FOODS OF JUVENILE COHO SALMON AND TWO INSECT GROUPS IN THE COHO DIET IN THREE TRIBUTARIES OF THE ALSEA RIVER, OREGON

by

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FOODS OF JUVENILE COHO SALMON AND TWO INSECT GROUPS IN THE COHO DIET IN THREE TRIBUTARIES OF THE ALSEA RIVER, OREGON

INTRODUCTION

A preliminary study of the food items comprising the diets of juvenile coho salmon, Oncorhynchus kisutch (Walbaum), from three tributary streams of Drift Creek in the Alsea River Basin was made from May 1959 to June 1960. They were Deer Creek, Flynn Creek and Needle Branch (figure 1). The main purpose was to ascertain the food items utilized by young coho in undisturbed habitats previous to anticipated logging scheduled for 1964 to 1965. In addition, stomach contents of three aquatic insect forms frequently present in the diets of young coho were examined periodically from Deer Creek and Needle Branch from November 1959 to October 1960.

These food habit studies were an integral part of a comprehensive investigation dealing with the effects of logging methods on aquatic resources being conducted by the Agricultural Experiment Station of Oregon State College.[1] Similar food habit studies will be made after logging the Deer Creek and Needle Branch watersheds. Flynn Creek, which is scheduled to remain

[1] The project, known as the Alsea Watershed Study, was originally under the Committee of Natural Resources, State of Oregon, but transferred to the Agricultural Experiment Station in July 1959.

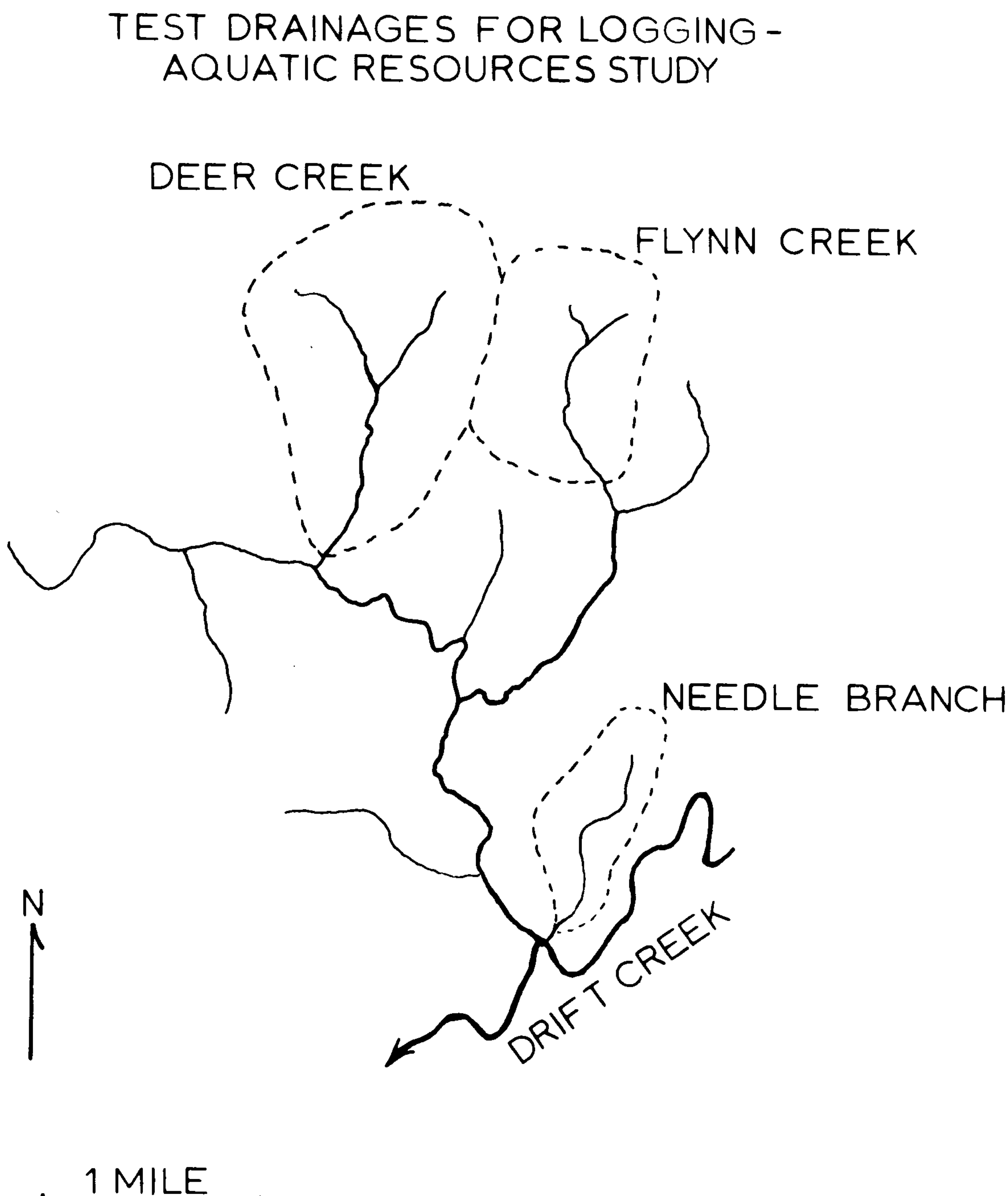
TEST DRAINAGES FOR LOGGING-
AQUATIC RESOURCES STUDY
DEER CREEK
FLYNN CREEK
NEEDLE BRANCH
DRIFT CREEK
N
1 MILE

Figure 1

unlogged, will be the control stream. A complete description of the over-all project has been given by Chapman (3, p. 1-8).

Fish stomach analyses from May 1959 to October 1959 indicated that midge larvae of the family Tendipedidae and mayfly nymphs of the family Baetidae were, at that time, the most important food items in each of the three streams. Of the Tendipedidae, Hydrobaeninae larvae appeared most often in stomachs of young coho. The species involved were not determined. Baetidae nymphs which occurred in coho stomachs most often were two undetermined species of the genus *Baetis*. A second mayfly nymph of the genus *Paraleptophlebia* was selected for stomach analyses because it was the dominate Baetid nymph in the three streams. The probable species involved was *P. debilis* (Walker), identified by Dr. G. F. Edmunds, University of Utah, Salt Lake City.

The three streams varied widely in flows. Deer Creek, the largest, ranged in flow from one c.f.s. in the late summer of 1959 to 68 c.f.s. in the winter of 1960; Flynn Creek for the same period varied from 0.5 c.f.s. to 45 c.f.s.; and Needle Branch ranged from <0.1 c.f.s. to 14 c.f.s. in 1959 and 1960. Temperature maxima in the three streams in 1959 and 1960 was 58° F., and occurred in September 1960. Minimum temperatures of 40°, 39° and 37° F. were recorded in February 1960 for Deer Creek, Flynn Creek and Needle Branch, respectively.

Deer Creek is naturally divided into a canyon and meadow. Substrate of the canyon portion was primarily composed of rock particles six inches in diameter to boulders. Stream flow in the canyon portion was rapid because of a series of cascades. The meadow portion was a meandering stream with alternating pools and riffles with bottom types ranging from silt to rubble. Bottom types in most of Flynn Creek and Needle Branch were quite similar to the bottom types in the meadow portion of Deer Creek, but rubble bottoms in Needle Branch were present only in the upper reaches.

Vegetative cover over the meadow portion of Deer Creek was composed primarily of red alder, Alnus rubra (Bong.), and the canopy, though usually complete, was on the average about 25-30 feet above stream level and rather sparse. The canyon streamside vegetation was predominately salmonberry, Rubus spectabilis (Pursh.), which seldom formed a complete canopy. Cover conditions in Flynn Creek and Needle Branch were similar to each other in that the canopy over these two streams was low and nearly complete, composed mainly of salmonberry with an overstory which was predominately Douglas fir, Pseudotsuga menziesii (Mirb.), Franco. Slopes adjacent to the three streams supported mainly Douglas fir.

METHODS AND PROCEDURES

Fish Stomach Analyses

Fish to be examined for stomach contents were collected with a small hand seine from riffles and pools. They were selected from the seine at random and preserved in a 10 percent formalin solution.

Since the numbers of juvenile coho present in the streams were somewhat limited and large collections over a 12-month period might seriously deplete the populations, five fish every two weeks were collected from each stream from May 1959 through September 1959. In Deer Creek and Flynn Creek, five fish per month were collected from October 1959 until the emergence of 0/ age fish[1] in March 1960. After that time, 10 0/ age fish and five 1/ age fish[2] were collected every two weeks. Sampling was terminated in Deer Creek on April 22, 1960, and in Flynn Creek on June 14, 1960. In Needle Branch sample size was reduced to three fish per month from October 1959 to February 19, 1960, after which sampling was terminated. In Needle Branch, 0/ age fish in the spring of 1960, resulting from eggs of late-spawning adults, were not present or occurred in very limited numbers.

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[1]Fish less than one year of age.
[2]Fish in their second year of life.

The fork length of each fish was measured to the nearest millimeter. Stomachs were removed by severing the esophagus at the junction with the stomach. The stomach was then cut at the bend and the posterior portion discarded. Identification of food organisms was facilitated by examination of the anterior portion of the stomach only, because most of the fragmented material, which is difficult and time consuming to identify, was eliminated by discarding the posterior portion.

Food items were identified mainly to families, but occasionally to genus and in some cases only to subclass or phylum, were placed in weighed aluminum pans, and then dried at 140° to 151° F. for 24 hours. Contents were allowed to cool and then weighed to the nearest 0.1 milligram on a triple-beam analytical balance. To increase accuracy in weighing small items, food organisms of each particular taxonomic group were combined. In compiling the data, a food group is designated as consisting of a major taxonomic division such as phylum, class or order. Food items were subdivisions of the food groups and, in most cases, were represented by families. Since stomach contents were dried, all weights refer to dry weights.

Data obtained from fish stomach analyses were corrected to equate sample size. For example, when two or more groups of fish were collected for any one month, the total dried weight of each food item was divided by the number of samples, obtaining a mean monthly weight. When only one sample was taken per month, the actual weight of each food item served as the mean monthly weight. In Needle Branch where sampling was terminated in February 1960, mean weights of food items for March and April 1960 were estimated by using the combined mean monthly weights of food items for February 1960 and May 1959. Resultant mean weights of these food items were only gross estimates of organisms which may have been eaten in March and April 1960.

Insect Stomach Analyses

To prevent bias in selecting sampling sites, an experimental design was followed in collecting insects for stomach analyses from Deer Creek and Needle Branch. Deer Creek has 76 permanent reference markers, 20 of which were selected at random as sampling stations. The canyon of Deer Creek, which had seven sampling stations, was not included in the sampling scheme until May 1960 due to high flows. Of the 27 permanent reference markers on Needle Branch, 10 were selected at random as sampling stations. Each station was divided into 12 substations at two-foot intervals. Sampling was begun at the most downstream substation in November 1959 and progressed upstream by two-foot intervals every two weeks. The most upstream substation was collected in April 1960. Sampling then reverted back to one foot below the original substation in May 1960 and progressed upstream by two-foot intervals every two weeks. The most upstream substation was collected in October 1960. In this way the particular stream area covered by the first sampling run, which occurred from November 1959 through April 1960, was not included in the second sampling run which occurred from May 1960 through mid-October 1960. Prior to sampling at each substation the right, middle or left side of the stream was selected at random for collecting.

Although the two sampling runs covered nearly the same stream area, conditions prevailing in the streams were somewhat dissimilar owing to seasonal changes in flow, cover and light intensity. The first sampling run occurred during a period of fluctuating stream flows, short day lengths and minimum cover. The second sampling run was a period of relatively stable stream flows and maximum cover and day lengths.

Bottom types were divided into five main groups: (1) silt, (2) sand, (3) pea-gravel, pea size to walnut size, (4) gravel, walnut size to three inches in diameter, and (5) rubble, three to 12 inches in diameter. Particles greater than 12 inches in diameter were considered boulders. This classification was general and seldom did one type occur alone, but rather as a mixture of more than one type. Therefore, analyses of insect feeding habits in relation to bottom type was based on the dominate particle size at each substation.

A small hand net was used to collect all insects. Insects were obtained by gently disturbing about a square foot area of stream bottom and catching the material set adrift. Most of the debris was removed from the collected material before the sample was placed in a 10-dram polyethylene vial. Samples were put on ice to retard the possibility of digestion of stomach contents. When a sample was collected, bottom type and vegetative cover intensity were recorded. Total elapsed time from collection through examination was usually about five hours. When laboratory facilities at the study area became available in July 1960, the total elapsed time was reduced to about four hours.

Two nymphs each of Baetis and Paraleptophlebia and two Hydrobaenid larvae were removed from each sample. With the exception of omitting those individuals with empty stomachs, specimens were removed from the sample at random.

The procedure used in removal of the stomach from mayfly nymphs was as follows: the specimen was placed on a clean glass slide and the abdomen removed with a cutting needle. A slight downward pressure on the dorsal surface of the thorax was usually sufficient to displace the anterior portion of the stomach. If necessary, the stomach was teased from the thorax region. Contents were then placed in a drop of water and pressed flat with a cover slip. Whole Hydrobaenid larvae were pressed flat with a cover slip.

Stomach contents were classified only as algae or detritus. The broad separation of food types into two groups was possible since algae were the dominate aquatic plants, except for moss which grew in the canyon portion of Deer Creek. Plant materials other than algae with chloroplasts were classified as detritus. Percentages of algae were estimated by visual observation, based on total stomach contents without regard to measured volume or weight of stomach contents. Mean monthly percentages of algae were determined by adding together the estimated percentages of algae and dividing by the number of specimens. Since estimates of algae in insect stomachs were gross and the percentages of algae in stomach contents ranged in some cases from zero to 100 percent, the arithmetic means are gross and not intended as precise estimates.

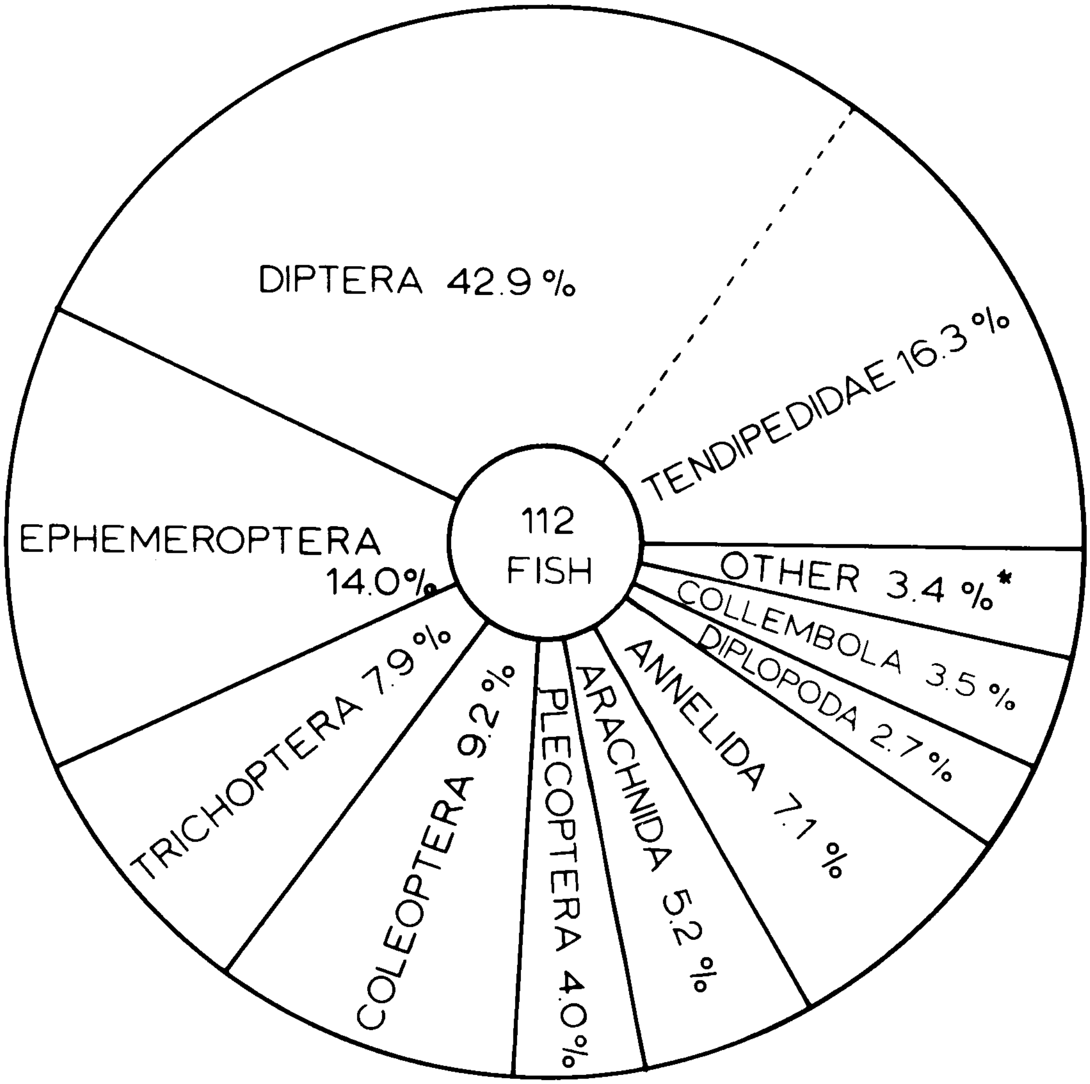
RESULTS OF FISH STOMACH ANALYSES

Identified food items from 272 coho stomachs (Deer Creek, 112; Flynn Creek, 116; Needle Branch, 44) were categorized as: aquatic items including immature forms and adults normally residing in the streams; aquatic aerial items, subimagoes and adult insects of aquatic origin; terrestrial items of land origin; and grossly identified items from uncertain habitats. Aquatic aerial items were categorized separately because their over-all importance as represented in stomach contents was relatively minor. For this reason they were omitted in the discussion concerning seasonal fluctuations of aquatic and terrestrial food items in relation to stream flows. Appendix tables 1, 2 and 3 show by percentage weights and habitat origins the four categories of food items. Figures 2 through 7 present graphically percentage weights of food items by taxonomic groups irrespective of habitat origin. Results are discussed separately by streams.

