./Sq.Ft.	Avg. Wt. of Larvae	Number Measured	Max. Length (mm.)	Min. Length (mm.)	Avg. Length (mm.)	Standard Deviation	Standard Error
Apr. 1, 2	571	26.1	2.3	112	6.0	2.0	3.93	.65	.06
Apr. 28,29	788	148.7	2.8	53	6.0	2.3	4.46	.89	.12
June 11,12	38	8.2	8.5	33	8.0	4.0	6.44	.78	.14
June 28,29	35	8.0	7.8	28	7.2	5.0	6.11	.55	.10
	*194	*58.0	*10.2	*51	*6.9	*4.7	*6.00	*.46	*.06
July 14,15	3			3	2.0	1.8	1.93	.10	.18
	*19	*5.6	*9.7	*10	*6.2	*5.0	*5.88	*.40	*.13
Aug. 20	1570	11.4	.3	80	2.1	1.0	1.45	.31	.03
Sept. 8, 9	6368	91.7	.5	86	2.9	1.3	1.98	.36	.04
Oct. 4, 5	6223	171.5	.7	108	4.4	1.8	2.75	.50	.05
Nov. 2,3,11	1871	85.2	1.1	118	5.6	1.8	3.13	.62	.06
Dec. 4,14,15	731	29.5	1.5	149	5.7	1.7	3.19	.61	.05

*<u>Lepidostoma</u> pupae.

SUMMARY

1. The original plan to make a year-round study of the population of insects in the Bitterroot River was modified into a statistical analysis of three species of aquatic insects. Data were secured from six selected stations on the main Bitterroot River and the East Fork of the Bitterroot River.

2. Temperatures, current velocities, water levels, and ice conditions are given for the six stations.

3. In quantitative cross-sectional samples of stations 1 and 7, differences were given as shown.

4. Quantitative data for all aquatic insects for all stations were given for April 1 and 2, 1956.

5. Analysis of data for <u>Pteronarcys californica</u> showed the following:

a. Station 3 was the lower altitudinal limit of this species.

b. This species emerged at water temperature of 51° F.

c. <u>P. californica</u> probably has a four-year life cycle.

d. Population densities varied from 0.10 nymphs per square-foot at station 3, to 4.20 at station 7.

6. Analysis of data for <u>Pteronarcella badia</u> showed the following:

a. Period of emergence was from the latter part of June to the middle of July.

b. A one-year life span is indicated.

c. A significant difference in size occurred between nymphs from the upper and lower stations; a different growth rate

was found between nymphs of these two areas.

d. Population densities varied from 0.06 nymphs per square-foot at stations 5 and 6, to 1.64 at station 2.

7. Analysis of data for Lepidostoma sp. showed the following:

a. Pupation and emergence occur during the latter part of June and middle of July.

b. A one-year cycle is evident.

c. Station 3 was the optimum habitat for this genus, showing 254.35 larvae per square-foot.

d. A significant difference in size occurred in this genus.

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APPENDIX

TABLE XVI

ANNUAL CLIMATOLOGICAL SUMMARY, U. S. WEATHER BUREAU
STATION 24 7964 1, SULA, MONTANA, 1956

	Temperatures °F.			Precipitation				
Date	Mean Max.	Mean Min.	Mean	Total	Greatest Daily Amount	Date	Inches Snow	Date
January	34.1	8.5	21.3	.77	.34	16	13.3	16
February	33.8	5.9	19.9	.42	.17	13	5.5	15
March	45.4	14.4	29.9	1.28	.25		22.5	14
April	57.3	27.9	42.6	1.18	.54	17	T	
May	66.2	35.5	50.9	1.89	.36		T	
June	74.3	40.1	57.2	2.62	1.00	16	.0	
July	82.6	47.2	64.9	2.08	.76	2	.0	
August	77.4	41.8	59.6	1.47	.46	27	.0	
September	75.2	35.6	55.4	.45	.17	27	.0	
October	56.4	26.1	41.3	1.52	.34	26		
November	40.6	16.0	28.3	.56	.23	17		
December	34.5	16.1	25.3	1.29	.60	10	6.0	5
Annual	56.5	26.3	41.4	15.53				

The above table is an annual climatological summary for 1956 from the U. S. Weather Bureau station at Sula. The annual mean maximum temperature was 56.5° F., mean minimum of 26.3° F., and the annual mean temperature was 41.4° F. The total precipitation for 1956 at Sula was 15.53 inches.