Deer Creek

Aquatic food items in Deer Creek made up 56 percent of the total dry weight. The other categories, which comprised 44 percent of the total weight, were terrestrial food items, 34 percent; aquatic aerial items, six percent; and food items of uncertain habitats, four percent. Aquatic Diptera larvae and pupae comprised 43 percent of the aquatic food weight and 24

COHO STOMACH CONTENTS, DEER CREEK,
MAY 25, 1959 TO APRIL 23, 1960



* HEMIPTERA	0.3%	GAMMARIDAE	0.6 %
HOMOPTERA	0.8%	CHILOPODA	0.2 %
HYMENOPTERA	0.4%	GASTROPODA	0.2 %
LEPIDOPTERA	0.5%	FISH EGGS	0.1 %
ISOPODA	0.3%		

PERCENT OF TOTAL DRY WEIGHT

Figure 2

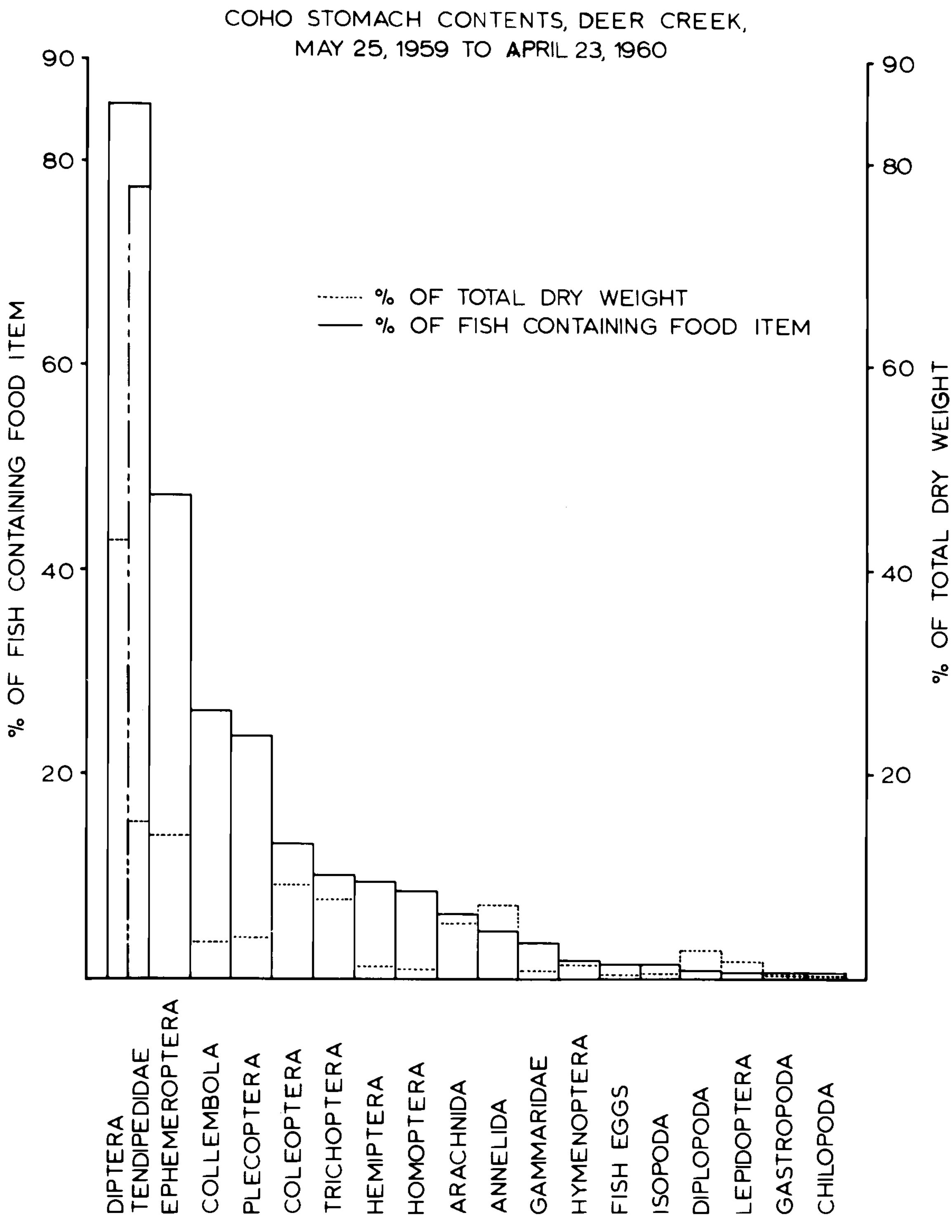

COHO STOMACH CONTENTS, DEER CREEK,
MAY 25, 1959 TO APRIL 23, 1960
% OF TOTAL DRY WEIGHT
% OF FISH CONTAINING FOOD ITEM
% OF FISH CONTAINING FOOD ITEM
% OF TOTAL DRY WEIGHT
90
80
60
40
20
DIPTERA
TENDIPEDIDAE
EPHEMEROPTERA
COLLEMBOLA
PLECOPTERA
COLEOPTERA
TRICHOPTERA
HEMIPTERA
HOMOPTERA
ARACHNIDA
ANNELIDA
GAMMARIDAE
HYMENOPTERA
FISH EGGS
ISOPODA
DIPLOPODA
LEPIDOPTERA
GASTROPODA
CHILOPODA

Figure 3

percent of the total weight, of which Tendipedid larvae and pupae accounted for 27 percent of the aquatic food weight and 15 percent of the total weight (Appendix table 1). Aquatic Diptera, especially Tendipedids, and Ephemeroptera, were present in fish stomachs throughout the entire fish sampling period. Ephemeroptera nymphs constituted 25 percent of the aquatic food weight and 14 percent of the total weight. Trichoptera larvae contributed 10 percent of the aquatic food weight and six percent of the total weight appearing mainly in 1/ age fish during the spring of 1960. Although Coleoptera comprised nearly 10 percent of the total weight, aquatic Coleoptera accounted for less than two percent of the aquatic food weight and less than one percent of the total weight. Aquatic Annelida, which were present in fish stomachs only during periods of disturbed stream conditions, amounted to 13 percent of the aquatic food weight and seven percent of the total weight. Other non-insect food groups of aquatic habitats were Gammarids, Gastropods and fish eggs, which collectively comprised less than two percent of the aquatic food weight. Aquatic aerial items accounted for six percent of the total weight. Aerial adults of Diptera, Trichoptera and Plecoptera accounted for 43, 38 and 13 percent respectively of the weight of aquatic aerial items and occurred mostly during the summer.

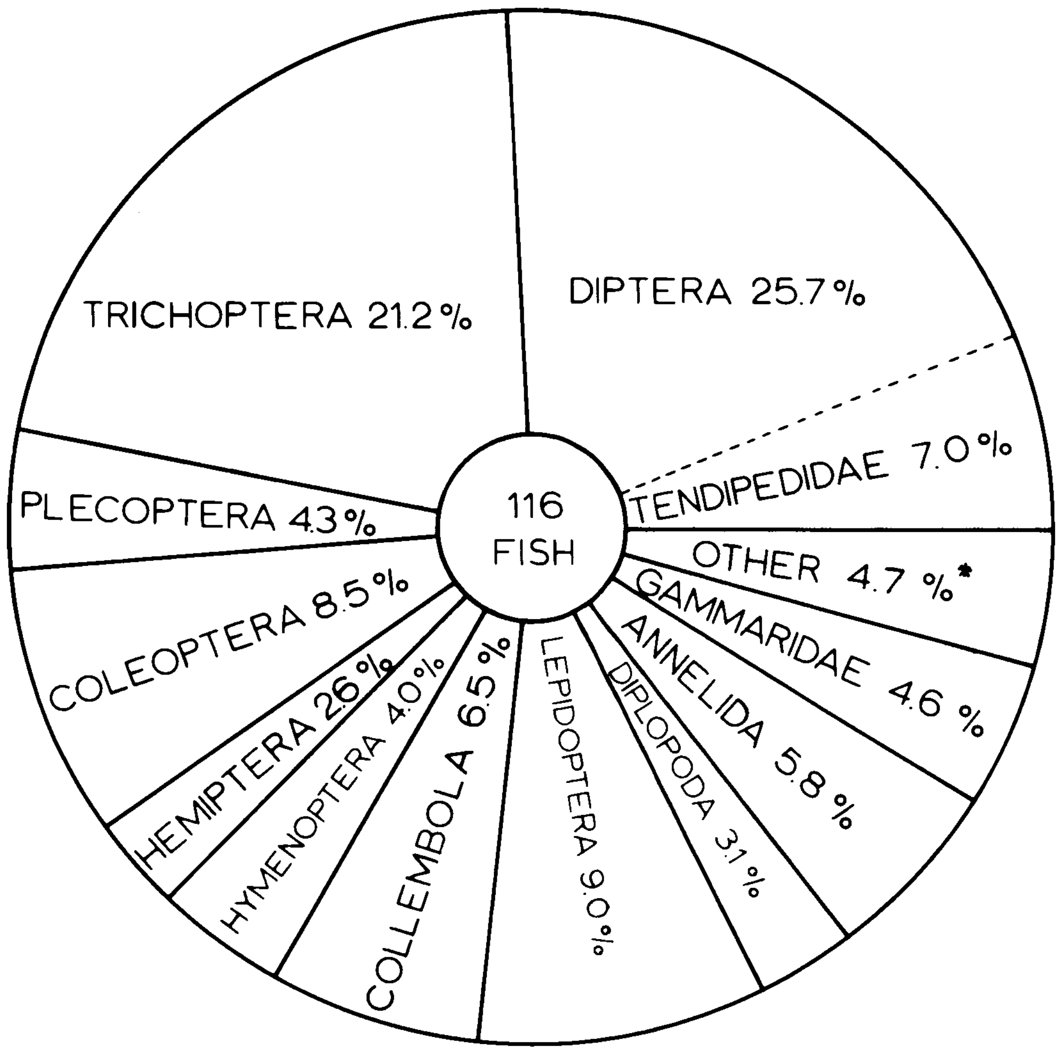
Terrestrial food items amounted to 34 percent of the total weight. Diptera, the most important group, accounted for 38 percent of the terrestrial food weight and 13 percent of the total weight. They occurred mostly during the early spring months and were probably Cecidomyiidae larvae. Coleoptera, which constituted 23 percent of the terrestrial food weight and eight percent of the total weight were mostly Staphylinids and Chrysomelids and occurred during the early spring and summer months. Other terrestrial food items were Arachnida and Collembola which accounted for 15 and 10 percent respectively of the terrestrial food weight and 5 and 4 percent respectively of the total weight. Collembola occurred throughout the fish sampling period, but Arachnida were present from early spring to early fall. Food items of uncertain habitats accounted for four percent of the total weight and were mostly Diptera, which comprised three percent of the total weight.

Taxonomically, Diptera was the most important food group in terms of dry weight, comprising approximately 43 percent of the total weight and occurring in 88 percent of the coho examined (figures 1 and 2 and Appendix table 4). Of the Diptera, Tendipedidae larvae and pupae constituted 15 percent of the total weight and occurred in 78 percent of the fish examined. The order Ephemeroptera comprised 14 percent of the total weight and occurred in 46 percent of the young coho; Coleoptera were nine percent of the total weight and occurred in 13 percent of the stomachs examined; Trichoptera accounted for eight percent of the total weight and occurred in 11 percent of the fish stomachs examined.

Flynn Creek

Aquatic food items in Flynn Creek accounted for 53 percent of the total dry weight (Appendix table 2). Terrestrial food items comprised 31 percent while aquatic aerial items and food items of uncertain habitats each constituted eight percent. Trichoptera larvae and pupae were the most important aquatic items accounting for nearly 38 percent of the aquatic food weight and 20 percent of the total weight. They were utilized by larger coho in the early spring months. Aquatic Diptera, which were next in importance, made up 28 percent of the aquatic food weight and 15 percent of the total weight, of which Tendipedid larvae and pupae comprised 12 percent of the aquatic food weight and six percent of the total weight. Aquatic Diptera, particularly the Tendipedids, were present in fish stomachs throughout the sampling period. Plecoptera nymphs and Corixidae each comprised five percent of the aquatic food weight and collectively constituted six percent of the total weight. They were present in fish stomachs mainly during the spring months as were Ephemeroptera nymphs which comprised three percent of the aquatic food weight and two percent of the total weight. Non-insect food items of aquatic habitats were Annelida and Gammaridae which accounted for 11 and 9 percent respectively

COHO STOMACH CONTENTS, FLYNN CREEK,
JUNE 20, 1959 TO JUNE 15, 1960



* EPHEMEROPTERA	2.0 %	GASTROPODA	0.3 %
ARACHNIDA	1.9 %	DETRITUS	0.3 %
HOMOPTERA	0.2 %		

PERCENT OF TOTAL DRY WEIGHT

Figure 4

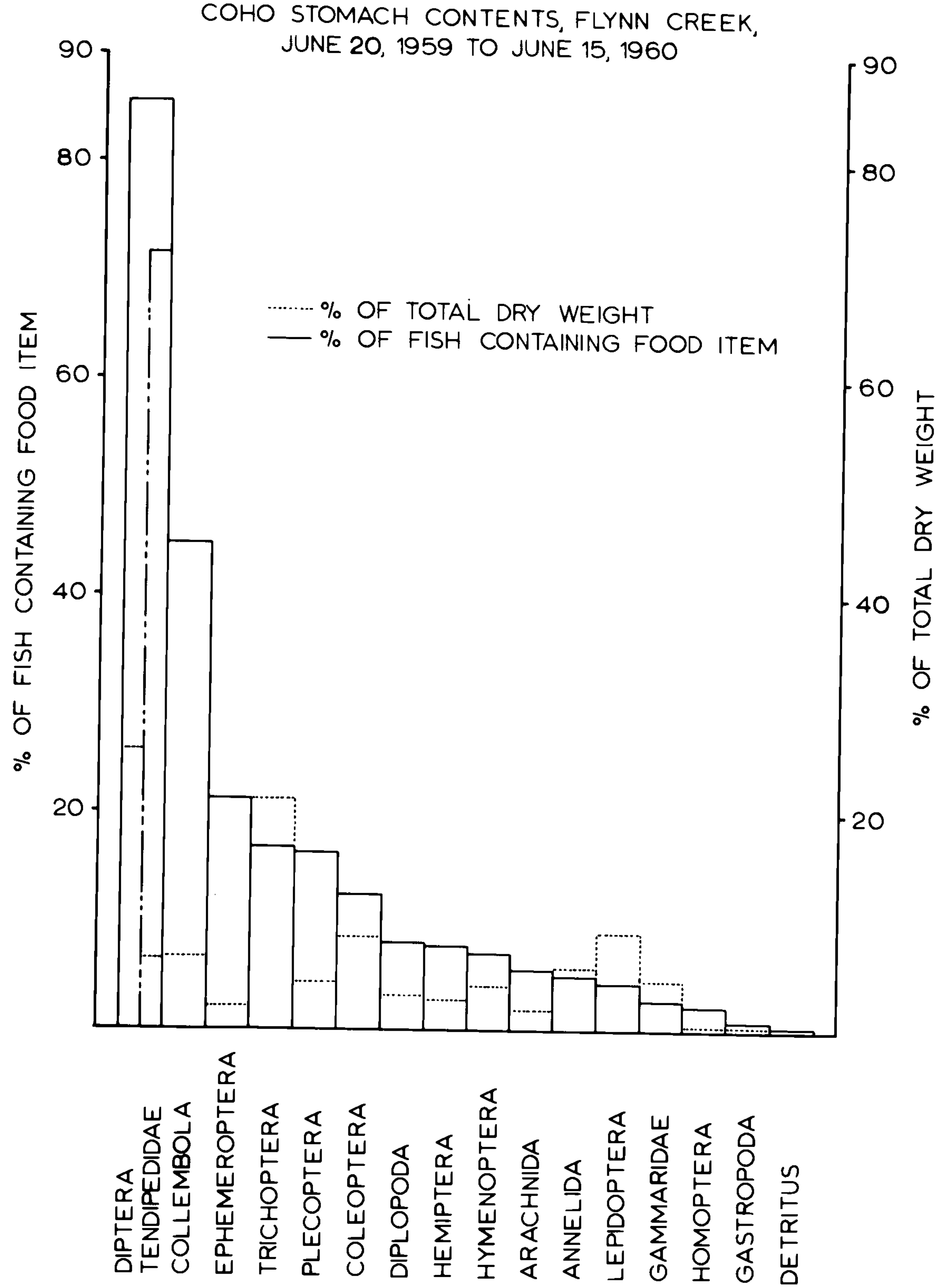

COHO STOMACH CONTENTS, FLYNN CREEK,
JUNE 20, 1959 TO JUNE 15, 1960
% OF TOTAL DRY WEIGHT
% OF FISH CONTAINING FOOD ITEM
% OF FISH CONTAINING FOOD ITEM
% OF TOTAL DRY WEIGHT
90
80
60
40
20
DIPTERA
TENDIPEDIDAE
COLLEMBOLA
EPHEMEROPTERA
TRICHOPTERA
PLECOPTERA
COLEOPTERA
DIPLOPODA
HEMIPTERA
HYMENOPTERA
ARACHNIDA
ANNELIDA
LEPIDOPTERA
GAMMARIDAE
HOMOPTERA
GASTROPODA
DETRITUS

Figure 5

of the aquatic food weight and 6 and 5 percent respectively of the total weight. They were present in fish stomachs during the early spring following a freshet period. Aquatic aerial items accounted for only eight percent of the total weight and were composed mainly of Diptera which comprised 57 percent by weight of the aquatic aerial items and four percent of the total weight and occurred during the summer months as did Plecoptera and Trichoptera which made up 20 and 17 percent respectively by weight of aquatic aerial items and two percent of the total weight.

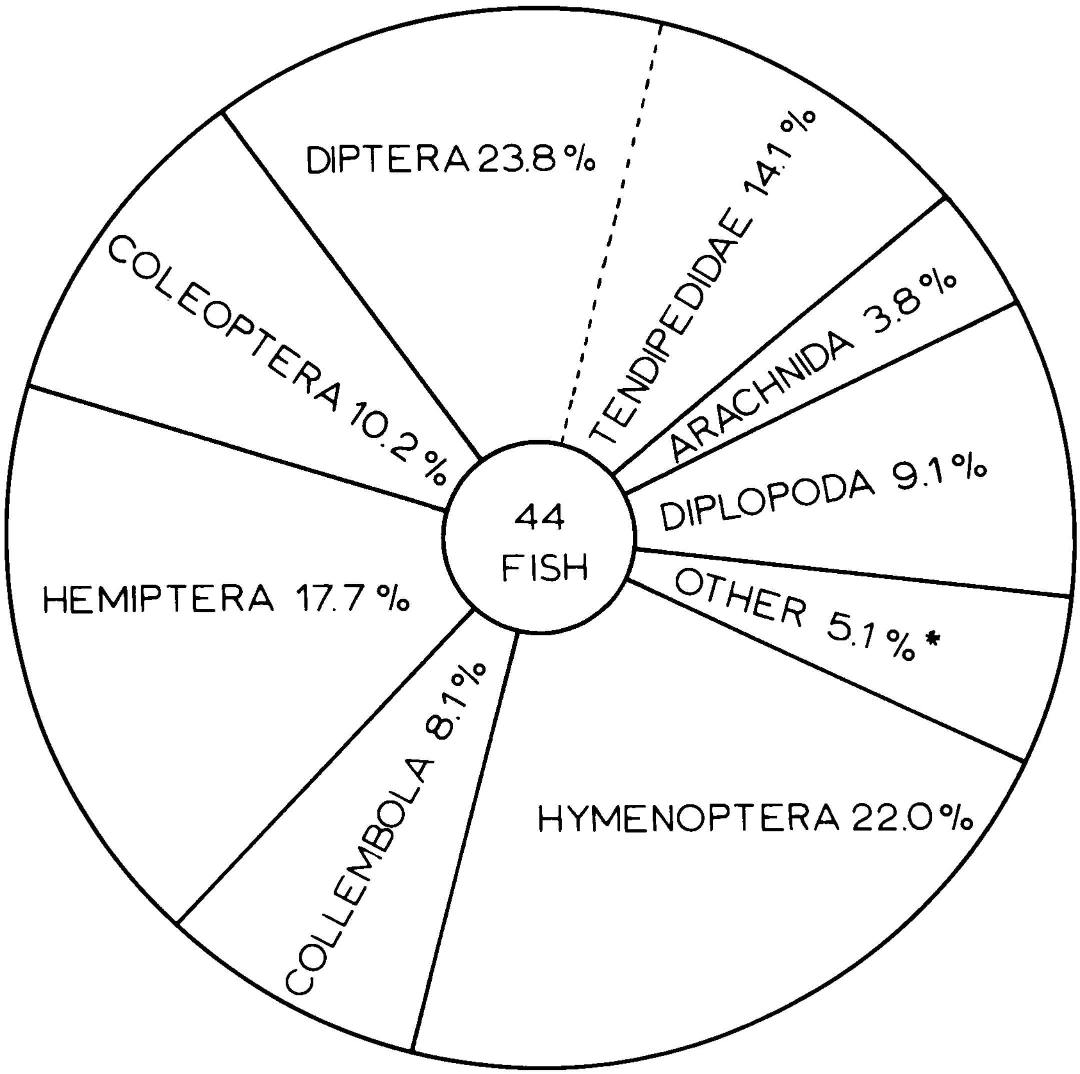
Terrestrial food items in Flynn Creek amounted to 31 percent of the total weight. Lepidoptera larvae, which occurred only during the spring months, accounted for 29 percent of the terrestrial food weight and nine percent of the total weight. Collembola amounted to 21 percent of the terrestrial food weight and seven percent of the total weight and were present in stomachs throughout the fish sampling period. Coleoptera and Diptera comprised 18 and 13 percent respectively of the terrestrial food weight and 6 and 4 percent respectively of the total weight and were present in fish stomachs from spring to fall. Diplopoda and Arachnida were present mostly during the summer months and accounted for 10 and 6 percent respectively of the terrestrial food weight, but together comprised only five percent of the total weight. Food items of uncertain habitats accounted for eight percent of the total weight. Hymenoptera accounted for 43 percent by weight of this category and four percent of the total weight. Diptera and Coleoptera accounted for 29 and 27 percent respectively by weight of food items of uncertain habitats and collectively comprised four percent of the total weight.

Taxonomically, Diptera was the primary food group, accounting for 26 percent of the total weight and occurring in 85 percent of the coho (figures 4 and 5 and Appendix table 4). Of Diptera, Tendipedids comprised seven percent of the total weight and occurred in 72 percent of the fish. Trichoptera amounted to 21 percent of the total weight and occurred in 17 percent of the fish. Lepidoptera was third in order of importance, accounting for nine percent of the total weight and occurring in 12 percent of the coho.

Needle Branch

Aquatic food items in Needle Branch accounted for 26 percent of the total weight (Appendix table 3). The other categories were terrestrial food items, 30 percent; aquatic aerial items, five percent; and food items of uncertain habitats, 39 percent. Aquatic Diptera accounted for 58 percent of the aquatic food weight and 15 percent of the total weight. Diptera, and especially Tendipedidae which amounted to 38 percent of the aquatic food weight and 10 percent of the total weight, occurred in fish stomachs throughout the sampling

COHO STOMACH CONTENTS, NEEDLE BRANCH, MAY 13, 1959 TO FEBRUARY 20, 1960



* EPHEMEROPTERA 1.8 %
TRICHOPTERA 2.1 %
PLECOPTERA 0.6 %
HOMOPTERA <0.1 %
DETRITUS 0.6%

PERCENT OF TOTAL DRY WEIGHT

Figure 6

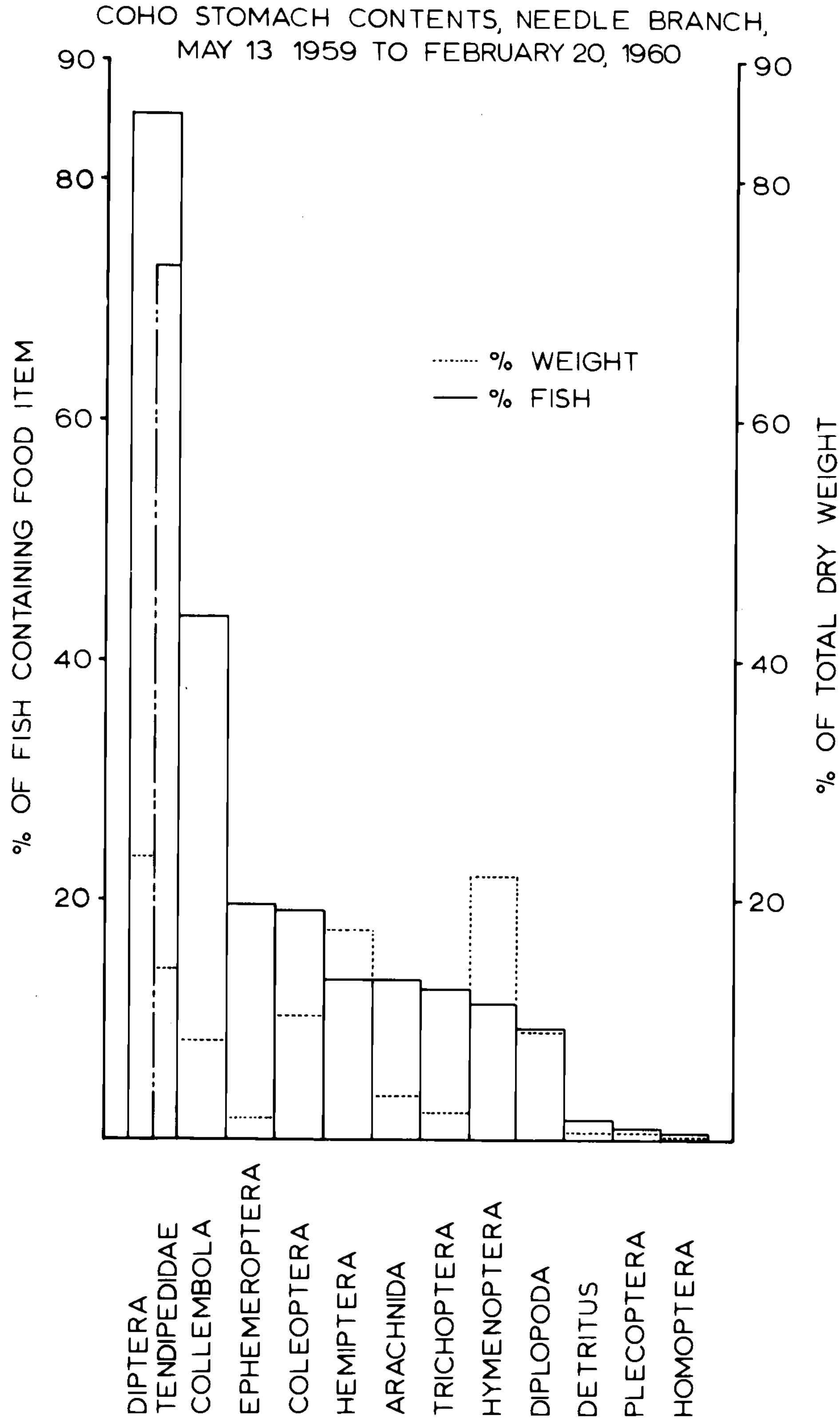

COHO STOMACH CONTENTS, NEEDLE BRANCH,
MAY 13 1959 TO FEBRUARY 20, 1960
% OF FISH CONTAINING FOOD ITEM
% OF TOTAL DRY WEIGHT
% WEIGHT
% FISH
20
40
60
80
90
DIPTERA
TENDIPEDIDAE
COLLEMBOLA
EPHEMEROPTERA
COLEOPTERA
HEMIPTERA
ARACHNIDA
TRICHOPTERA
HYMENOPTERA
DIPLOPODA
DETRITUS
PLECOPTERA
HOMOPTERA

Figure 7

period as did Ephemeroptera which made up seven percent of the aquatic food weight, but only two percent of the total weight. Gerridae nymphs, Dytiscidae, and Trichoptera larvae accounted for 16, 11 and 8 percent respectively of the aquatic food weight and together comprised nine percent of the total weight. They were present in fish stomachs during the summer months. Aquatic aerial items accounted for five percent of the total weight. They were composed mainly of Diptera and Plecoptera which comprised 87 and 13 percent respectively of the weight of aquatic aerial items. They occurred in fish stomachs during the summer months.

Terrestrial food items in Needle Branch accounted for 30 percent of the total weight. Diplopoda and Arachnida comprised 31 and 13 percent respectively of the terrestrial food weight and 9 and 4 percent respectively of the total weight. Diplopoda were present only during the early spring months and Arachnida were encountered during the summer months. Terrestrial insects were: Collembola, which made up 27 percent of the terrestrial food weight and eight percent of the total weight; Hymenoptera, 16 percent of the terrestrial food weight and five percent of the total weight; and Coleoptera, 10 percent of the terrestrial food weight and three percent of the total weight. Collembola were present in fish stomachs throughout the sampling period, but Hymenoptera and Coleoptera occurred mostly during the late summer months. Food items of uncertain habitats accounted for

39 percent of the total weight. They were mostly Hymenoptera, which were probably of terrestrial origin and accounted for 44 percent of the weight of food items of uncertain habitats and 17 percent of the total weight. Homoptera and Hemiptera comprised 35 percent of this category and 14 percent of the total weight. Hymenoptera and Homoptera-Hemiptera were probably of terrestrial origin. Other items in this category were Coleoptera and Diptera which accounted for 11 and 10 percent respectively by weight of food items of uncertain habitats and four percent each of the total weight.

Taxonomically, Diptera was the most important food group, accounting for 24 percent of the total weight and occurring in 84 percent of the coho. Tendipedids comprised 10 percent of the total weight and occurred in 70 percent of fish examined. Hymenoptera amounted to 22 percent of the total weight and occurred in 14 percent of the fish. Other food items of importance included Homoptera and Hemiptera which collectively comprised 18 percent of the total weight and occurred in 14 percent of the fish. Coleoptera accounted for 10 percent of the total weight and occurred in 22 percent of the fish.

Coho Stomach Analyses for the Summer Months of 1959

Approximately half the fish stomach samples (Deer Creek, 45; Flynn Creek, 40; and Needle Branch, 29) were collected during the summer months when stream flows were minimum and vegetative cover maximum. Feeding patterns of coho differed between the three streams with respect to percentage weights of aquatic and terrestrial food items as follows: Deer Creek, aquatic items 57 percent, terrestrial items 21 percent; Flynn Creek, aquatic items 30 percent, terrestrial items 29 percent; and Needle Branch, aquatic items 27 percent, terrestrial items, 40 percent. Collectively, aquatic aerial items and food items of uncertain habitats were Deer Creek, 22 percent; Flynn Creek, 41 percent; and Needle Branch, 33 percent (Appendix tables 6, 7 and 8).

Results of coho stomach analyses for the summer period, which extended from May through September in Deer Creek and Needle Branch and from June through September in Flynn Creek, are further discussed separately by streams.

Deer Creek. Aquatic items accounted for 57 percent of the total weight in Deer Creek during the summer period. Aquatic dipterous larvae and pupae comprised 29 percent of the total weight and Ephemeroptera nymphs amounted to 21 percent. Trichoptera larvae and Plecoptera nymphs comprised five percent of the total weight. Aquatic aerial items accounted for nine percent of the total weight and were mostly Diptera, which amounted to eight percent of the total weight.

Terrestrial food items in Deer Creek comprised 21 percent of the total weight during the summer period. Insects of terrestrial origin were: Collembola, two percent; Aphids, three percent; Coleoptera and Diptera, two percent. Diplopoda and Arachnida comprised 13 percent of the total weight, 10 percent of which was attributed to Diplopoda. Food items of uncertain habitats accounted for 12 percent of the total weight and were composed mostly of Diptera which made up eight percent.