TABLE XVII

TEMPERATURES: STATION 1, APRIL THROUGH JANUARY

Date	Time of Day	Water Temp.	Ground Temp.	Air Temp.
Apr. 1,1956	10:35	39 °F.	35 °F.	31 °F.
Apr. 28,1956	10:00	44	49	48
May 5,1956	10:45	50		52
June 11,1956	10:45	54	66	62
June 28,1956	13:00	61	84	88
July 15,1956	15:00	67	80	79
Aug. 20,1956	09:00	62	60	62
Sept. 8,1956	10:00	62	63	68
Oct. 5,1956	16:30	56	57	63
Nov. 2,1956	14:00	45	44	43
Dec. 14,1956	13:30	42	40	42
Jan. 12,1957	09:00	36	Frozen	31

TABLE XVIII

TEMPERATURES: STATION 2, APRIL THROUGH JANUARY

Date	Time of Day	Water Temp.	Ground Temp.	Air Temp.
Apr. 1,1956	14:00	39 °F.	35 °F.	37 °F.
Apr. 28,1956	12:30	44	52	51
June 11,1956	14:00	56	68	68
June 28,1956	16:30	64	81	81
July 15,1956	10:00	60	72	68
Aug. 3,1956	11:00	63	67	64
Aug. 20,1956	10:25	62	70	74
Sept. 8,1956	12:00	61	74	76
Oct. 5,1956	14:00	57	62	71
Nov. 2,1956	16:00	43	39	43
Dec. 14,1956	15:00	38	38	41
Jan. 12,1957	11:00	32	Frozen	36

TABLE XIX

TEMPERATURES: STATION 3, APRIL THROUGH JANUARY

Date	Time of Day	Water Temp.	Ground Temp.	Air Temp.
Apr. 1,1956	16:30	39 °F.	35 °F.	41 °F.
Apr. 28,1956	14:50	42	50	54
June 11,1956	17:00	55	69	71
June 29,1956	09:00	53	53	62
July 14,1956	14:00	63	79	81
Aug. 20,1956	12:00	69	68	76
Sept. 8,1956	14:00	66	58	75
Oct. 4,1956	15:00	46	44	65
Nov. 3,1956	15:00	41	37	35
Dec. 14,1956	16:30	36	37	39
Jan. 12,1957	12:30	34	Frozen	42

TABLE XX

TEMPERATURES: STATION 4, APRIL THROUGH SEPTEMBER

Date	Time of Day	Water Temp.	Ground Temp.	Air Temp.
Apr. 2,1956	15:00	42 °F.	41 °F.	39 °F.
Apr. 29,1956	16:00	43	48	48
June 12,1956	15:00	53	68	72
June 29,1956	15:00	60	74	75
July 14,1956	12:00	60	84	80
Aug. 20,1956	13:10	64	66	78
Sept. 9,1956	12:45	57	68	78

TABLE XXI

TEMPERATURES: STATION 5, APRIL THROUGH JANUARY

Date	Time of Day	Water Temp.	Ground Temp.	Air Temp.
Apr. 2,1956	14:00	39 °F	42 °F.	39 °F.
Apr. 29,1956	15:30	41	46	56
June 12,1956	12:00	51	65	69
June 29,1956	13:00	56	70	74
July 14,1956	11:00	54	74	79
Aug. 20,1956	14:00	62	73	78
Sept. 9,1956	11:45	52	63	71
Oct. 4,1956	12:15	45	44	64
Nov. 3,1956	12:30	32	Frozen	30
Dec. 15,1956	12:00	32	Frozen	36
Jan. 12,1957	14:00	32	Frozen	38

TABLE XXII

TEMPERATURES: STATION 6, APRIL THROUGH JANUARY

Date	Time of Day	Water Temp.	Ground Temp.	Air Temp.
Apr. 2,1956	12:00	38 °F.	39 °F	42 °F.
Apr. 29,1956	14:00	43	55	54
June 12,1956	10:30	48	66	64
June 29,1956	11:30	54	62	62
July 14,1956	09:00	54	65	75
Aug. 20,1956	15:00	64	75	77
Sept. 9,1956	10:30	51	58	65
Oct. 4,1956	11:00	46	46	61
Nov. 3,1956	11:00	34	Frozen	28
Dec. 15,1956	10:00	32	Frozen	35
Jan. 12,1957	15:00	32	Frozen	38

TABLE XXIII

WATER TEMPERATURES FOR STATIONS 1 TO 6, APRIL THROUGH JANUARY
(STATION 4, APRIL THROUGH SEMPTEMBER)

	1	2	3	4	5	6
Max. Water Temp.	67.0°F	64.0°F	69.0°F.	64.0°F.	62.0°F.	64.0°F.
"Avg." Water Temp.	51.6	51.6	49.5	54.1	45.1	45.1
Min. Water Temp.	36.0	32.0	34.0	42.0	32.0	32.0

TABLE XXIV

AVERAGE CURRENT VELOCITIES IN FEET PER SECOND FOR EACH STATION

Date	1	2	3	4	5	6
Apr. 1	2.5	3.0	2.5			
Apr. 2				4.6	4.6	2.4
Apr. 28	3.7	4.0	2.8			
Apr. 29				4.4		
May 5	1.8					
June 11	3.1	2.8	2.6			
June 12				5.2	5.1	4.5
June 28	2.4	2.2				
June 29			4.4	4.1	4.6	4.2
July 14			4.1	3.6	4.0	3.0
July 15	1.9	2.6				
Aug. 20	.4	.5	1.9	1.2	3.1	2.2
Sept. 8	1.0	.4	1.9			
Sept. 9				1.0	3.3	2.2
Oct. 4			1.9		3.1	1.8
Oct. 5	1.0	1.7				
Nov. 2	1.0	1.5				
Nov. 3			2.4		2.8	1.6
Nov. 11						**3.4
Dec. 4	*3.1					
Dec. 14	1.7	1.6	3.4			
Dec. 15					4.4	2.0
Jan. 12	1.0	1.0	2.7		3.1	2.3

*Measured at lower end of station site when cross-sectional samples were taken.

**Recorded at station 7, one-half mile above station 6 when cross-section samples were taken.

TABLE XXV

AVERAGE NUMBER OF BOTTOM ORGANISMS PER SQUARE-FOOT OCCURRING IN STATIONS 1 TO 6, APRIL 1 AND 2, 1956 (BASED ON 51 SQUARE-FOOT BOTTOM SAMPLES)

Bottom Fauna Collected	1	2	3	4	5	6
Plecoptera	10.07	15.62	3.80	7.50	7.25	2.86
Chloroperlidae						
Nemouridae						
Perlidae						
Perlodidae						
Ephemeroptera	29.64	60.08	33.40	637.25	82.63	384.00
Baetidae						
Heptageniidae						
Diptera	4.64	23.85	9.40	48.75	10.13	35.86
Tendipedidae						
Tipulidae						
Simulidae						
Ephydridae						
Coleoptera	0.50	0.54	0.40	0.25	0.13	0.
Elmidae larvae and adults and Unknown Coleopteran larvae						
Trichoptera	1.64	32.54	28.20	0.	0.25	0.
Lepidostomatidae						
Brachycentridae						
Hydropsychidae						
Rhyacophilidae						
Annelida	2.00	0.15	10.60	4.00	8.88	15.00
Gastropoda	0.	0.	0.	1.00	0.	0.
Fish	0.07	0.	0.	0.	0.	0.
Rhinichthys cataractae						