Taxonomically, Diptera in Deer Creek accounted for 47 percent of the total weight, of which 14 percent was attributed to Tendipedids. Ephemeroptera comprised 21 percent of the total weight. Diplopoda, which was next in importance, amounted to 10 percent of the total weight.

Flynn Creek. Aquatic items in Flynn Creek accounted for 30 percent of the total weight, composed mainly of aquatic dipterous larvae and pupae, which made up 16 percent of the total weight, and Trichoptera larvae, which accounted for nearly five percent of the total weight (Appendix table 7). Plecoptera nymphs amounted to seven percent of the total weight. Aquatic aerial items comprised 25 percent of the total weight and were represented by Diptera and Trichoptera which accounted for 21 and 4 percent respectively of the total weight.

Terrestrial food items comprised 29 percent of the total weight. Diplopoda, which was most important, accounted for seven percent of the total weight. Other terrestrial organisms utilized were: Diptera, six percent; Coleoptera, four percent; Hymenoptera, three percent; and Collembola, two percent. Food items of uncertain habitats amounted to 16 percent of the total weight to which Hymenoptera, Coleoptera, and Diptera each contributed approximately five percent.

Taxonomically, Diptera in Flynn Creek accounted for 50 percent of the total weight of food items during the summer months. Coleoptera, which was next in importance, comprised 10 percent of the total weight. Trichoptera accounted for nearly nine percent of the total weight and Hymenoptera comprised eight percent.

Needle Branch. In Needle Branch, aquatic items accounted for 27 percent of the total weight and were composed mostly of Diptera and Homoptera-Hemiptera which made up 11 and 8 percent respectively of the total weight (Appendix table 8). Collectively, Ephemeroptera nymphs, Trichoptera larvae and aquatic Coleoptera comprised seven percent of the total weight. Aquatic aerial items comprised 15 percent of the total weight and were composed mostly of Diptera, which accounted for 14 percent of the total weight.

Terrestrial items in Needle Branch comprised 40 percent of the total weight. Hymenoptera and Coleoptera each accounted for nine percent of the total weight, followed by Collembola which amounted to seven percent of the total weight. Diplopoda and Arachnida made up 13 percent of the total weight, of which eight percent was attributed to Diplopoda. Food items of uncertain habitats accounted for 19 percent of the total weight of which Homoptera-Hemiptera, Coleoptera and Diptera each contributed approximately six percent.

Taxonomically, Diptera in Needle Branch amounted to 31 percent of the total weight during the summer period. Coleoptera and Homoptera-Hemiptera were next in importance and accounted for 17 and 14 percent respectively of the total weight. Hymenoptera and Collembola comprised 10 and 7 percent respectively of the total weight.

Seasonal Fluctuations of Aquatic and Terrestrial Food Items

Since fish of a single year class were not sampled throughout the entire period of stream life (usually 12 to 15 months from March until March and April of the following year) data compiled from fish stomach analyses in Deer Creek and Flynn Creek were arranged to form a history span from emergence to seaward migration. This was accomplished by assuming that newly emerged fish of the 1960 year class during March and April had feeding habits similar to newly emerged fish of the 1959 year class which were not sampled. Inasmuch as sample size in Needle Branch was limited to only three fish per month after September, only the period from May through September will be discussed. Percentage weights of terrestrial food items are the complement of the percentage weights of aquatic items (Appendix table 5).

In Deer Creek from April to July 1960, young coho fed predominately on aquatic items, the percentage weight of aquatic items being greater than 60 percent (figure 8). During July the percentage weight of aquatic items decreased from 72 percent to eight percent. Stream flows during this period were stable. Aquatic items in August increased to 83 percent. From August to December 1959 the percentage weight of aquatic items decreased from 83 to 35 percent except for a slight increase from 72 to 82 percent in late September apparently resulting from the first fall freshet. From January through March 1960 the percentage weight of aquatic items was greater than 90 percent which was apparently due to freshets and lack of terrestrial food items.

Similar to Deer Creek, newly emerged fish in Flynn Creek fed predominately on aquatic items except for fish collected in March from slowly moving water whose stomachs contained mostly Collembola. In early July the percentage weight of aquatic items decreased from 100 percent to 17 percent in the latter part of the month and by September had increased to 60 percent. Following a freshet in late September the percentage weight of aquatic items increased to 82 percent in October. In January 1960 the percentage weight of aquatic items had increased from 45 percent in November to 93 percent. Unlike Deer Creek where the percentage weight of aquatic food items exceeded 90 percent in both February and March 1960, the percentage weight of aquatic items in Flynn Creek during February and March was 50 and 48 percent respectively. In April the percentage weight of

COHO STOMACH CONTENTS

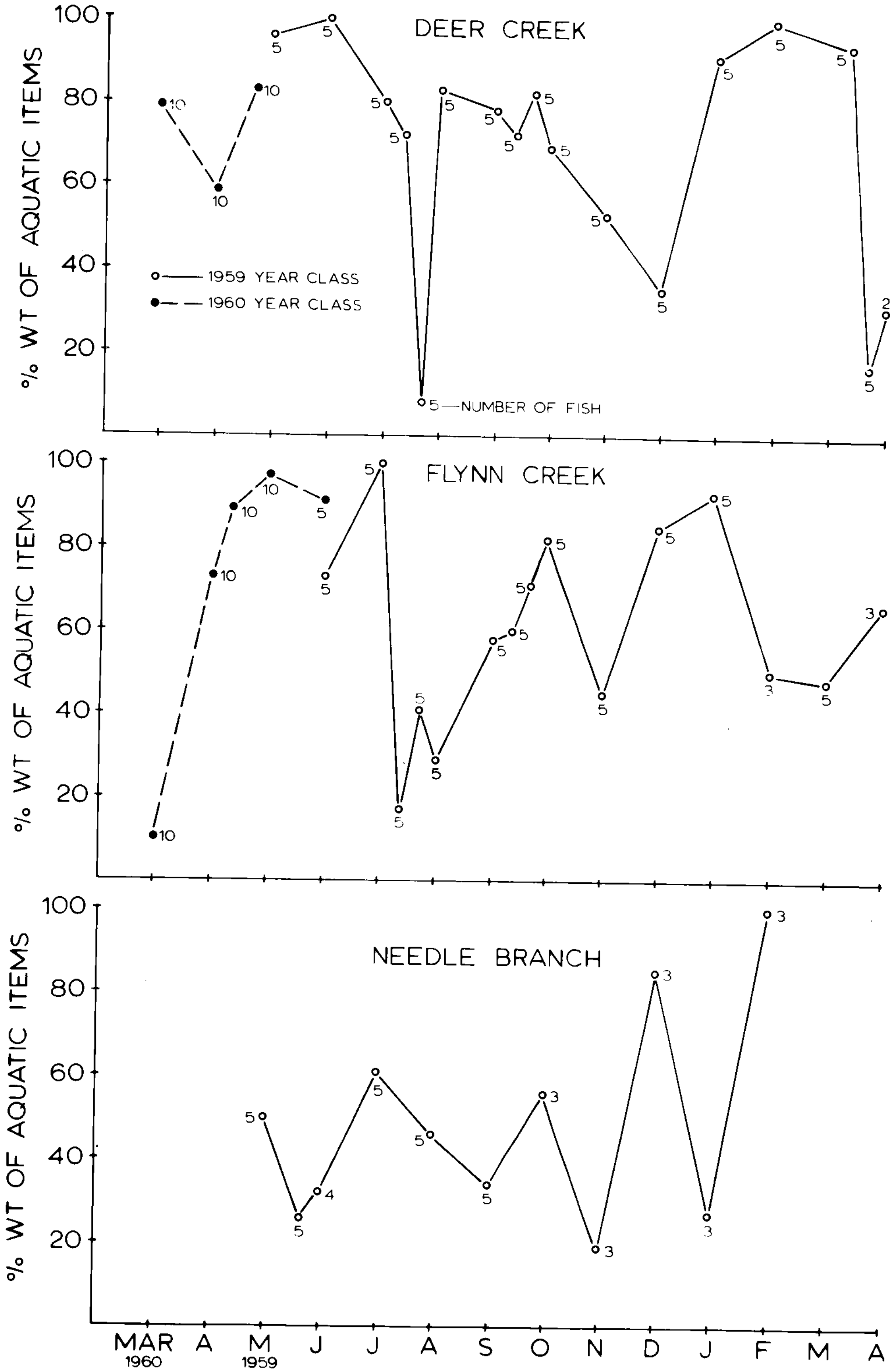


Figure 8

aquatic items was 66 percent.

In Needle Branch from May through September 1959 the maximum percentage weight of aquatic items was 61 percent occurring in early July. This peak was reached after increasing from 26 percent in May. In September the percentage weight of aquatic items was 34 percent following a steady decline from 61 percent in July.

RESULTS OF INSECT STOMACH ANALYSES

It was determined by the first six months of fish sampling that Baetidae nymphs and Tendipedidae larvae were the chief food items represented in stomachs of young coho. Two undetermined species of the genus *Baetis* occurred most often in fish stomachs. Of Tendipedidae, larvae of several undetermined species of the subfamily Hydrobaeninae predominated in fish stomachs. In addition to *Baetis* nymphs and Hydrobaenid larvae, a second mayfly nymph, *Paraleptophlebia*, was chosen for stomach analyses because it was the dominate Baetid nymph in the three study streams. The probable species was *P. debilis* (Walker).

Algae contained in insect stomachs from November 1959 to October 1960 were almost entirely diatoms. The most common genera were *Cocconeis* and *Navicula*. In addition to diatoms, considerable amounts of algae contained in insect stomachs from Needle Branch were *Chamaesiphon* sp., a blue-green algae. Stomachs of *Baetis* nymphs collected in the canyon portion of Deer Creek contained considerable quantities of *Protoderma* sp., a green algae. The canyon portion also had considerable quantities of moss, but this material was easily discernable in insect stomachs upon microscopic examination. Since insect stomach contents were classed only as algae or detritus, results are discussed in terms of algae only; percentages of detritus are, in all cases, the complement of the percentages of algae.

Generally, feeding habits of the insects as indicated by stomach analyses, followed a definite seasonal pattern since proportions of algae in stomachs of insects were greatest during spring and early summer and least during summer and late fall. Results of stomach analyses of 634 Baetis nymphs, 907 Paraleptophlebia nymphs and 632 Hydrobaenid larvae are presented graphically in figures 9 and 10 and are discussed separately by insects.

Baetis nymphs

In the meadow portion of Deer Creek, stomachs of 290 Baetis nymphs contained a mean algal content of nearly 70 percent (Appendix table 9). From November 1959 to May 1960, the mean proportion of algae in stomachs of Baetis nymphs increased from 20 percent to nearly 95 percent then declined to 50 percent in August. However, sample size in August was only two specimens, too few for accurate interpretation. A second peak of about 80 percent was reached in September, and in October when sampling was terminated the mean proportion of algae was approximately 40 percent. Stomachs of 124 Baetis nymphs collected from May to October 1960 in the canyon portion of Deer Creek contained a mean proportion of algae of nearly 90 percent. The peak in September was nearly 100 percent and by October, when sampling was terminated, had declined to 65 percent (Appendix

INSECT STOMACH CONTENTS, DEER CREEK, NOVEMBER 16, 1959 TO OCTOBER 18, 1960

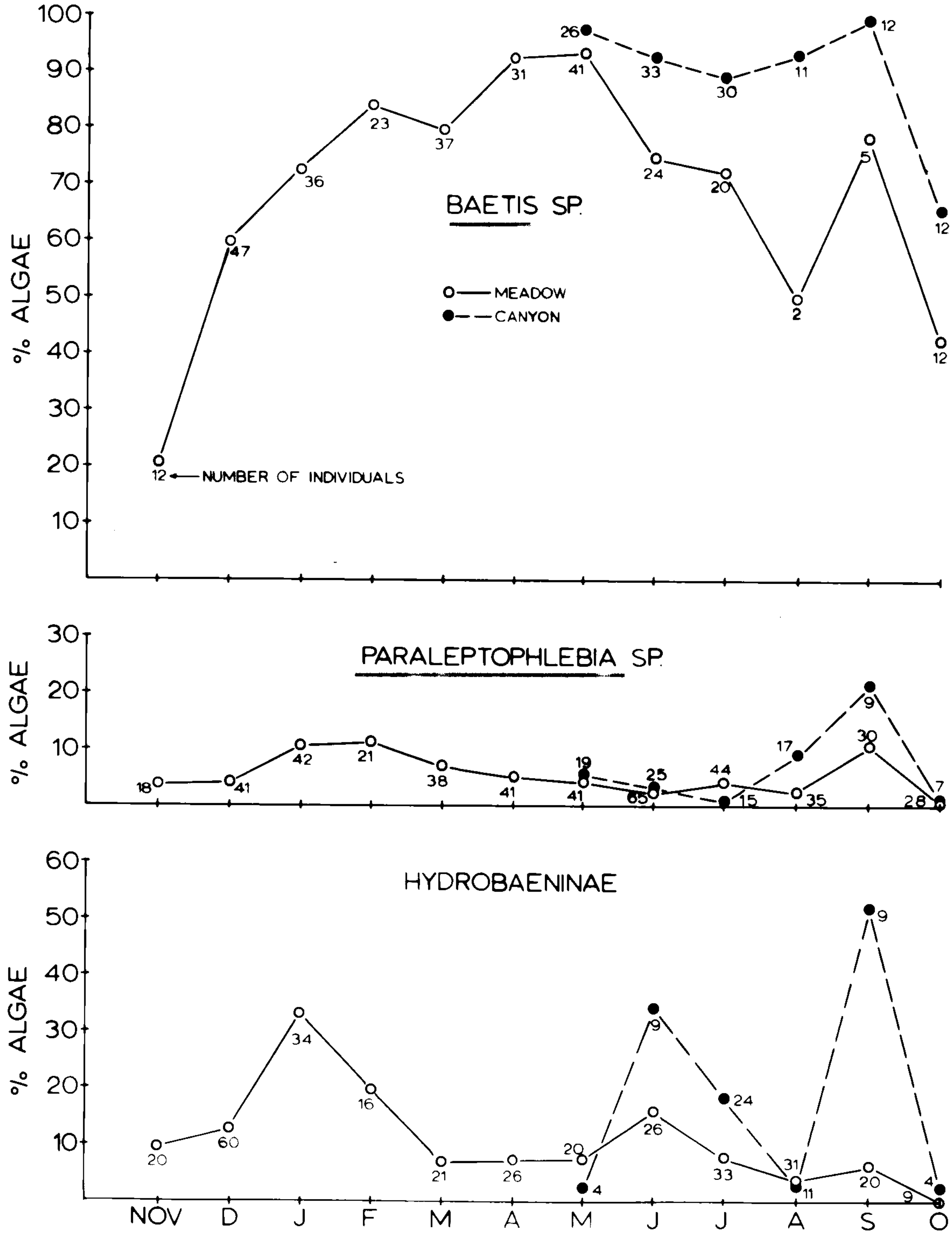


Figure 9

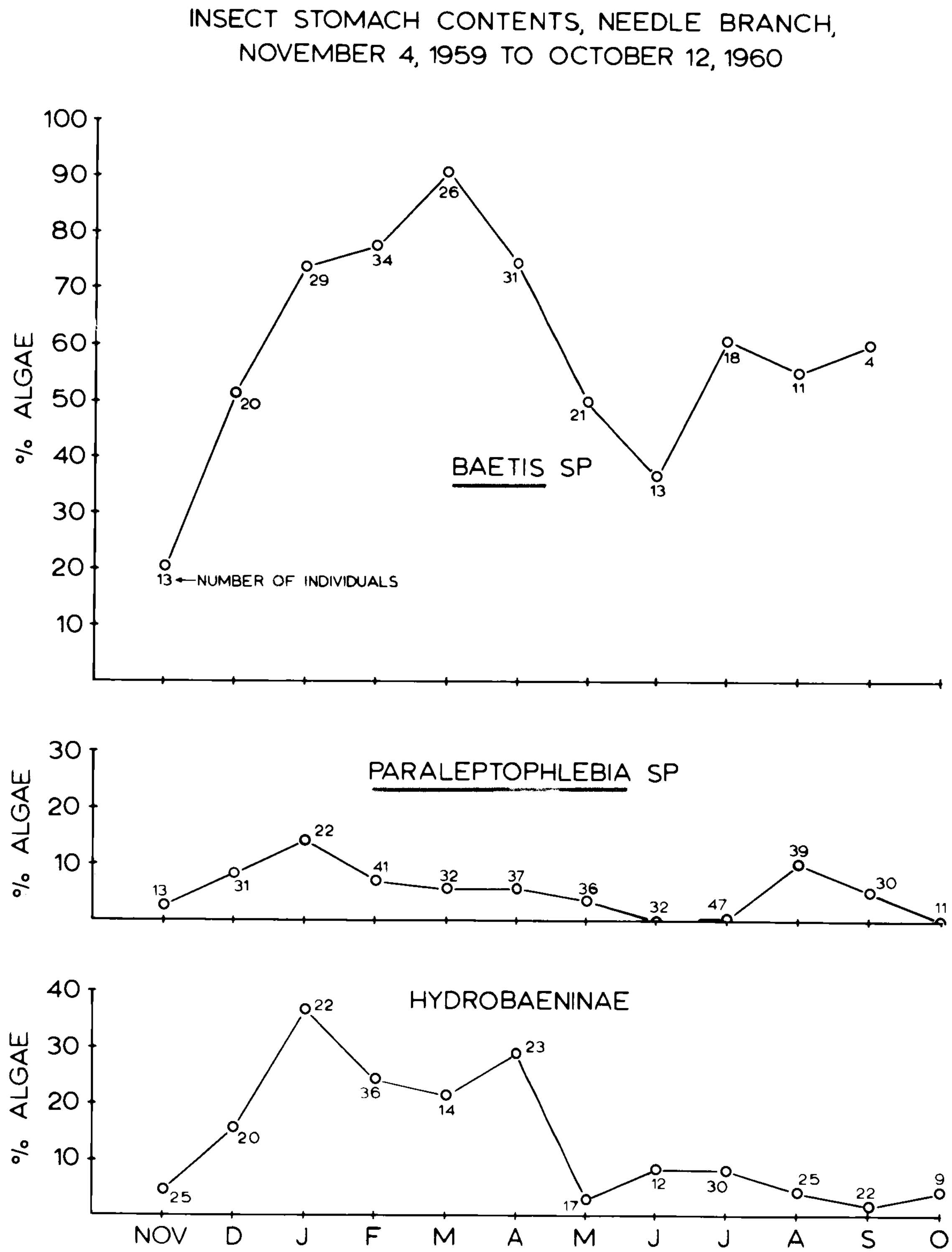

INSECT STOMACH CONTENTS, NEEDLE BRANCH,
NOVEMBER 4, 1959 TO OCTOBER 12, 1960
% ALGAE
BAETIS SP
13 ←NUMBER OF INDIVIDUALS
PARALEPTOPHLEBIA SP
HYDROBAENINAE
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Figure 10

table 9).

In Needle Branch, the mean contents of algae in stomachs of 222 Baetis nymphs was about 55 percent (Appendix table 10). From November 1959 to March 1960 the mean proportion of algae increased from 20 percent to 90 percent, then decreased to about 35 percent in June 1960. In July, August and September the mean proportion of algae in stomachs of Baetis nymphs was about 60 percent.

Paraleptophlebia nymphs

Results from stomach analyses of 536 Paraleptophlebia nymphs from Deer Creek and 371 from Needle Branch indicated that these nymphs fed predominately on detritus (figures 9 and 10). The mean proportions of algae in stomachs of Paraleptophlebia nymphs was about five percent in both portions of Deer Creek and in Needle Branch. In the meadow portion of Deer Creek the maximum proportions of algae in stomachs of Paraleptophlebia nymphs were approximately 10 percent occurring in January and September. During the summer the mean proportion of algae was less than five percent. In the canyon portion of Deer Creek, the maximum proportion of algae in stomachs was 20 percent, occurring in September. Except for the peak in September, the mean proportions of algae in stomachs of these nymphs from the canyon portion were generally less than five percent.

In Needle Branch the maximum proportions of algae in stomachs of _Paraleptophlebia_ nymphs were 5 and 10 percent respectively and occurred in January and August. During the summer months, except for August, the mean proportions of algae were generally less than five percent.

Hydrobaeninae Larvae

Similar to _Paraleptophlebia_, 377 Hydrobaenid larvae from Deer Creek and 255 from Needle Branch were predominately detritus feeders, the mean proportions of algae being 10 and 20 percent respectively for the meadow and canyon portions of Deer Creek and nearly 15 percent in Needle Branch (Appendix tables 9 and 10). In the meadow portion of Deer Creek the period of most intensive algal feeding occurred during January 1960, when the mean proportion of algae in stomachs of these larvae was approximately 35 percent (figure 9). The peak in January was followed by a decline which ended in March at about 10 percent and, except for a slight rise to nearly 15 percent in June, the mean contents of algae were 10 percent or less until sampling was terminated. In the canyon portion of Deer Creek, two peaks in algal feeding occurred; one in June of 35 percent and one in September of 50 percent.

In Needle Branch, the mean proportion of algae in stomachs of 255 Hydrobaenid larvae was nearly 15 percent (Appendix table 10). Two distinct levels of algal feeding were apparent for these larvae in Needle Branch; an upper level which, on the average, was approximately 20 percent, occurring from November 1959 through April 1960, and a lower level which, on the average, was approximately five percent and occurred from May to October 1960 (figure 10).

Influence of Bottom Types on Insect Feeding Habits

As was noted in the section on methods and procedures, bottom types were divided into five main groups. In the meadow portion of Deer Creek, stomachs of *Baetis* nymphs collected from gravel and pea-gravel bottom types contained a greater proportion of algae than did stomachs of those nymphs collected from rubble, sand and silt bottom types. Mean proportions of algae in stomachs of *Baetis* nymphs from gravel and pea-gravel in the meadow portion of Deer Creek were approximately 70 and 65 percent respectively (Appendix table 11). The mean proportions of algae in stomachs of *Baetis* nymphs from rubble and sand bottom types in the meadow portion of Deer Creek were about 55 and 45 percent respectively. From May to October 1960, mean proportions of algae in stomachs of *Baetis* nymphs from rubble bottoms in the canyon portion of Deer Creek were nearly 90 percent, and in the meadow portion approximately 60 percent. This difference of 30 percent was probably due to the absence of over-head cover from most of the canyon portion allowing more light for algal production. The mean proportions of algae in stomachs of

Baetis nymphs from pea-gravel and sand bottom types in the canyon portion were 65 and 30 percent respectively.

In Needle Branch samples, the mean algae content in stomachs of *Baetis* nymphs collected from sand bottom types was about 55 percent and in stomachs of *Baetis* nymphs from gravel and pea-gravel bottom types was approximately 50 and 40 percent respectively (Appendix table 12). Rubble bottom types were absent from Needle Branch sampling stations.

In the meadow portion of Deer Creek the mean proportions of algae in stomachs of *Paraleptophlebia* nymphs were about five percent from both gravel and sand bottom types and in those nymphs collected from rubble and pea-gravel bottom types were less than five percent. Sample size from silt bottom types amounted to 17, too limited for interpretation (Appendix table 11). The mean proportion of algae in stomachs of *Paraleptophlebia* nymphs collected from rubble bottom types in the canyon portion was approximately 10 percent. Sample sizes from other bottom types collectively comprised 41, too few for accurate interpretation. In Needle Branch, stomachs of *Paraleptophlebia* nymphs from gravel, pea-gravel and sand contained mean proportions of algae of about five percent. Stomachs of those nymphs from silt contained about 10 percent algae.

Stomachs of Hydrobaenid larvae from the meadow portion of Deer Creek contained a mean proportion of algae of approximately five percent from gravel and sand bottom types. Stomachs of those larvae from rubble and pea-gravel bottom types contained a mean proportion of algae of less than five percent. Larvae collected from rubble bottom types in the canyon portion contained a mean of about 35 percent algae. The total sample size of larvae from silt bottom types in the meadow portion and from all bottom types except rubble in the canyon portion amounted to 48, too few for accurate interpretation (Appendix table 11).

In Needle Branch the mean proportions of algae in stomachs of Hydrobaenid larvae were about 15 percent from gravel and pea-gravel bottom types. Stomachs of those larvae collected from sand and silt bottom types contained means of about 10 and 5 percent algae respectively.

DISCUSSION

Results from fish stomach analyses indicated that availability of food organisms and their relative sizes influenced the numbers and kinds of food organisms ingested. These factors in combination resulted in an abundance of midge larvae and small mayfly nymphs of the genus Baetis in coho stomachs and a relative scarceness of large Plecoptera nymphs and large case-bearing Trichoptera.

Tendipedidae in the three streams occurred in 70 percent or more of the young coho. Ephemeroptera nymphs were present in 46 percent of the Deer Creek coho sampled, but in about 20 percent of the Flynn Creek and Needle Branch coho. Collembola in Deer Creek were present in 26 percent of the fish sampled, but occurred in about 43 percent of the Flynn Creek and Needle Branch coho. Midge larvae, mayfly nymphs and Collembola occurred more often in 0/ age fish of 40 to 60 millimeters in length than in 1/ age fish of 60 to 95 millimeters in length. Trichoptera larvae, which occurred in a maximum of 16 percent of the fish, were found mostly in stomachs of 1/ age fish. Lepidoptera larvae, which occurred in only four percent of the fish, were present in 1/ age fish during the spring of 1960.

Since young coho normally spend but one year in fresh water, they seldom attain a size greater than 100 millimeters and are usually unable to utilize some invertebrates such as large stonefly nymphs or large case-bearing Trichoptera larvae. Consequently, coho in the three study streams were more dependent on smaller organisms such as midge larvae, small mayfly nymphs and Collembola. Allen (1, p. 50-59) working with juvenile Atlantic salmon, Salmo salar (Linneaus), in some English streams, observed that 0/ age fish selected smaller organisms than did 1/ age fish. White (8, p. 500-505), working with the same species in Eastern Canada, showed similar results.

Observations made in glass-walled aquaria through which a portion of Deer Creek was diverted indicated that, because of clinging powers, mayfly nymphs of the genus Epeorus were not readily available as fish food. Nymphs dropped in the aquaria were immediately seized by coho of about 60 millimeters in length, but only smaller nymphs of 3 and 4 millimeters in length were swallowed. Larger Epeorus nymphs 8 to 10 millimeters in length clung to the jaws of the coho and, in several cases, the fish were unable to swallow or reject the larger nymphs unless the grasp of the larvae was broken or given up voluntarily. Another situation causing rejection of prey by coho occurred in Deer Creek when an adult Tabanid 12 millimeters in length was dropped on the surface of a pool. It was immediately seized by fish of 50 to 60 millimeters in length, but because of its bulk was never swallowed.

The above observations are in general supported by work done by Hartman (5, p. 233-234) in which he recorded that a combination of size and clinging power of prey caused young rainbow trout, Salmo gairdnerii (Richardson), to reject large stonefly nymphs and large Trichoptera larvae.

Paraleptophlebia nymphs were never observed to be too large for ingestion, but were present in coho stomachs mainly during late winter and early spring of 1960, a general freshet period. These nymphs were abundant in the three streams but rarely occurred in the coho diet, probably because of nocturnal behavior of the nymphs. Occurrences of Paraleptophlebia in coho diet might be attributed to dislodgement by freshets or increased availability due to lower light intensities. Baetis nymphs, which seemed to be preferential algal feeders and would thus have been on the upper surface of the bottom particles, should have been readily available to young coho at all seasons because of feeding location. Hydrobaenid larvae and Tendipedidae in general were readily available because of large numbers and small size. They might also have been an important constituent of organic drift as demonstrated by Müller (7, p. 139-142) in streams of Northern Sweden.

Freshets, which began in late September 1959, apparently caused an increase of aquatic food intake by young coho probably because increased flows dislodged aquatic organisms. In the early spring of 1960 new standing crops of aquatic insects, the lack of terrestrial organisms and freshets apparently resulted in the increase of aquatic food in the diets of young coho.

During the summer months, the percentage weight ratio of aquatic to terrestrial food items was 2.7 in Deer Creek, 1.0 in Flynn Creek and 0.7 in Needle Branch. Two conditions which might explain the differences in utilization of aquatic and terrestrial food items between Deer Creek and Needle Branch would be the ratio of stream area to canopy area and the amount of organic drift. Since the canopy over Deer Creek was sparse but that over Needle Branch was dense, the observed ratio of stream area to canopy area along Deer Creek was greater than the corresponding observed ratio of stream area to canopy area along Needle Branch. In other words, there was a greater chance in Needle Branch for terrestrial food items to fall into the stream than in Deer Creek; Flynn Creek was intermediate and more nearly like Needle Branch.

Observations in glass-walled aquaria on Deer Creek indicated that young coho fed almost entirely on organic drift even though benthic insects in the aquaria were plentiful. Since little or no surface flow occurred between pools in Needle Branch during late summer, this might help explain the small percentage weight ratio (0.7) of aquatic to terrestrial food items since organic drift would be greatly limited. In Deer Creek, and to some extent in Flynn Creek, surface flows between pools probably enabled organic drift to pass between pools even at low flows. This might partially explain the high percentage weight ratio of 2.7 in Deer Creek and the intermediate percentage weight ratio of 1.0 in Flynn Creek since inter-pool flows were greatest in Deer Creek, least in Needle Branch and intermediate in Flynn Creek.

Results from insect stomach analyses indicated that insect feeding habits were affected by seasonal availability of algae, light intensity and cover densities. The occurrence of of algae in stomachs of *Baetis* nymphs was apparently related to seasonal availability of algae. Mean proportions of algae were greatest during spring and least during summer and late fall (figures 9 and 10). Butcher (2, p. 269) showed in highly calcareous English streams that algae cell counts from glass slides increased steadily during the late fall and early winter, reaching a maximum in late spring, decreasing during the summer and increasing again in late summer and early fall. Although Deer Creek and Needle Branch were not calcareous, the seasonal occurrence of algae in stomachs of *Baetis* nymphs was, in general, quite similar to the seasonal occurrence of algae demonstrated by Butcher.

Availability of algae appeared to be limited because of decreased light intensity owing to densities of the overhead canopies; Needle Branch was shaded by a low, dense deciduous canopy and by Douglas fir which bounded the south side of the stream; the canopy over the meadow portion of Deer Creek was mainly deciduous, sparse and about 25 feet above stream level. When figures 9 and 10 showing percentages of algae in stomachs of _Baetis_ nymphs from Deer Creek and Needle Branch were superimposed, the monthly percentages from November 1959 to April 1960 were quite similar. The percentages averaged about 65 percent in Deer Creek and about 60 percent in Needle Branch, suggesting that availabilities of algae were similar. This, in turn, suggests that light levels were similar.

From May to August the monthly percentages of algae in stomachs of _Baetis_ nymphs in Deer Creek averaged about 85 percent and in Needle Branch about 55 percent. This 30 percent difference was apparently due to the high, sparse canopy over Deer Creek which allowed more light for algae production than did the low, dense canopy over Needle Branch.

Results from two night sampling experiments indicated that _Paraleptophlebia_ nymphs were nocturnal and fed to some extent on algae at night. The mean proportion of algae in stomachs of 44 _Paraleptophlebia_ nymphs collected in Needle Branch before daylight on September 7, 1960, was 22 percent, approximately five times greater than all daylight collections. The mean proportion of algae in stomachs of 19 nymphs collected before dawn in Deer Creek on January 27, 1961, was four percent. Stomachs of 16 nymphs collected in daylight the previous day contained no algae.

In Deer Creek from November 1959 to October 1960, mean proportions of algae in stomachs of _Paraleptophlebia_ nymphs collected from areas of heavy and light cover were 4 and 9 percent respectively (figure 11). The five percent difference suggests that *Paraleptophlebia* nymphs collected from areas of heavy cover were feeding to some extent on algae during daylight hours owing to reduced light intensity, but those nymphs collected from areas of sparse cover were feeding almost entirely on detritus during daylight hours because of increased light intensity. Similarly, stomachs of *Paraleptophlebia* nymphs in Needle Branch from areas of heavy cover contained a greater proportion of algae in their stomachs than did nymphs from areas of light cover (figure 12). Analyses of stomachs of *Baetis* nymphs and Hydrobaenid larvae not included here indicated light in relation to cover densities apparently was not a factor important to their behavior in feeding.

In addition to light, effects of freshets on feeding habits of *Paraleptophlebia* nymphs were also considered since the greatest percentage of algae in stomachs of *Paraleptophlebia* nymphs (nearly 15 percent) occurred in January 1960, a freshet period. Gangmark (4, p. 156) has reported shifting of gravel during freshet periods. Because of gravel movement and overturning, algae might have been available to *Paraleptophlebia* nymphs.

On the basis of coho and insect stomach analyses it was found that energy entering the stream from the terrestrial environment was important to young coho. Approximately 30 percent of the coho diet was of terrestrial origin, mainly in the form of terrestrial insects. In addition, since

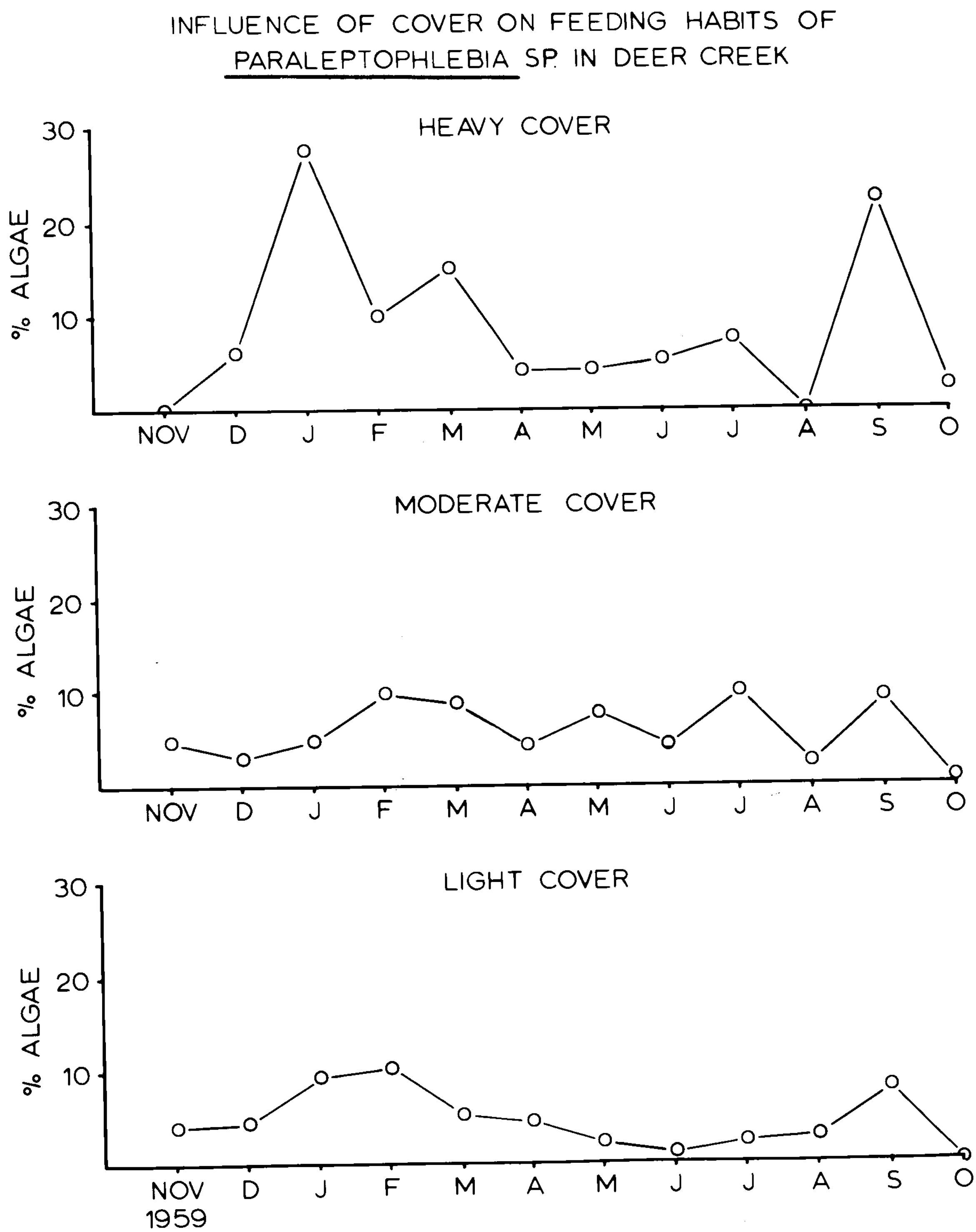
INFLUENCE OF COVER ON FEEDING HABITS OF
PARALEPTOPHLEBIA SP. IN DEER CREEK
HEAVY COVER
MODERATE COVER
LIGHT COVER
% ALGAE
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Figure 11

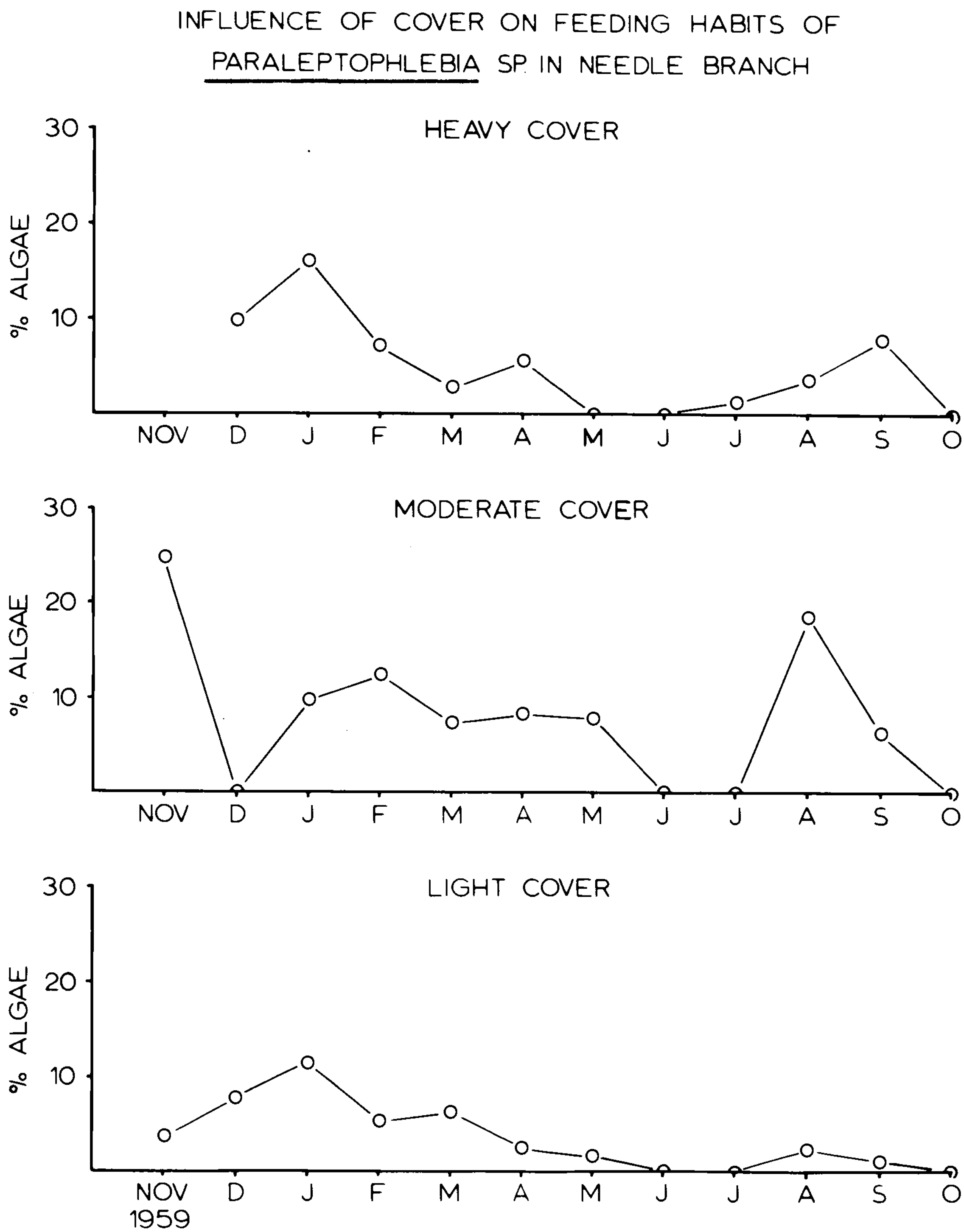
INFLUENCE OF COVER ON FEEDING HABITS OF
PARALEPTOPHLEBIA SP. IN NEEDLE BRANCH
HEAVY COVER
MODERATE COVER
LIGHT COVER
% ALGAE
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Figure 12

Paraleptophlebia nymphs, Hydrobaenid larvae and, to some extent, *Baetis* nymphs fed on terrestrial detritus, the amount of terrestrial energy reaching young coho was increased. In *Paraleptophlebia* nymphs and Hydrobaenid larvae about 75 percent or more of the diet was of terrestrial origin and in *Baetis* nymphs about 40 percent was terrestrial. Chapman (3, p. 154) estimated that about 66 percent of coho energy in Deer Creek was of terrestrial origin, directly through terrestrial food items and indirectly through aquatic insects feeding on terrestrial detritus. Estimates from Flynn Creek and Needle Branch were not computed.

When the proposed logging methods are considered, examination of data gained from stomachs analyses leads to some assumptions as to possible effects of logging on the study streams. The logging method proposed for the Deer Creek watershed will involve staggered settings, or cutting in small blocks of 20 to 40 acres interspersed through the watershed. Most of Deer Creek runs through a meadow and has an alder canopy which will probably be little disturbed by logging. The Needle Branch watershed will be clear-cut, with most of the land cover being removed. Much of the stream canopy will also be disturbed. Flynn Creek will serve as the control stream and remain unlogged.

Since fish in Needle Branch fed predominately on terrestrial food items, removal of the canopy and stream-side vegetation could result in serious depletion of food organisms, especially during the summer months. This may be partially offset by the increased importance of algae as insect food, since removal of the canopy will result in increased light intensity and greater algal production, provided stream flows and dissolved nutrients remain sufficient to support aquatic algae. Flow patterns may be greatly disturbed since run-off from precipitation will be practically unchecked. This could result in silting and scouring until vegetation on adjacent slopes becomes stabilized. Flows during the summer will probably be less, resulting in lower fish-carrying capacity.

Flows in Deer Creek will be affected by watershed logging, but to a lesser degree than in Needle Branch. Inasmuch as coho in Deer Creek relied heavily on aquatic items during the study period, terrestrial food items may assume more importance, especially during the summer months if reduced flows should limit organic drift.

CONCLUSIONS

1. Diptera in the three streams was the most important group of food items in terms of dry weight. They were represented mostly by Tendipididae. Other food groups of importance were Ephemeroptera in Deer Creek, Trichoptera in Flynn Creek and Hymenoptera in Needle Branch.

2. Fish in Deer Creek and Flynn Creek fed mainly on organisms of aquatic habitats, but fish in Needle Branch fed mainly on terrestrial organisms. During the summer months of 1959, fish in Deer Creek fed primarily on aquatic items, but in Needle Branch the diet was composed mainly of terrestrial items. Fish in Flynn Creek selected aquatic and terrestrial food items in about equal proportions.

3. The predominance of aquatic items in fish stomachs from Deer Creek during the summer months of 1959 was apparently due to organic drift resulting from surface flows between pools. In Needle Branch the predominance of terrestrial items was apparently due to lack of organic drift because of little or no surface flow between pools late in the summer.

4. Generally, 0/ age fish utilized the smaller invertebrate organisms such as Tendipedid larvae, Collembola and small mayfly nymphs. Trichoptera and other larger insects were utilized mainly by 1/ age fish.

5. *Baetis* nymphs were predominately algal feeders, diatoms being the dominate algal forms present in the stomachs. Amounts of algae available to *Baetis* nymphs were limited by reduced light levels due to cover densities.

6. *Paraleptophlebia* nymphs were predominately detritus feeders during daylight hours because of a strong negative-phototropic response. Two night sampling experiments indicated that these nymphs fed to a greater extent on algae at night.

7. Examination of Hydrobaenid larvae indicated that they were primarily detritus feeders and fed only to a limited extent on algae.

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APPENDIXES

APPENDIX TABLE I. Summary data of food items, based on dry weights, found in fish stomachs and arranged by habitat origin, Deer Creek, May 25, 1959 to April 22, 1960.

Food items	Aquatic items				Aquatic aerial items				Terrestrial items				Items of uncertain habitats				Total		
	Wt. in mg.	% of total wt.	% wt. of aquatic items	% wt. of food group	Wt. in mg.	% of total wt.	% wt. of aerial items	% wt. of food group	Wt. in mg.	% of total wt.	% wt. of terrestrial items	% wt. of food group	Wt. in mg.	% of total wt.	% wt. of items of uncertain habitats	% wt. of food group	Wt. in mg.	% of total wt.	% wt. of food group
ANNELIDA	0.68	7.1	12.6	100.0															
TOTALS	0.68	7.1	12.6	100.0													0.68	7.1	100.0
ISOPODA									0.03	0.3	0.9	100.0							
TOTALS									0.03	0.3	0.9	100.0					0.03	0.3	100.0
GAMMARIDAE	0.06	0.6	1.1	100.0															
TOTALS	0.06	0.6	1.1	100.0													0.06	0.6	100.0
CHILOPODA									0.02	0.2	0.6	100.0							
TOTALS									0.02	0.2	0.6	100.0					0.02	0.2	100.0
DIPLOPODA									0.26	2.7	7.9	100.0							
TOTALS									0.26	2.7	7.9	100.0					0.26	2.7	100.0
COLLEMBOLA									0.34	3.5	10.4	100.0							
TOTALS									0.34	3.5	10.4	100.0					0.34	3.5	100.0
EPHEMEROPTERA																			
Heptageniidae	0.22	2.3	4.1	16.4															
Epeorus nymphs	0.05	0.5	1.0	3.7															
Baetidae	0.33	3.4	6.1	24.6															
Baetis nymphs	0.13	1.4	2.4	9.7															
Paraleptophlebia nymphs	0.27	2.8	5.0	20.1															
Ephemerella nymphs	0.06	0.6	1.1	4.5															
Misc. Ephemeroptera	0.28	2.9	5.2	20.9															
TOTALS	1.34	14.0	24.9	99.9													1.34	14.0	99.9
PLECOPTERA	0.31	3.2	5.7	81.6	0.07	0.8	12.5	18.4											
TOTALS	0.31	3.2	5.7	81.6	0.07	0.8	12.5	18.4									0.38	4.0	100.0
HOMOPTERA and HEMIPTERA																			
Aphididae									0.08	0.8	2.4	72.7							
Corixidae	0.02	0.2	0.4	18.2															
Misc. Homoptera and Hemiptera													0.01	0.1	2.7	9.1			
TOTALS	0.02	0.2	0.4	18.2					0.08	0.8	2.4	72.7	0.01	0.1	2.7	9.1	0.11	1.1	100.0
TRICHOPTERA																			
Psychomyiidae	0.04	0.4	0.7	5.3	0.21	2.2	37.5	27.6											
Limnephilidae	0.11	1.1	2.1	14.5															
Misc. Trichoptera	0.40	4.2	7.4	52.6															
TOTALS	0.55	5.7	10.2	72.4	0.21	2.2	37.5	27.6									0.76	7.9	100.0
LEPIDOPTERA									0.05	0.5	1.5	100.0							
TOTALS									0.05	0.5	1.5	100.0					0.05	0.5	100.0
HYMENOPTERA													0.04	0.4	10.8	100.0			
TOTALS													0.04	0.4	10.8	100.0	0.04	0.4	100.0
COLEOPTERA																			
Dytiscidae	0.02	0.2	0.4	2.2															
Staphylinidae									0.20	2.1	6.1	22.7							
Elmidae	0.06	0.6	1.1	6.9															
Chrysomelidae									0.55	5.7	16.8	62.5							
Heteroceridae									0.04	0.4	7.1	4.5							
Misc. Coleoptera													0.01	0.1	2.7	1.1			
TOTALS	0.08	0.8	1.5	9.1					0.75	7.8	22.9	85.2	0.01	0.1	2.7	1.1	0.88	9.2	99.9
DIPTERA																			
Tipulidae	0.02	0.2	0.4	0.5															
Culicidae					0.03	0.3	5.4	0.7											
Dixidae	0.16	1.7	3.0	3.9															
Simuliidae	0.28	2.9	5.2	6.8															
Tendipedidae	1.47	15.3	27.2	35.7	0.10	1.0	17.8	2.4											
Heleidae	0.01	0.1	0.2	0.2															
Bezzia larvae	0.02	0.2	0.4	0.5															
Tabanidae					0.08	0.8	14.3	1.9											
Dolichopodidae	0.02	0.2	0.4	0.5															
Empididae					0.03	0.3	5.4	0.7											
Misc. Diptera	0.34	3.5	6.2	8.2					1.25	13.0	38.1	30.3	0.31	3.2	83.8	7.5			
TOTALS	2.32	24.2	43.0	56.3	0.24	2.5	42.9	5.8	1.25	13.0	38.1	30.3	0.31	3.2	83.8	7.5	4.12	42.9	99.9
ARACHNIDA									0.50	5.2	15.2	100.0							
TOTALS									0.50	5.2	15.2	100.0					0.50	5.2	100.0
GASTROPODA	0.02	0.2	0.4	100.0															
TOTALS	0.02	0.2	0.4	100.0													0.02	0.2	100.0
FISH EGGS	0.01	0.1	0.2	100.0															
TOTALS	0.01	0.1	0.2	100.0													0.01	0.1	100.0
CATEGORY TOTALS	5.39	56.1	100.0	—	0.56	5.8	100.0	--	3.28	34.2	99.9	—	0.37	3.9	100.0	--	9.60	100.0	--
TOTAL WEIGHT																	9.60	--	--

APPENDIX TABLE 2. Summary data of food items, based on dry weights, found in fish stomachs and arranged by habitat origin, Flynn Creek, June 20, 1959 to June 14, 1960.

Food Items	Aquatic items				Aquatic aerial items				Terrestrial items				Items of uncertain habitats				Total		
	Wt. in mg.	% of total wt.	% wt. of aquatic items	% wt. of food group	Wt. in mg.	% of total wt.	% wt. of aerial items	% wt. of food group	Wt. in mg.	% of total wt.	% wt. of terrestrial items	% wt. of food group	Wt. in mg.	% of total wt.	% wt. of items of uncertain habitats	% wt. of food group	Wt. in mg.	% of total wt.	% wt. of food group
ANNELIDA	0.68	5.8	10.9	100.0															
TOTALS	0.68	5.8	10.9	100.0													0.68	5.8	100.0
GAMMARIDAE	0.54	4.6	8.7	100.0															
TOTALS	0.54	4.6	8.7	100.0													0.54	4.6	100.0
DIPLOPODA									0.36	3.1	10.0	100.0							
TOTALS									0.36	3.1	10.0	100.0					0.36	3.1	100.0
COLLEMBOLA									0.76	6.5	20.9	100.0							
TOTALS									0.76	6.5	20.9	100.0					0.76	6.5	100.0
EPHEMEROPTERA																			
Heptageniidae	0.005	<0.1	<0.1	2.1															
Baetidae	0.09	0.8	1.4	37.5	0.05	0.4	5.6	20.8											
Baetis nymphs	0.06	0.5	1.0	25.0															
Paraleptophlebia nymphs	0.007	<0.1	<0.1	2.9															
Misc. Ephemeroptera	0.03	0.3	0.5	12.5															
TOTALS	0.19	1.6	3.0	79.2	0.05	0.4	5.6	20.8									0.24	2.0	100.0
PLECOPTERA																			
Chloroperlidae	0.01	0.1	0.2	2.0															
Hastaperla nymph	0.007	<0.1	<0.1	—															
Perlidae					0.18	1.5	20.2	35.3											
Misc. Plecoptera	0.32	2.7	5.1	62.7															
TOTALS	0.33	2.8	5.3	64.7	0.18	1.5	20.2	35.3									0.51	4.3	100.0
HOMOPTERA and HEMIPTERA																			
Aphididae									0.03	0.2	0.8	9.1							
Corixidae	0.29	2.5	4.6	87.9															
Misc. Homoptera and Hemiptera													0.01	0.1	1.0	3.0			
TOTALS	0.29	2.5	4.6	87.9					0.03	0.2	0.8	9.1	0.01	0.1	1.0	3.0	0.33	2.8	100.0
TRICHOPTERA																			
Rhyacophila larva	0.02	0.1	0.3	0.8															
Psychomyiidae	1.43	12.2	22.9	57.4															
Pupa	0.68	5.8	10.9	27.3															
Misc. Trichoptera	0.21	1.8	3.4	8.4	0.15	1.3	16.9	6.0											
TOTALS	2.34	19.9	37.5	94.0	0.15	1.3	16.9	6.0									2.49	21.2	100.0
LEPIDOPTERA									1.05	9.0	28.9	100.0							
TOTALS									1.05	9.0	28.9	100.0					1.05	9.0	100.0
HYMENOPTERA																			
Tenthredinidae									0.05	0.4	1.4	10.6							
Ichneumonidae									0.007	<0.1	<0.1	--							
Misc. Hymenoptera													0.42	3.6	43.3	89.4			
TOTALS									0.05	0.4	1.4	10.6	0.42	3.6	43.3	89.4	0.47	4.0	100.0
COLEOPTERA																			
Dytiscidae	0.08	0.7	1.3	8.0															
Staphylinidae									0.24	2.0	6.6	24.0							
Chrysomelidae									0.42	3.6	11.6	42.0							
Misc. Coleoptera													0.26	2.2	26.8	26.0			
TOTALS	0.08	0.7	1.3	8.0					0.66	5.6	18.2	66.0	0.26	2.2	26.8	26.0	1.00	8.5	100.0
DIPTERA																			
Tipulidae	0.07	0.6	1.1	2.3	0.15	1.3	16.9	5.0											
Culicidae					0.07	0.6	7.9	2.3											
Dixidae	0.38	3.2	6.1	12.6															
Simuliidae	0.11	0.9	1.8	3.7	0.06	0.5	6.7	2.0											
Tendipedidae	0.72	6.1	11.5	23.9	0.10	0.9	11.2	3.3											
Heleidae					0.02	0.1	2.2	0.6											
Bezzia larvae	0.18	1.5	2.9	6.0															
Stratiomyidae					0.02	0.1	2.2	0.6											
Tabanidae	0.21	1.8	3.4	7.0															
Empididae					0.09	0.8	10.1	3.0											
Misc. Diptera	0.09	0.8	1.4	3.0					0.46	3.9	12.7	15.3	0.28	2.4	28.9	9.3			
TOTALS	1.76	15.0	28.2	58.5	0.51	4.3	57.3	16.9	0.46	3.9	12.7	15.3	0.28	2.4	28.9	9.3	3.01	25.7	100.0
ARACHNIDA									0.22	1.9	6.1	100.0							
TOTALS									0.22	1.9	6.1	100.0					0.22	1.9	100.0
GASTROPODA	0.03	0.3	0.4	100.0															
TOTALS	0.03	0.3	0.4	100.0													0.03	0.3	100.0
DETRITUS									0.04	0.3	1.1	100.0							
TOTALS									0.04	0.3	1.1	100.0					0.04	0.3	100.0
CATEGORY TOTALS	6.24	53.2	99.9	--	0.89	7.6	100.0	--	3.63	30.9	100.0	--	0.97	8.3	100.0	--	11.73	100.0	--
TOTAL WEIGHT																	11.73	—	—

APPENDIX TABLE 3. Summary data of food items, based on dry weights, found in fish stomachs and arranged by habitat origin, Needle Branch, May 13, 1959 to February 19, 1960.

Food items	Aquatic items				Aquatic aerial items				Terrestrial items				Items of uncertain habitats				Total		
	Wt. in mg.	% of total wt.	% wt. of aquatic items	% wt. of food group	Wt. in mg.	% of total wt.	% wt. of aerial items	% wt. of food group	Wt. in mg.	% of total wt.	% wt. of terrestrial items	% wt. of food group	Wt. in mg	% of total wt.	% wt. of items of uncertain habitats	% wt. of food group	Wt. in mg.	% of total wt.	% wt. of food group
DIPLOPODA									0.55	9.1	30.7	100.0							
TOTALS									0.55	9.1	30.7	100.0					0.55	9.1	100.0
COLLEMBOLA									0.49	8.1	27.4	100.0							
TOTALS									0.49	8.1	27.4	100.0					0.49	8.1	100.0
EPHEMEROPTERA																			
Heptageniidae	0.03	0.5	1.9	27.3															
Baetidae	0.04	0.7	2.5	36.4															
Paraleptophlebia nymphs	0.03	0.5	1.9	27.3															
Misc. Ephemeroptera	0.01	0.1	0.6	9.0															
TOTALS	0.11	1.8	6.9	100.0													0.11	1.8	100.0
PLECOPTERA					0.04	0.6	12.9	100.0											
TOTALS					0.04	0.6	12.9	100.0									0.04	0.6	100.0
HOMOPTERA and HEMIPTERA																			
Aphididae					0.01	—	—	—											
Gerridae	0.25	4.1	15.6	23.4															
Misc. Homoptera and Hemiptera													0.82	13.6	34.9	76.6			
TOTALS	0.25	4.1	15.6	23.4									0.82	13.6	34.9	76.6	1.07	17.7	100.0
TRICHOPTERA	0.13	2.1	8.1	100.0															
TOTALS	0.13	2.1	8.1	100.0													0.13	2.1	100.0
HYMENOPTERA																			
Tenthredinidae									0.29	4.8	16.2	21.8							
Misc. Hymenoptera													1.04	17.2	44.3	78.2			
TOTALS									0.29	4.8	16.2	21.8	1.04	17.2	44.3	78.2	1.33	22.0	100.0
COLEOPTERA																			
Dytiscidae	0.18	3.0	11.3	29.0															
Staphylinidae									0.15	2.5	8.4	24.2							
Chrysomelidae									0.01	0.2	0.6	1.6							
Misc. Coleoptera									0.02	0.3	1.1	3.2	0.26	4.2	11.1	42.0			
TOTALS	0.18	3.0	11.3	29.0					0.18	3.0	10.1	29.0	0.26	4.2	11.1	42.0	0.62	10.2	100.0
DIPTERA																			
Tipulidae	0.19	3.2	11.9	13.2	0.02	0.3	6.5	1.4											
Culicidae					0.01	0.2	3.2	0.7											
Dixidae	0.13	2.1	8.1	9.0															
Tendipedidae	0.61	10.1	38.1	42.4	0.24	4.0	77.4	16.7											
Misc. Diptera									0.01	0.1	0.6	0.6	0.23	3.8	9.8	16.0			
TOTALS	0.93	15.4	58.1	64.6	0.27	4.5	87.1	18.8	0.01	0.1	0.6	0.6	0.23	3.8	9.8	16.0	1.44	23.8	100.0
ARACHNIDA									0.23	3.8	12.8	100.0							
TOTALS									0.23	3.8	12.8	100.0					0.23	3.8	100.0
DETRITUS									0.04	0.6	2.2	100.0							
TOTALS									0.04	0.6	2.2	100.0					0.04	0.6	100.0
CATEGORY TOTALS	1.60	26.4	100.0	--	0.31	5.1	100.0	--	1.79	29.6	100.0	--	2.35	38.8	100.0	—	6.05	100.0	--
TOTAL WEIGHT																	6.05	--	--

APPENDIX TABLE 4. Percentage occurrences by streams of food groups in fish stomachs; total number of stomach samples in parentheses.

Food Group	Deer Creek (112)	Flynn Creek (116)	Needle Branch (44)
Annelida	4.6	5.0	
Isopoda	1.4		
Gammaridae	3.6	2.9	
Chilopoda	0.4		
Diplopoda	0.9	8.0	
Collembola	26.1	42.4	43.8
Ephemeroptera	46.2	21.2	19.8
Plecoptera	23.9	16.4	1.0
Homoptera	8.5	2.1	0.7
Hemiptera	9.8	7.9	13.6
Trichoptera	11.1	16.0	12.5
Lepidoptera	0.4	4.3	
Hymenoptera	1.8	7.0	11.6
Coleoptera	13.3	12.4	19.1
Diptera	87.5	85.4	85.4
Tendipedidae	77.5	71.6	72.7
Arachnida	6.1	5.6	13.6
Gastropoda	0.4	0.9	
Fish eggs	1.4		
Detritus		0.4	1.7

APPENDIX TABLE 5. Summary data of food items from aquatic and terrestrial habitats, based on dry weights, and arranged by fish age classes and sampling dates; total number of fish stomach samples in parentheses.

Date and fish age class	Deer Creek (112)				Flynn Creek (116)				Needle Branch (44)			
	Aquatic food		Terrestrial food		Aquatic food		Terrestrial food		Aquatic food		Terrestrial food	
	Wt. mg.	% wt.	Wt. mg.	% wt.	Wt. mg.	% wt.	Wt. mg.	% wt.	Wt. mg.	% wt.	Wt. mg.	% wt.
0/ age fish:												
III-17-60	4.1	79	1.1	21	1.1	10	8.5	90				
IV-9-60					0.8	73	0.3	27				
IV-14-60	11.2	59	7.8	41								
IV-22-60	21.9	83	4.6	17	3.2	89	0.4	11				
V-20-60					15.6	97	0.4	3				
VI-14-60					2.0	91	0.2	9				
1/ age fish:												
V-13-59									0.4	50	0.4	50
V-27-59	4.2	96	0.5	4					0.9	26	4.3	74
VI-20-59	3.1	100	0.0	0	1.6	73	0.6	27	1.9	32	4.0	68
VII-2-59	0.8	80	0.2	20	4.5	100	0.0	0				
VII-16-59	1.8	72	0.7	28	1.8	17	8.5	83				
VII-30-59	1.1	8	12.1	92	0.7	41	1.0	59	2.5	61	1.6	39
VIII-17-59	1.5	83	0.3	17	0.4	29	1.0	71	3.5	46	4.1	54
IX-1-59	11.8	78	3.4	22	1.2	58	0.9	42				
IX-15-59	1.3	72	0.5	28	0.3	60	0.2	40	1.4	34	2.7	66
IX-30-59	15.6	82	3.4	18	6.8	71	2.8	29				
X-12-59	1.3	69	0.6	31	5.8	82	1.3	18	0.5	56	0.4	44
XI-13-59	2.5	53	2.2	47	3.7	45	6.0	55	0.5	19	2.1	81
XII-19-59	1.7	35	3.1	65	3.8	85	0.7	15	2.2	85	0.4	15
I-15-60	10.0	91	1.0	9	27.3	93	1.9	7	2.3	27	6.1	73
II-19-60	7.1	100	0.0	0	1.2	50	1.2	50	2.0	100	0.0	0
III-17-60	7.8	94	0.5	6	19.3	48	21.0	52				
III-28-60	6.5	17	31.1	83								
IV-9-60	4.0	31	8.9	69	1.9	66	1.0	34				

APPENDIX TABLE 6. Summary data of food items, based on dry weights, found in fish stomachs and arranged by habitat origin, Deer Creek, May 1959 through September 1959.

Food items	Aquatic items		Aquatic aerial items		Terrestrial items		Items of uncertain habitats		Total	
	Wt. mg.	% wt.	Wt. mg.	% wt.	Wt. mg.	% wt.	Wt. mg.	% wt.	Wt. mg.	% wt.
DIPLOPODA					0.73	10.3				
TOTALS					0.73	10.3			0.73	10.3
COLLEMBOLA					0.17	2.4				
TOTALS					0.17	2.4			0.17	2.4
EPHEMEROPTERA										
Heptageniidae	0.19	2.8								
Baetidae	0.53	7.5								
Misc. Ephemeroptera	0.76	10.6								
TOTALS	1.48	20.8							1.48	20.8
PLECOPTERA	0.06	0.8								
TOTALS	0.06	0.8							0.06	0.8
HOMOPTERA & HEMIPTERA										
Aphididae					0.22	3.1				
Misc. Homoptera and Hemiptera							0.09	1.3		
TOTALS					0.22	3.1	0.09	1.3	0.31	4.4
TRICHOPTERA	0.29	4.1								
TOTALS	0.29	4.1							0.29	4.1
HYMENOPTERA							0.12	1.7		
TOTALS							0.12	1.7	0.12	1.7
COLEOPTERA										
Dytiscidae	0.06	0.8								
Heteroceridae					0.10	1.4				
Misc. Coleoptera							0.08	1.1		
TOTALS	0.06	0.8			0.10	1.4	0.08	1.1	0.24	3.3
DIPTERA										
Culicidae			0.07	1.0						
Dixidae	0.45	6.3								
Simuliidae	0.05	0.7								
Tendipedidae	0.73	10.3	0.25	3.5						
Bezzia	0.01	0.1								
Tabanidae			0.21	3.0						
Empididae			0.07	1.0						
Misc. Diptera	0.85	12.0			0.06	0.8	0.58	8.2		
TOTALS	2.09	29.4	0.60	8.4	0.06	0.8	0.58	8.2	3.33	46.8
ARACHNIDA					0.23	3.2				
TOTALS					0.23	3.2			0.23	3.2
GASTROPODA	0.06	0.8								
TOTALS	0.06	0.8							0.06	0.8
FISH EGGS	0.04	0.6								
TOTALS	0.04	0.6							0.04	0.6
TOTALS	4.08	57.4	0.65	9.1	1.51	21.2	0.87	12.2	7.11	99.9

APPENDIX TABLE 7. Summary data of food items, based on dry weights, found in fish stomachs and arranged by habitat origin, Flynn Creek, June 1959 through September 1959.

Food items	Aquatic items		Aquatic aerial items		Terrestrial items		Items of uncertain habitats		Total	
	Wt. mg.	% wt.	Wt. mg.	% wt.	Wt. mg.	% wt.	Wt. mg.	% wt.	Wt. mg.	% wt.
DIPLOPODA					0.46	6.9				
TOTALS					0.46	6.9			0.46	6.9
COLLEMBOLA					0.14	2.1				
TOTALS					0.14	2.1			0.14	2.1
EPHEMEROPTERA										
Heptageniidae	0.02	0.3								
Baetidae	0.04	0.6								
Misc. Ephemeroptera	0.08	1.2								
TOTALS	0.14	2.1							0.14	2.1
PLECOPTERA	0.47	7.0								
TOTALS	0.47	7.0							0.47	7.0
HOMOPTERA & HEMIPTERA										
Aphididae					0.09	1.3				
TOTALS					0.09	1.3			0.09	1.3
TRICHOPTERA										
Rhyacophila	0.08	1.2								
Misc. Trichoptera	0.23	3.4	0.26	3.9						
TOTALS	0.31	4.6	0.26	3.9					0.57	8.5
LEPIDOPTERA					0.04	0.6				
TOTALS					0.04	0.6			0.04	0.6
HYMENOPTERA										
Tenthredinidae					0.20	3.0				
Misc. Hymenoptera							0.34	5.1		
TOTALS					0.20	3.0	0.34	5.1	0.54	8.1
COLEOPTERA										
Staphylinidae					0.28	4.2				
Misc. Coleoptera							0.36	5.4		
TOTALS					0.28	4.2	0.36	5.4	0.64	9.6
DIPTERA										
Tipulidae			0.51	7.6						
Culicidae			0.25	3.7						
Dixidae	0.53	8.0								
Simuliidae	0.01	0.1								
Tendipedidae	0.52	7.8	0.15	2.3						
Bezzia	0.01	0.1								
Stratiomyidae			0.01	0.1						
Empididae			0.32	4.8						
Misc. Diptera					0.43	6.4	0.39	5.8		
TOTALS	1.07	16.0	1.44	21.5	0.43	6.4	0.39	5.8	3.33	49.8
ARACHNIDA					0.03	0.4				
TOTALS					0.03	0.4			0.03	0.4
GASTROPODA	0.11	1.6								
TOTALS	0.11	1.6							0.11	1.6
DETRITUS					0.13	1.9				
TOTALS					0.13	1.9			0.13	1.9
TOTALS	1.99	29.7	1.70	25.4	1.91	28.6	1.09	16.3	6.69	99.9

APPENDIX TABLE 8. Summary data of food items, based on dry weights, found in fish stomachs and arranged by habitat origin, Needle Branch, May 1959 through September 1959.

Food items	Aquatic items		Aquatic aerial items		Terrestrial items		Items of uncertain habitats		Total	
	Wt. mg.	% wt.	Wt. mg.	% wt.	Wt. mg.	% wt.	Wt. mg.	% wt.	Wt. mg.	% wt.
DIPLOPODA					0.62	8.3				
TOTALS					0.62	8.3			0.62	8.3
COLLEMBOLA					0.50	6.7				
TOTALS					0.50	6.7			0.50	6.7
EPHEMEROPTERA										
Baetidae	0.10	1.3								
Misc. Ephemeroptera	0.05	0.7								
TOTALS	0.15	2.0							0.15	2.0
PLECOPTERA	0.07	0.9	0.04	0.6						
TOTALS	0.07	0.9	0.04	0.6					0.11	1.5
HOMOPTERA & HEMIPTERA										
Aphididae					0.01	0.1				
Gerridae	0.60	8.1								
Misc. Homoptera and Hemiptera							0.48	6.5		
TOTALS	0.60	8.1			0.01	0.1	0.48	6.5	1.09	14.7
TRICHOPTERA	0.20	2.7								
TOTALS	0.20	2.7							0.20	2.7
HYMENOPTERA										
Tenthredinidae					0.70	9.4				
Misc. Hymenoptera							0.04	0.5		
TOTALS					0.70	9.4	0.04	0.5	0.74	9.9
COLEOPTERA										
Dytiscidae	0.16	2.2								
Staphylinidae					0.36	4.8				
Chrysomelidae					0.30	4.1				
Misc. Coleoptera							0.46	6.2		
TOTALS	0.16	2.2			0.66	8.9	0.46	6.2	1.28	17.2
DIPTERA										
Tipulidae			0.36	4.8						
Culicidae			0.22	3.0						
Dixidae	0.26	3.5								
Tendipedidae	0.54	7.3	0.49	6.6						
Misc. Diptera							0.42	5.6		
TOTALS	0.80	10.8	1.07	14.4			0.42	5.6	2.29	30.8
ARACHNIDA					0.36	4.8				
TOTALS					0.36	4.8			0.36	4.8
DETRITUS					0.10	1.3				
TOTALS					0.10	1.3			0.10	1.3
TOTALS	1.98	26.6	1.11	15.8	2.95	39.7	1.40	18.8	7.44	100.0

APPENDIX TABLE 9. Mean percentages of algae in aquatic insect stomachs from the two main stream habitats, Deer Creek, November 16, 1959, to October 18, 1960; insects per minthly sample in parentheses.

Date	Baetis nymphs	Paraleptophlebia nymphs	Hydrobaeninae larvae
Meadow portion:			
November	20.8 (12)	3.9 (18)	9.5 (20)
December	59.8 (47)	4.1 (41)	12.8 (60)
January	72.5 (36)	10.9 (42)	33.4 (34)
February	83.9 (23)	11.1 (21)	19.8 (16)
March	79.6 (37)	7.1 (38)	7.0 (21)
April	92.4 (31)	5.1 (41)	7.3 (26)
May	93.3 (41)	4.2 (41)	7.5 (20)
June	74.8 (24)	2.6 (65)	16.2 (26)
July	72.4 (20)	4.3 (44)	8.0 (33)
August	50.0 (2)	2.6 (35)	4.0 (31)
September	78.4 (5)	11.8 (30)	6.5 (20)
October	42.5 (12)	0.8 (28)	0.0 (9)
Mean	68.4	5.7	11.0
Canyon portion:			
May	97.5 (26)	5.9 (19)	2.5 (4)
June	92.9 (33)	3.6 (25)	34.2 (9)
July	89.4 (30)	1.0 (15)	18.7 (24)
August	93.2 (11)	9.1 (17)	2.7 (11)
September	99.5 (12)	21.7 (9)	52.2 (9)
October	65.9 (12)	0.0 (7)	2.5 (4)
Mean	89.7	6.9	18.8

APPENDIX TABLE 10. Mean percentages of algae in aquatic insect stomachs, Needle Branch, November 4, 1959, to October 12, 1960; insects per monthly sample in parentheses.

Date	*Baetis* nymphs	*Paraleptophlebia* nymphs	Hydrobaeninae larvae
November	20.3 (13)	2.6 (13)	4.9 (25)
December	51.2 (20)	8.3 (31)	15.9 (20)
January	73.9 (29)	14.2 (22)	36.7 (22)
February	77.5 (34)	7.0 (41)	24.4 (36)
March	90.7 (26)	5.9 (32)	21.5 (14)
April	74.3 (31)	5.9 (37)	29.0 (23)
May	49.6 (21)	3.7 (36)	3.0 (17)
June	36.8 (13)	0.0 (32)	8.4 (12)
July	60.7 (18)	0.4 (47)	8.1 (30)
August	55.0 (11)	10.2 (39)	4.1 (25)
September	60.0 (4)	5.1 (30)	1.7 (22)
October		0.0 (11)	4.4 (9)
Mean	54.2	5.3	13.5

APPENDIX TABLE 11. Mean percentages of algae in aquatic insect stomachs arranged by stream bottom types, Deer Creek, November 16, 1959, to October 18, 1960; insects per monthly sample in parentheses.

Bottom type:	Rubble	Gravel	Pea-gravel	Sand	Silt
Baetis nymphs					
Meadow portion:					
November	10.0 (3)	37.5 (4)	0.0 (2)	17.5 (4)	
December	48.2 (11)	36.3 (8)	75.5 (20)	58.8 (8)	
January	48.0 (10)	85.5 (11)	91.3 (8)	65.7 (7)	
February	77.5 (8)	91.1 (9)	95.0 (4)	55.0 (2)	
March	80.0 (11)	82.5 (12)	80.0 (3)	73.6 (11)	
April	96.7 (6)	88.7 (15)	92.0 (5)	96.0 (5)	
May	87.5 (8)	100.0 (6)	90.0 (11)	95.6 (16)	
June	90.0 (2)	71.6 (19)	90.0 (1)	55.0 (2)	
July		76.5 (17)	53.3 (3)		
August		50.0 (3)			
September		66.7 (3)	90.0 (2)		
October	100.0 (2)	40.0 (3)	36.0 (5)		90.0 (2)
Mean	53.2	68.9	66.1	43.1	7.5
Canyon portion:					
May	96.8 (22)		100.0 (2)	100.0 (2)	
June	97.1 (22)	96.7 (7)	100.0 (2)	0.0 (2)	90.0 (2)
July	85.7 (14)	100.0 (4)	100.0 (4)		90.0 (2)
August	92.2 (10)			95.0 (2)	
September	98.8 (8)	100.0 (2)	100.0 (4)		
October	45.0 (9)	50.0 (4)			
Mean	85.9	57.8	66.7	32.5	30.0
Paraleptophlebia nymphs					
Meadow portion:					
November	1.7 (6)	1.7 (6)		8.3 (6)	
December	3.3 (6)	6.3 (8)	3.5 (19)	2.9 (7)	10.0 (1)
January	3.8 (8)	19.2 (12)	2.0 (10)	9.0 (10)	40.0 (2)
February	7.5 (8)	14.0 (5)	3.3 (3)	16.0 (5)	
March	5.0 (10)	13.3 (9)	1.4 (7)	5.8 (12)	
April	1.3 (9)	4.7 (14)	8.6 (7)	2.7 (11)	
May	6.0 (5)	5.7 (7)	6.0 (10)	2.1 (19)	
June	5.0 (4)	2.5 (39)	3.0 (10)	2.7 (11)	0.0 (1)
July	0.0 (2)	4.0 (30)	2.5 (8)		12.5 (4)
August	5.0 (2)	1.4 (14)	4.2 (12)	1.7 (6)	0.0 (1)
September		7.3 (15)	11.1 (9)	16.7 (6)	
October	0.0 (2)	1.3 (8)	0.0 (10)		2.5 (8)
Mean	2.8	6.8	3.8	5.7	5.4
Canyon portion:					
May	6.9 (13)		0.0 (4)	15.0 (2)	
June	3.8 (14)	3.3 (6)	0.0 (2)	0.0 (2)	20.0 (1)
July	1.4 (7)	0.0 (2)	1.7 (6)	0.0 (2)	
August	4.3 (10)	40.0 (2)	10.0 (3)	0.0 (2)	
September	55.0 (2)	0.0 (2)	7.5 (4)	10.0 (1)	
October	0.0 (5)				
Mean	11.9	7.2	3.2	4.2	3.3
Hydrobaeninae larvae					
Meadow portion:					
November	7.8 (9)	6.7 (3)		12.2 (9)	
December	2.5 (4)	17.9 (14)	10.8 (26)	16.6 (15)	10.0 (1)
January	40.0 (5)	37.5 (12)	2.4 (8)	30.0 (7)	0.0 (2)
February	25.0 (4)	10.0 (4)	3.3 (3)	6.7 (3)	0.0 (2)
March	10.0 (6)	6.0 (5)	5.0 (2)	5.0 (8)	
April	24.0 (5)	2.2 (9)	15.0 (2)	3.8 (10)	
May	5.0 (2)	20.0 (6)	2.0 (5)	3.3 (6)	0.0 (1)
June	3.3 (3)	12.2 (18)	0.0 (2)	30.0 (3)	
July	0.0 (2)	1.2 (17)	21.1 (9)	0.0 (2)	15.0 (2)
August	0.0 (2)	3.1 (13)	3.3 (9)	4.0 (5)	5.0 (2)
September		1.4 (7)	0.0 (5)	6.0 (5)	30.0 (3)
October	0.0 (1)	0.0 (1)	0.0 (4)		0.0 (3)
Mean	2.8	6.8	3.8	5.7	4.4
Canyon portion:					
May	2.5 (4)				
June	36.0 (5)	0.0 (1)	5.0 (2)		0.0 (1)
July	33.3 (12)	0.0 (2)	0.0 (6)		10.0 (4)
August	0.0 (3)	2.5 (2)	2.0 (5)	0.0 (1)	
September	90.0 (2)	0.0 (2)	30.0 (3)	5.0 (2)	
October	36.7 (3)	0.0 (1)			
Mean	33.1	0.4	6.2	0.8	1.7

APPENDIX TABLE 12. Mean percentages of algae in aquatic insect stomachs arranged by stream bottom types, Needle Branch, November 4, 1959, to October 12, 1960; insects per monthly sample in parentheses.

Bottom types:	Gravel	Pea-gravel	Sand	Silt
Baetis nymphs				
November	7.5 (4)	5.0 (4)	17.5 (4)	70.0 (1)
December	74.0 (5)	50.9 (11)	10.0 (1)	20.0 (3)
January	50.0 (2)	79.1 (23)	65.0 (4)	
February	70.7 (14)	72.4 (17)	100.0 (2)	80.0 (1)
March	78.0 (5)	89.3 (14)	77.5 (4)	93.3 (3)
April	74.4 (16)	73.3 (6)	73.3 (9)	
May	43.3 (3)	50.8 (13)	52.5 (4)	10.0 (1)
June	10.0 (1)	31.3 (8)	47.5 (4)	
July	68.8 (8)	55.6 (9)	20.0 (1)	
August	46.7 (9)		90.0 (2)	
September	46.7 (3)		100.0 (1)	
October				
Mean	47.5	42.3	54.4	2.8
Paraleptophlebia nymphs				
November	2.9 (7)	2.5 (4)	10.0 (1)	100.0 (1)
December	2.9 (7)	10.7 (15)	5.0 (4)	10.0 (5)
January		12.5 (16)	10.0 (6)	
February	6.9 (16)	6.7 (18)	4.0 (5)	15.0 (2)
March	10.0 (5)	4.7 (19)	8.0 (5)	3.3 (3)
April	3.3 (18)	7.5 (8)	7.3 (11)	
May	20.0 (6)	0.9 (23)	0.0 (5)	0.0 (2)
June	0.0 (10)	0.0 (12)	0.0 (9)	0.0 (2)
July	1.2 (17)	0.0 (15)	0.0 (11)	0.0 (4)
August	3.3 (12)	19.4 (16)	5.0 (6)	0.0 (4)
September	5.8 (13)	6.4 (11)	7.5 (4)	5.0 (2)
October	0.0 (3)	0.0 (8)		
Mean	4.7	5.9	4.7	11.1
Hydrobaeninae larvae				
November	8.0 (10)	2.0 (5)	7.9 (7)	0.0 (3)
December	3.3 (5)	11.1 (9)	16.7 (3)	40.0 (2)
January	10.0 (2)	47.1 (14)	20.0 (6)	
February	45.0 (10)	16.7 (18)	18.6 (7)	10.0 (1)
March	33.3 (3)	25.0 (6)	6.7 (3)	15.0 (2)
April	24.2 (12)	46.0 (5)	26.7 (6)	
May	10.0 (3)	2.7 (11)	0.0 (2)	0.0 (2)
June	0.0 (3)	0.0 (2)	18.0 (5)	5.0 (2)
July	11.1 (9)	14.3 (7)	3.3 (12)	5.0 (2)
August	4.4 (9)	4.4 (9)	2.5 (4)	5.0 (3)
September	3.0 (11)	0.0 (4)	2.0 (5)	0.0 (2)
October	0.0 (2)	12.0 (5)	0.0 (2)	
Mean	12.7	15.1	10.2	6.7

APPENDIX TABLE 13. Mean percentages of algae in *Paraleptophlebia* stomachs collected from stream areas of different vegetative cover densities; nymphs per monthly sample in parentheses.

Date	Deer Creek (meadow portion)			Needle Branch		
	Light cover	Moderate cover	Heavy cover	Light cover	Moderate cover	Heavy cover
November	4.0 (15)	5.0 (2)	0.0 (1)	3.8 (9)	25.0 (4)	
December	4.3 (28)	3.3 (6)	6.0 (7)	7.7 (22)	0.0 (2)	10.0 (7)
January	9.2 (36)	5.0 (2)	27.5 (4)	11.8 (17)	10.0 (2)	16.7 (3)
February	10.6 (17)	10.0 (3)	10.0 (1)	5.8 (30)	12.5 (4)	7.1 (7)
March	5.4 (28)	8.8 (8)	15.0 (3)	6.7 (21)	7.5 (4)	2.9 (7)
April	4.2 (24)	4.3 (7)	4.0 (10)	2.5 (16)	8.5 (13)	6.3 (8)
May	2.2 (23)	7.7 (13)	4.0 (5)	1.8 (12)	6.0 (20)	0.0 (5)
June	1.1 (37)	4.1 (17)	5.5 (11)	0.0 (8)	0.0 (19)	0.0 (6)
July	2.5 (31)	10.0 (8)	7.5 (4)	0.0 (9)	0.0 (22)	1.3 (16)
August	2.9 (21)	2.5 (12)	0.0 (2)	2.5 (4)	18.8 (17)	3.5 (16)
September	8.0 (15)	9.1 (11)	22.5 (4)	1.4 (7)	6.6 (9)	7.9 (14)
October	0.0 (7)	0.8 (13)	2.5 (8)	0.0 (3)	0.0 (3)	0.0 (5)
Mean	4.5	5.9	8.7	3.7	7.9	4.6